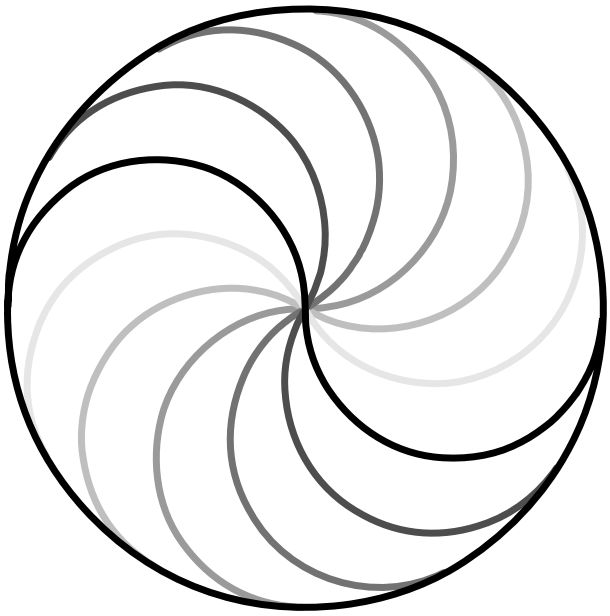

LEARNING IN A VIRTUAL WORLD:

Expanding Activity theory for the design and evaluation of group praxis

by

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This text responds to the increasing demand for frameworks to support the design and evaluation of virtual worlds which are effective in their particular learning context by developing, a meta-theoretical framework for understanding "learning in a virtual world" and the novel dialectical methodology for designing and evaluating learning activities in it by "expanding activity theory for the design and evaluation of group praxis". It emerges from exploring learning in a virtual world in all of its complexity. It illuminates two competing perspectives of learning and VR. On the one side, individualistic learning (mental representations) and rationalistic VR, based on the dualistic ontology; and on the other, social learning (human development) and dialectical or relational VR, based on the non-dualistic ontology. This historical perspective reflexively leads to Cultural-historical activity theory, which is identified as the most appropriate and productive framework for considering learning in a virtual world. Activity theory facilitates the comparative evaluation of learning in virtual worlds; i.e. comparing them to the same learning activity in another situation. Activity theory furthermore provides the key analytical category of object-relatedness, necessary to make such a comparison possible. True to the dialectical method this text proposes it then moves to applying theory in practice. The approach utilizes Activity theory as an instrument and analytical lens to describe, design and evaluate learning activities in virtual worlds (3D videogame implementations utilizing the Unreal2Engine). The approach is applied to two case studies conducted in the domain of Film Studies. Activity theory proves a successful analytical tool for describing the structures of the activities analyzed. These descriptions are adequate for informing the design of the virtual worlds. However, the more complex second scenario proposes challenges for the traditional activity system representation and unit of analysis. Activity cell transformation develops in response to these challenges and enables the dialectical reflection back on Activity theory to provide new insights into contemporary Activity theory and some of the 3rd generation theoretical challenges identified. In addition to the individual and collective activity analysis, this new intermediary lens focuses on the interrelationship between the individual and collective activity, i.e. collaborative group activity.

Dedication

Hierdie werk word opgedra aan my Moeder, Cornelia Petronella Elizabeth Vermeulen, sonder wie se liefde en ondersteuning dit nie sou moontlik gewees het nie, baie dankie.

This work is dedicated to my Mother, Cornelia Petronella Elizabeth Vermeulen, without whose love and support it would not have been possible, thank you so much.

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1. Introduction

The thesis developed and defended herein consists of two parts as indicated by the title of the text. The first part is theoretical and posits that human reality is culturally constructed, pluralistic and hence we are already living in a virtual world. To productively understand "learning in a virtual world", a meta-theoretical framework is required based on a non-dualistic ontology and the dialectical materialist epistemology, i.e. activity theory. The second part explicates the practical development of the dialectical methodology by "expanding activity theory for the design and evaluation of group praxis". This practical development reflexively leads back to theory by proposing a new intermediary unit of analysis and analytic lens for activity theory. The result and novel products of this text and its research is a novel meta-theoretical framework for understanding learning in a virtual world, a dialectic methodology for designing and evaluating the learning activities taking place in these worlds, and a representational system for representing group activity.

Virtual worlds typically refers to 3D computer-generated interactive environments, and since this definition fits a whole range of 3D computer environments already in existence (high-end head-mounted displays (HMD), photo realistic graphics, arcade, CD-ROM and on-line multi-player computer games, QuickTime VR movies, VRML and graphical chat environments)(Manovich, 2001), this text considers these virtual worlds as part of the greater cultural phenomenon of Virtual Reality (VR). VR technologies have entered the main stream in the form of virtual worlds: "mirror worlds" (Gelernter, 1992) such as Google Earth, video games and massively multiplayer online games (MMOGs). Google Earth has been downloaded more than 250 million times (Roush, 2007). According to analyst reports from PriceWaterhouseCoopers the video game industry worldwide is projected to grow from $25 billion in 2004 to $55 billion in 2009 (Jenkins, 2005). A report from the media research company Screen Digest suggests that the Western market for massively multiplayer online games surpassed $1 billion dollars for the first time in 2006 due to the continuing success of "World of Warcraft" as well as the introduction of more casual MMOGs such as "Second Life" (J. Dobson, 2007). According to research by analyst group DFC Intelligence, the online game market is further expected to spike to a $13 billion dollar industry over the next 5 years with digital distribution and virtual item sales expected to account for 40 percent of the market (Gamasutra, 2007). The main objective of these systems is entertainment. None the less these entertainment experiences necessitate learning in order to master these complex environments and achieve success in resolving the complex challenges they pose (Gee, 2003; Nardi *et al.*, 2007; Squire, 2005; Stahl, 2006a).

Educational technologists are now recognizing the educational potential of these technologies (Aldrich, 2005; Crocker, 2003; De Aguilera & Méndiz, 2003; Gee, 2005; Moser, 1997; Prensky, 2004; Shaffer *et al.*, 2004; Wolz *et al.*, 2006). Scientists are also starting to realize: "The Scientific Research Potential of Virtual Worlds" (Bainbridge, 2007). The 7 September 2007 Special Issue of the magazine "Science", focusing on Social Cognition (Ash *et al.*, 2007), reports that virtual worlds offer social psychologists a exciting new terrain for exploring human behavior and complex social interactions (G. Miller, 2007a). Organizations like the MacArthur Foundation has launched its five-year, $50 million digital media and learning initiative in 2006 to help determine how digital technologies are changing the way young people learn, play, socialize, and participate in civic life (MacArthur Foundation, 2007). Some academic exploration is already taking place in virtual worlds. SciLands, the scientific portion of Second Life (a popular social MMOG), is a cooperative effort among researchers across the globe who created the Second Life destination known as the International Spaceflight Museum (Toto, 2007).

Clearly, Virtual Worlds offer a cornucopia of learning experiences by providing learners with access to rich virtual contexts. However, utilizing virtual reality and worlds for educational purposes is complicated through a plethora of challenges. The central, yet unanswered challenge can be formulated as the following question: How can virtual worlds be understood and developed for custom educational contexts and consequently which frameworks are most appropriate and productive for the design and evaluation of such virtual worlds? *This text developed dialectically in response to these challenges, reciprocating between theory and practice, exploring the complex but exciting terrain of learning in a virtual world.* This text is unconventional in that it charts the exploration and navigation of an intellectual terrain, rather than the top-down hierarchical analysis and rationalist explication of a traditional academic text based on the modernist paradigm. This is congruent with the postmodern perspective promoted herein and it is suggested that this text is most productively read with this perspective in mind. It will also be assumed that the reader is familiar with the central themes of postmodernism. As such this text presents the "bricolage" (Lévi-Strauss, 1968) style, where *the thesis* emerged from the critical and creative exploration and application of theory (combining theoretical concepts and methods); rather than the typical modernistic thesis' *priori* problem formulation, literature review, methodology, implementation, results, discussion and conclusion. This style is a valid way of organizing scientific work (Turkle, 1995). To overcome the challenge of the linear representation of this text, it deconstructs the assumption about learning in a virtual world in order to orient the reader to the emergence of *the thesis*.

1.1. Deconstructing the assumptions about learning in a virtual world

One of the main assumptions about learning in a virtual world is reflected in the following question: How can we learn anything about the real world in virtual reality and worlds, *which are by their very definition virtual and alternatives to our world and reality*? Rita Lauria (1997), in her article "Virtual Reality: An Empirical-Metaphysical Testbed", agues that a fundamental message of the VR medium may be to illumine timeless philosophical inquiries concerning the nature of knowing and being and thus direct our attention to what Aristotle called the eternal question: What is reality? Similarly, Sherry Turkle (1995) in her seminal book "Life on the Screen: Identity in the age of the Internet" suggests that virtual communities, worlds and simulations make concrete many of the facets of postmodernism, including the epistemological question "what is real?". This text will argue that this deeply philosophical question is indeed central to our understanding of both learning and VR, and consequently learning in a virtual world. It is only when we consider learning and Virtual Reality in a philosophical "light" that these two complex concepts are illuminated and the affordances of learning in virtual worlds will become apparent. The deconstructive question of "What is reality?" is a metaphysical challenge.

1.1.1. Metaphysical challenge

The term metaphysics was originally used by Andronicus of Rhodes, one of the first editors of Aristotle, to describe Aristotle's treatise on the topic of things which come after the treatise on natural things (Silverman, 2003). In his treatise on "metaphysics" Aristotle dealt with topics (mind and body, substances, events, causation, existence, etc.) which do not belong to any particular science; and this led to the term being applied to any enquiry that raises questions about reality that lie beyond those capable of being tackled by the empirical methods of science (Blackburn, 1996; Bowker, 2000), including the occult and supernatural. Metaphysics in this text will consequently refer back to the terms original philosophical meaning, as the study of the most basic non-empirical presuppositions of reality. However, unlike traditional metaphysics, it does not attempt to conceptualize reality as an abstraction existing outside human activities (first principles), but as part of our cultural-historical praxis. Reality is always a human reality, and part of the dialectical meaning making activity we engage in with one another and our environment. From this perspective, Aristotle's "what comes after physics" is the study of reality as a cultural-historical product. This "metaphysics as culture" underlies contemporary Cultural-historical Activity Theory and can be traced back through Marx to Giambattista Vico (1725/1968).

Vico's “Scienza Nuova” (The New Science, 1725/1968) sets free philosophy from the subjectivity of the metaphysics of existences and the dominance of the conceptual word rooting itself openly in philology. It reveals Vico's “New Science” as a genuine phenomenology of the historical appearance of the human world, one that does not fly off into an abstract ontology of existence, but a vision of man's historical engagement in the concrete history of the truth of existence (Vincenzo, 1998). Vico's metaphysics, therefore, does not attempt to conceptualize universal, unchanging truth as an abstraction existing outside human activities, but contemplates the invisible substance of historicity in and through praxis (Vincenzo, 1998). *Likewise, this text aims to account for the “reality of humanity” by tracing the cultural-historical development of the nature of existence; an ontological challenge. This ontological challenge can be formulated as the following research question: What ontological perspective and worldview most productively views learning in a virtual world?*

1.1.2. Ontological challenge

Ontology is the consideration in philosophy and metaphysics of what truly exists, what underlies the appearance by way of existent reality, i.e. the nature of being or existence (Bowker, 2000; Colman, 2006; Scott & Marshall, 2005). *This text contributes to this challenge the explication of the development of Western ontological thought in philosophy, revealing two perspectives competing for dominance the last 2500 years.* The tension between the *dualistic* and *non-dualistic* paradigms has driven the intellectual development of human thought and culture. The dualistic perspective presupposes the existence of two worlds: The world of change and appearance and the stable “real” world (reality), which can only be known through reason. The non-dualistic perspective in contrast presupposes eternal change and transformation (becoming) as the true nature of reality. The world of appearance is consequently the projection of a stable rational “reality” unto the world, leading to the paradoxical dialectic of the *unity of mutually exclusive opposites*.

The two ontological perspectives are two different ways of looking at the world, i.e. two different ways of being, seeing and knowing. However, the true power of these perspectives lies in the productive tension which binds them together. It is tempting to privilege the non-dualistic perspective and interpret these two perspectives as opposing forces driving transformation as the ultimate “unity of mutually exclusive opposites”. However, this would marginalize the role of the dualistic perspective and consequently diminish the productive tension at the heart of the development of human thought. This is the paradox of human understanding: to know anything we have to differentiate between ourselves and the rest of “reality” (dualism); yet, we also understand

this very process (dialectic) and its limitations. In this text, which aims to explore learning in a virtual world, human understanding is of central significance, the non-dualistic paradigm will therefore be proposed as the most appropriate perspective.

VR provides an opportunity to "materialize" ontological perspectives by simulating different relationships between the user and the synthetic computational world. The typical VR system represents the dualistic ontological perspective, wherein the user as observer/subject relates to the virtual world as observed/object. However, despite the dominance of this ontological "materialization" in VR, other ontological configurations are also possible. For example Char Davies' virtual worlds Ephémère and Osmose (Davies, 2003) which aim to communicate subjective experiences of intermingling interior self and external world, of body and nature. This "materialization" of ontology opens up the possibility of Lauria's (1997) proposal for using VR as an "Empirical-Metaphysical Testbed". Consequently VR not only afford us new and exciting learning opportunities, but also has the potential to shed light on the ontological perspectives that shape our conception of reality, knowledge and cognition. This is particularly relevant for the crisis in contemporary education.

Martin J. Packer and Jessie Goicoehea (2000) in their article entitled "Sociocultural and Constructivist Theories of Learning: Ontology, Not Just Epistemology" suggest that ontological matters have been marginalized in contemporary theories of learning. Indeed, educational debates in the twentieth century have myopically focused on the epistemological challenges facing education, while ignoring the ontological basis on which these epistemologies rest. This neglect is the result of modern skepticism regarding metaphysics and consequently ontology, traceable to the logical positivist notion that discussion of ontology is merely "metaphysical," untestable, and therefore unscientific or even meaningless (Packer & Goicoehea, 2000). *The ontological challenge facing education today therefore surfaces as an epistemological challenge. This epistemological challenge can be formulated as the following research question: What epistemology, theoretical framework and unit of analysis define learning in a virtual world to facilitate our productive understanding of it?*

1.1.3. Epistemological challenge

Epistemology is the study of what knowledge is and how it comes to be known. It includes logic, belief, perception, language, science, and knowledge. Contemporary education has been caught up in the postmodernity of the last century and consequently is facing what can be labeled as an "epistemological crisis" (Patraglia, 1998b). This "conceptual upheaval" (Sfard, 1998) in education is

the result of a ontological shift taking place, moving away from the objectivistic model of education based on the rationalist epistemology and dualistic ontology. This shift is a reaction against troublesome questions in education that refuse to go away, including the theory-praxis gap (Roth & Tobin, 2000), the tensions between the epistemological and ontological aspects of human development (Packer & Goicoehea, 2000), the differences between decontextualized and embodied knowledge (Lave, 1993), the difficulty of planning for specific forms of learning (Holzkamp, 1992), and the apparent disjunction between individual learners with other learners and their social environments (Barab & Plucker, 2002; Roth & Lee, 2007; Schutz, 1986).

This text contributes to this challenge the meta-theoretical framework developed in the subsequent chapter by expanding its explication of the development of Western ontological thought in philosophy, by relating it to the development of educational theories and their respective epistemological systems. The dualistic ontological perspective will be linked to individualistic learning theories; while the non-dualistic ontological perspective will be linked to social learning theories. This ontological exposition on learning theories leads to Cultural-historical Activity Theory (CHAT or Activity theory), the oldest and most developed of the social learning theories (Nardi, 1995b), which has taken upon itself the task to "dialectically link the individual and the social structure" (Yrjö Engeström, 1999, p. 19). *Activity theory is based on a viable alternative to the rationalist epistemology, namely dialectical materialist epistemology.*

Dialectical materialism rejects both: the mechanical materialists' conception of reality as pure matter (knowable through objective experience, devoid of human sensuousness and subjectivity) and the idealists' conception of reality as pure spirit or consciousness (abstract and unable to know sensuous reality). Dialectical materialism transcends and unifies these two *opposing* conceptions. Clearly, an objective material world exists, it is clear from the increasingly dependable knowledge that humans have produced of it. However, absolute knowledge is unattainable. Knowledge of the world is attained through human praxis, which is both objective and subjective, i.e. relative to the perspective taken when studying the world. This does not mean that the attained knowledge is absolutely relative either: "It is a relative Truth, since it is the Truth of a set of inter-relations and inter-actions viewed from within those relations" (Jackson, 1971, p. 68). However, some perspectives are, improvements on older ones, some have better consequences for humanity, etc. So, although there are no ultimate truth and knowledge, there is also no absolutely relative truth and knowledge either. It is tempting to suggest that the true criterion by which to measure the extent

of our knowledge is the number of perspectives we can take on the world and its phenomena. Furthermore the ability to take another's perspective lies at the heart of human empathy and ethics.

This text promotes the dialectical materialist epistemology and this clearly has important implications for truth, knowledge and learning. Learning will be defined in the subsequent chapter as "learning activity". The concept of a learning activity proposed by Engeström's (1987) can be embodied as learning by expanding, i.e. the mastery of the expansion from actions to a new activity. Engeström (2001) regards such expansive learning is essentially a collective endeavor. This emphasis has resulted in diminishing the role of human subjectivity, which is endowed with the capacity to generate new cycles of activity (Stetsenko, 2005), within the learning activity. This text concurs with Holzkamp's (1983) suggestion that individual and collective learning should be linked. This expanded learning activity is consequently a cultural-historical developmental process, a human activity, dialectically reciprocating between the individual, society and the world. *Learning, defined as learning activity, is clearly a dialectical process which unites the individual and the social structure in mutual transformation. For the practical purposes of the research for this text the collaborative group will be presented as the most productive unit of analysis for the learning activity.*

Having defined learning, this text will then illustrate that the very ontological and epistemological tension underlying the developed concept of learning is also prevalent in debates regarding VR. On the one hand, from the dualistic ontological perspective, VR can be defined as a technology which aims to fulfill the age old rationalist fantasy of representing reality by seeking presence through its correspondence to "objective" reality. On the other hand, from the non-dualistic ontological perspective, VR can be defined as a new representational system (Riva & Mantovani, 1999) or cultural interface (Manovich, 2001) which afford new opportunities for human praxis and meaning making, through the mediation of activities and actions. All human reality according to this perspective is culturally constructed, pluralistic and hence also virtual, i.e. not rational "objective" reality. Virtual reality therefore provides another cultural context, albeit computer generated and mediated; and thus is as valid a context for learning as any other. This has important implications for the "assumptions about of learning in a virtual world" (See 1.1), since we can indeed learn something about the "real world" in VR, i.e. about human cultural practice and social activities, including learning activities.

As learning is defined as a cultural-historical process and activity, this means that this text can reflexively learn about learning in a virtual world through this very practice. Activity theory offers the most appropriate framework to frame both definitions of learning and VR in this text.

Activity theory is particularly well suited for representing, communicating and understanding human practice. This text therefore proposes Activity theory as the conceptual framework from which to consider learning in a virtual world. *It aims to practice what it preaches by conducting a comparative evaluation of a learning activity in a virtual world by using Activity theory as theoretical framework. However, such an implementation introduces methodological challenges. The methodological challenges can be formulated as the following research question: What methodologies can be most productively used to design and evaluate learning in a virtual world?*

1.1.4. Methodological challenges

Choosing the alternative ontological perspective and epistemology to that which has been dominant in the West does not come without its consequences. Indeed, much of contemporary science and its methods derive from rational assumptions, seeking validity and objective knowledge about phenomena through the quantification, categorization and the elimination of alternate hypotheses. *Clearly, the first methodological challenge is finding the appropriate methods for conducting research from a dialectical approach to science.* The dialectical materialist epistemology proposes a radically different understanding of truth and consequently science. Giambattista Vico laid the foundation for this dialectical science 300 years ago with his "New Science" (Scienza Nuova, 1725/1968). Hegel systematically devised dialectical logic, Marx placed Hegel "back on his feet" with the articulation of the dialectical materialist epistemology and Vygotsky formulated his historical approach on these foundations preparing the way for Activity theory.

This text will therefore begin the development of its "alternative" method by considering how Vygotsky had approached this methodological challenge, and so propose the dialectical method for the design and evaluation of learning in virtual worlds. This text will explicate Vygotsky's historical approach, unit of analysis and method; and in particular his double stimulation method. At the end of this exposition of Vygotsky's historical approach, insufficiencies in his approach will be identified and Engeström's (1987) expansive method will be explicated to address some of these challenges. *This text will contribute a synthesis and expansion of Vygotsky's historical approach and Engeström's (1987) expansive method, to develop the dialectical method for designing and evaluating learning in a virtual world.*

Clearly, before a learning activity in a virtual world can be evaluated, it needs to be designed as an interactive system. *The second methodological challenge therefore is designing the virtual world as an interactive system.* Design is a wicked and ill-defined problem; it is as much science as it

is art. *This text contributes the integration of the Hartson & Hix's (1989) "star life cycle" into the dialectical method to systematically consider the design of the virtual world.* Activity theory will be used as task analysis, as well as evaluative framework within the "star life cycle". *The third methodological challenge identified is the challenge of evaluating learning in a virtual world.* The dialectical materialist epistemology promoted in this text through the Activity theory framework clearly has important implications for the evaluation of learning. If truth, knowledge and learning are indeed relative to the perspective taken, how can learning be evaluated? Even learning defined as cultural activities are problematic from the dialectical materialist perspective because no objective measures for such evaluation exist. Reality, truth, knowledge are relative to the perspective taken; however, not absolutely relative. *This text contributes an alternative criterion to evaluate the learning activity, i.e. the comparative evaluation of the learning activity in two different situations.* This text aims to evaluate learning in a virtual world by comparing it to the same learning activity in another situation. In the research for this text the situation will be the classroom. It is important to note that the classroom is not regarded as the "objective" or "true" activity. Rather it provides a normative base-line or benchmark from which to make a comparative evaluation. Activity theory affords this comparative evaluation, on the basis that an activity is identified by its object. Although the actions and operations will vary between these two situations, the activity occurring in different situations can be compared on the basis of its object. *This criterion for the evaluation of the learning activity, however, does introduce a limitation to the method, i.e. that it can only be applied to existing learning activities.* This text will then apply the dialectical method to the acid test of practical validity in two case studies in the domain of Film and Media.

The dialectical method goes some way towards realizing Engeström's (1999) "need for a methodology for studying expansive cycles" (p. 35) and as he anticipates: "Key findings and outcomes of such research are novel activity-specific, intermediate-level theoretical concepts and methods – intellectual tools for reflective mastery of practice" (p. 36). Ironically, the intermediate-level theoretical concepts and methods developed in this text come about as a direct result, of the challenges that arose from using Engeström's triangular representation to analyze and represent the learning activities of the case studies, i.e. the representational challenge. *The representational challenge can be formulated as the following research question: What representations and models can be used to most productively represent and communicate learning in a virtual world?*

1.1.5. Representational challenge

During the second implementation of the dialectical method, on the more complex of the two case studies, various challenges arose from using the Engeström Activity System (EAS) to represent the learning activities. *It was in response to these challenges that this text contributes Activity Cell Transformation (ACT).* ACT is a novel model and representational system. Activity Cell Transformation as "lens", arising from practice, enables the dialectical reflection back on Activity Theory to provide new insights into contemporary Activity theory and some of the 3rd generation theoretical challenges. In addition to the individual and collective activity analysis, this new intermediary lens focuses on the interrelationship between the individual and collective activity, i.e. collaborative group activity.

The dialectical method combined with the ACT's zoom lens (individual cell, collective cell an intermediary collaborative group cell focuses) constitutes the novel methodology and product of this text. Clearly the development of the dialectical method is "simultaneously the prerequisite and product, the tool and the result of the study" (Vygotsky, 1978). *The contribution of the dialectical methodology, combining the dialectical method and its ACT, expands Activity theory for the design and evaluation of group praxis.* This text will conclude with a summary of the intellectual journey it had charted. The route explicated will emerge from the exploration of learning in virtual worlds and the summary will therefore again be structured according to the assumptions deconstructed in this introduction. This will account for the novel contributions developed throughout this text, its validity and limitations. The future opportunities foreseen for the dialectical methodology will also be considered. This text will then close on a more subjective note.

2. Meta-theoretical framework

The conceptual framework described in this chapter aims to develop a meta-theoretical perspective on philosophical grounds to view the phenomenon of learning in virtual worlds in all its complexity. Despite the clear trend that learning in virtual worlds and simulations are set to increase, there have been few attempts to introduce frameworks to support the evaluation of virtual worlds to be most effective in their particular learning context (Amory & Seagram, 2003; de Freitas & Oliver, 2006; Kirriemuir & McFarlane, 2004). Such frameworks are necessary as the emerging perspectives focusing their attention on virtual reality, worlds, communities, simulations, MMOGs, etc. suffers from various "nascent" growing pains (de Freitas, 2006; Fors & Jakobsson, 2002; Messinger *et al.*, 2008; Steinkuehler, 2008). Virtual reality, virtual worlds and learning are defined in very different terms depending on the domains, approaches and methodologies of their developers and researchers. This presents a gargantuan "tower of Babel" of research, where communication is hampered, as theorists and researchers use the same words to refer to very different meanings, depending on their epistemological frames of reference. The meta-theoretical framework developed in this chapter takes a cultural-historical perspective on learning in virtual worlds. The historical development of the concepts of "learning" and "virtual reality" will be considered within the larger context of human cultural development. From this perspective it will become clear that both learning and VR are both subjected to culture.

Over the last decades, within various schools of thought, there has been revolutions questioning the very foundation of Western thought, albeit Reason. Postmodernism developed not as a new unified cultural theory per se, but rather has been formulated as divergent reactions against the formalities of modernism, which assumptions are based on rationality, Newtonian science, the Enlightenment, individualism and Cartesian dualism. This crisis and growing awareness of these paradoxes has lead to the revision of the assumptions underlying the western world view. These ontological assumptions form the foundations of contemporary epistemology, science; and theories of learning and cognition. It is therefore not surprising that similar protests are voiced against the ontological assumptions of the domain of education, which has largely gone unnoticed, in western educational theories (Packer & Goicoehea, 2000). Central to the conception of learning, as developed in this text, is offering an alternative to the dualistic assumptions underlying the objectivistic model of education. These very same ontological and epistemological tensions are prevalent in debates regarding VR.

Within the domain of computation there has also occurred such a paradigm shift, a move from the modernist culture of calculation to the postmodernist culture of simulation (Turkle, 1995). Virtual reality, worlds and simulations are products of this paradigm shift within the domain of computation and so embody themes of postmodernism. Turkle (1995) suggests that virtual communities, realities and simulations can function as evocative objects that can help us think about the complexities of postmodernism in more concrete terms (Turkle, 1995). This is particularly relevant if we consider that contemporary challenges facing education stem from not understanding the ontological basis of the new paradigm we are entering. *Clearly, virtual worlds have the potential to serve as a vehicle for driving the transformation of our contemporary learning theory and practice.* The meta-theoretical framework necessary for contextualizing this text will therefore be built on a strong philosophical basis. This will demonstrate that to develop a coherent theory of learning and human development, which can incorporate VR, this framework needs to be developed from the dialectical perspective established in history and culture. *The meta-theoretical framework therefore aims to illuminate the ontological assumptions underlying learning and virtual reality; and in so doing address the theoretical accessibility of learning theories and the practical accessibility of VR as a technological innovation.*

2.1. Learning

Learning like VR is intrinsically multidimensional (Mantovani, 2003). The term learning is used to describe various aspects and capabilities of human beings, for example: evolution, adaptation, cognition, collaboration, knowledge construction, meaning making, understanding, history, society, culture, etc. These diverse aspects of learning can be interpreted on many levels and from various units of analysis: organism, individual, group, community, society and humanity. Human learning is complicated, the terminology used to describe it is inconsistent and our understanding of it is often based on diverse and sometimes inconsistent philosophies, psychological theories and value judgments. *Developing a concise definition of learning and formulating the coherent theoretical frame to support this definition has been one of the major challenges that this text had to overcome.* Much of the confusion and crisis in education today can be directly attributed to the ontological short sightedness of learning theories and theorists. Our focus will therefore be on the explication of the ontological and epistemological tensions between the foundational theories of learning. Developing a conceptual frame from a perspective that considers these tensions will afford a focused view of learning and narrow down the appropriate approach and unit of analysis. Tension between learning theories can so be understood in historical terms as part of the process of the

evolving and competing paradigms for learning (Bruner, 1990; Cole, 1996; Mayer, 1992, 1996; Sfard, 1998; Wilson & Myers, 2000). The two paradigms being the Individualistic learning theories based on the dualistic ontology and social learning theories based on non-dualistic ontological perspectives. History affords an inclusive perspective of the larger context from which to recognize the progression of educational theory resulting from this tension and driving its transformation. Indeed history is the key to unlocking the meaning of learning in a virtual world.

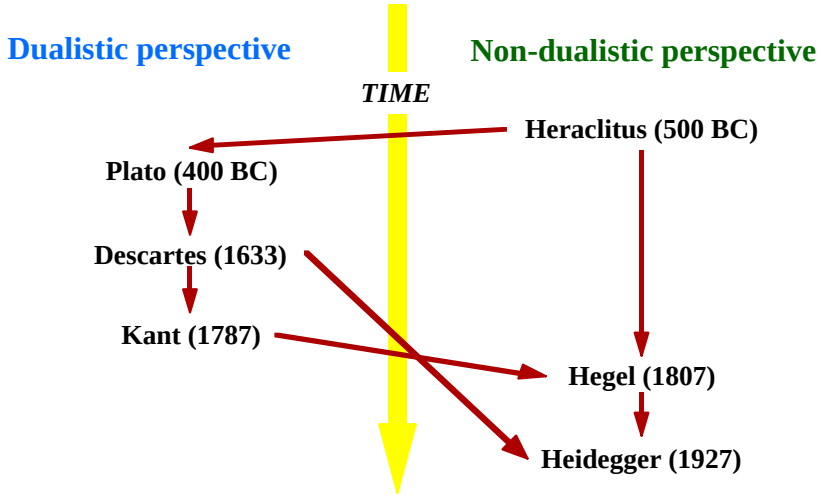
2.1.1. History of the ontological perspectives underlying learning

Central to understanding learning is the philosophical traditions which form the foundations of our ontological views and that shape our understanding of knowledge, learning and human development (Koschmann, 2002a, 2002b; Packer & Goicoehea, 2000; Stahl, 2003b, 2006c).

> *The nature of meaning has been a hot topic in the 2500-year-long conversation that we call Western philosophy, since its origin in Socrates' dialogues. In our generation, this conversation has spread into the theoretical reflections of the human sciences (Stahl, 2003b, 2006c).*

This text will explicate this 2500 year development of the conversation of Western Philosophy, by identifying key philosophers who contributed to this conversation and whose ideas will be further developed in the following sections of this text, to consider both individualistic and social learning theories. *This explication is intended to build a foundation for the later discussions regarding learning theories, which are based on these historical and philosophical developments.* Plato, René Descartes, Immanuel Kant are identified as contributors to the dualistic ontology, while Heraclitus, Georg Wilhelm Hegel and Martin Heidegger are identified as contributors to non-dualistic ontological perspectives. The epistemological implications of these ontological perspectives will also be considered, as this will be of significance for the educational theories considered later. The identified philosophers played a constituting role in their respective paradigms, and responded on one another's work. The exposition will be organized chronologically, from top to bottom. However, the historical developments of the philosophers' ideas should not be interpreted as chronological, as their philosophical works cross pollinated and influenced one another. These "cross pollinations" are indicated by the red arrows in Figure 1:

Figure 1. **Philosophical influences on ontological development**



The constraints of this text regrettably does not allow for a more detailed exploration of these intellectual giants. This inevitably leads to the omission and reduction of their contributions. However, it is hoped that what is included in this exposition carries a sense of their remarkable work and is sufficient to support the argument for which their inclusion in this text is motivated. We start a little earlier than the typical exposition of Western philosophy with the pre-Socratic philosopher Heraclitus.

2.1.1.1. Heraclitus (500 BC)

The Greek philosophical pioneer Heraclitus (also spelled Heracleitus) of Ephesus can be credited for being the first person in the West to develop a sound philosophical system. Central to Heraclitus philosophy is the paradoxical notion that the nature of reality is a “unity of opposites”. Indeed this contradictory principle lies at the heart of much of the misunderstanding surrounding Heraclitus; who sought to expose this contradictory nature of reality through his paradoxical texts. The “unity of opposites” should not be misunderstood superficially as two opposing forces in conflict. The opposition is essential to the unity, yet the unity is more fundamental. Not surprisingly Heraclitus is recognized as one of the earliest dialectical philosophers.

Plato reported that Heraclitus was a theorist of "panta rhei", which regarded the entire universe in flux, as contrasted with Parmenides' conception of a fixed and stable reality (Kahn, 1981). Indeed, interpreters of Heraclitus cannot have it both ways, Heraclitus cannot be both a believer in radical flux and an advocate of monism; either he must believe in a merely illusory reality

or at most a limited kind of change, or he must be a pluralist (Graham, 2007). Heraclitus' "unity of opposites" reflexively overcomes the apparent dichotomy between monism and pluralism. Heraclitus writes: "On those stepping into rivers staying the same other and other waters flow", although this statement is on the surface paradoxical, it makes perfectly good sense to call a body of water a river precisely because it consists of changing waters (Graham, 2007). Heraclitus' process-ontology of becoming, is clearly non-dualistic, it emphasizes the interrelationship of the opposites united in and emerging from process.

Heraclitus' epistemological view recognizes experience as the source of knowledge; however, experience is not sufficient. Although Heraclitus aligns himself with the empiricism of his contemporaries Xenophanes and Hecataeus, who followed the practice of firsthand experience (historiê), he was critically aware that the testimony of the senses is already shaped by our perceptions (Hussey, 1999). Knowledge according to Heraclitus is the revelation of this hidden, latent structure underlying nature. The "Logos" referring to "what is said" meaning "word" reveals this truth. It is "shared by all", not a private fantasy or experience and publicly accessible. This fundamental truth underlying all knowledge according to Heraclitus' words is the structure of all things; i.e. the unity of opposites.

2.1.1.2. Plato (400 BC)

Plato, student of Socrates, teacher of Aristotle; together this trio of ancient Greeks are credited to have laid down the philosophical foundations of Western culture (Plato, 2007). Heraclitus influenced Plato's thoughts on metaphysics and epistemology and his notion of 'flux', in particular, can be interpreted to have influenced Plato's thinking about ordinary material objects as opposed to Forms (Silverman, 2003). Plato's Forms were needed to provide stable objects for knowledge as well as to answer the question of what is ultimately real (Metaphysics, 2007). Plato's "Theory of Forms" can therefore be interpreted as a direct response to Heraclitus' philosophical system.

It is widely agreed that Plato introduces Forms in the *Phaedo* (Plato, 1995), Plato's eulogy to his teacher Socrates. In it Plato makes a series of arguments to prove the immortality of the soul and mind (psychê). The early Greek philosophers had not made a distinction between the two (soul and mind). Plato argues that the soul/mind seeks freedom from the body, it understands best when it is detached from the body and when it is itself by itself (Silverman, 2003). Plato then introduces the Forms (eidos) as beings that which are, what they are, in virtue of themselves (Silverman, 2003). He distinguishes Forms from "particulars", i.e. the physical world and its components. Forms are simple,

monoeidetic, immaterial, non-spatial and atemporal; while particulars are complex, divisible, consist by partaking of many forms and change, they may even be subject to change in any respect and at any given moment, i.e. total Heraclitean flux (Silverman, 2003). It is also agreed that with this introduction to the Forms Plato's classical mind-body dualism originates (Robinson, 2006). Plato views the body as the prison of the soul/mind. The dualistic ontology inherent in Plato's philosophy becomes even more explicit in his in his allegory of the Cave in the *Republic* (Plato, 360 BC) and its "Two Worlds Doctrine" (philosophical anthropology, 2007).

The allegory of the cave in context of the Forms introduced in the *Phaedo* (Plato, 1995) and the Republic's metaphors of Sun, Line and Cave, imply that Plato is a skeptic about knowledge of the physical, sensible world (Silverman, 2003). Plato posits two worlds: The world of the senses or "particulars" and the world of Forms. The physical world of particulars is a shadow, image, reflection, copy of the world of Forms. The world of our senses is therefore imperfect, impermanent and dependent on the Forms. This has important implications for Plato's epistemology. Forms according to Plato are objects of knowledge; and since the world of particulars is subject to change, humans can only have beliefs about the physical world we know. Knowledge should be sought from the world of Forms. Plato's epistemology consequently rejects empiricism. How can humans imprisoned in the world of particulars know anything about the world of Forms? In response to this question Plato proposes the "Doctrine of Recollection". In several of the dialogues Plato's character Socrates suggest that knowledge derives not from observations, learning or study but through recollection. The soul/mind retains the ability to recollect what it once grasped of the forms when it was disembodied (Plato, 2007). Plato's dualism is therefore not simply a doctrine in the philosophy of soul/mind but an integral part of his whole metaphysical system (Robinson, 2006). The dualistic ontology underlying the "Theory of Forms" is central in Plato's philosophy. The dialogues supporting the "Theory of Forms" played a crucial role in the future development of philosophical thought regarding ontological perspectives and their epistemological implications. French philosopher René Descartes was the first to formulate Plato's dualistic ontology explicitly in his philosophical argument for a rationalist epistemology.

2.1.1.3. Descartes (1633)

Stephen Buckle (2007) in his article "Descartes, Plato and the Cave" emphasizes Descartes' indebtedness to Plato; and encourages the reading of the "Meditations on First Philosophy" in the light of distinctively Platonic doctrines, and in particular, as a rewriting of the Platonic allegory of

the cave for modern times (Buckle, 2007). Descartes proposes a philosophical methodology which aims to structure knowledge much like an architect structures a strong physical structure, i.e. beginning with strong foundations. Finding inspiration from Euclidian geometry, used in architecture, Descartes proposes to develop the first principles for a foundationalist epistemological system. He proposes to "discover" these principles of knowledge by removing the "soft sand" of knowledge through methodological doubt. Implementing his systematic Method of Doubt, Descartes aims to find the kernel of truth, that which cannot be doubted. This means that Descartes Method of Doubt is designed for constructive ends: "to reach certainty, to cast aside the loose earth and sand so as to come upon rock or clay", and not simply epistemological destruction: "the skeptics, who doubt only for the sake of doubting" (Descartes, 1904, p. 28-29). Descartes discovers that which cannot be doubted is that he is thinking. He further concludes that since he is thinking he can also not doubt his own existence. So existence and thought are inextricably linked:

> *At last I have discovered it, thought; this alone is inseparable from me. I am, I exist, that is certain. But for how long? For as long as I am thinking. For it could be that were I totally to cease from thinking, I should totally cease to exist. … I am a thing which is real and which truly exists. But what kind of a thing? As I have just said: a thinking thing (Descartes, 1984, p. 18).*

Descartes through his methodological doubt believed himself to have discovered the kernel of absolute truth, which would form the foundation of his rationalist epistemology, namely "Cogito ergo sum" (I think therefore I am). Whether we are dreaming or being deceived by a malicious demon, the one thing that we cannot draw into doubt, is that we are thinking and consequently that we exist. Discovering this first principle of his epistemology provided Descartes with the foundation on which to construct his stable structure of knowledge. What remains for Descartes is to construct a knowledge structure of our experiences, bodies and the world on top of his newly discovered first principle "I think therefore I am". To do this Descartes argues for the externality of the causes of sensation and subsequently for the materiality of these external causes. According to this argument sensations come involuntary to the mind, hence they come from something outside of mind; and therefore there exist something external to mind, i.e. the material world. However, this argument does not hold up to Descartes' own method of doubt, since these sensations could be caused by the subconscious mind. In response to this challenge Descartes develops the thesis that the mind and body consist of two completely different substances or essences; i.e. the mind (the thinking part) and the body (physical part) are essentially two different substances (dualism). In so doing, Descartes

unfortunately also creates the dichotomy between mind and body. Descartes is consequently a substance dualist, he argues that there are two kinds of substance: matter, of which the essential property is that it is spatially extended; and mind, of which the essential property is that it thinks (Robinson, 2006). His dualistic ontology posits a strict division of the thinking subject and world of objects outside of our minds.

2.1.1.4. Kant (1787)

Rationalists Benedict de Spinoza and Gottfried Wilhelm Leibniz sought to build outward from fundamental principals of consciousness, such as Descartes' kernel of certainty: "I think, therefore I am." Kant likens his "Transcendental Idealism" to the Copernican revolution in astronomy, which moved away from the narrow vision which regarded the earth as the centre of the universe. Likewise Kant suggests a move away from the "I" as the seat of consciousness. The self as subject presupposes itself as object (Scruton, 1981). The subjective nature of self-consciousness, and the elusiveness of the "I" in the context of that activity, is thus the well known bases for Kant's response to rational psychology, and the doctrine of apperception plays an important role in Kant's rejection of it (Grier, 2007).

> *"The claim that the 'I' of apperception yields no object of knowledge (for it is not itself an object, but only the "vehicle" for any representation of objectivity as such) is fundamental to Kant's critique of rational psychology" (Grier, 2007).*

Kant develops this cornerstone of his anti-skeptical proof in the passage of the "Critique of Pure Reason" (Kant, 1965) called "The Transcendental Deduction of Categories", wherein he begins his explication of an aspect of self-consciousness as Descartes had (Scruton, 1981). However, unlike Descartes' methodological doubt Kant assigns a role to sense experience. He reserves to reason the more important role of providing form or structure to experience (Prawat, 1995). Kant removes the privilege from subjectivity and thereby destroys the possibility for an empiricist theory of mind, with the result that epistemology becomes secondary to metaphysics (Scruton, 1981). Kant suggests that neither the empiricist nor the rationalist can provide a coherent theory of knowledge: The empiricist who elevates experience over understanding deprives themselves of concepts with which experience might be described; while the rationalist emphasizes understanding at the expense of experience depriving themselves of the very subject matter of knowledge (Scruton, 1981). Kant argues that knowledge and the rational order of the world as objective, consisting of space, time, causality, and objects etc. is constituted through our mind's constructive capacity of applying such cognitive

structures to sense experience, i.e. the product of the rule-based activity of "synthesis". These structures consequently exist as necessary *a priori* conditions for any possible experience.

Kant consequently inverted Descartes, Spinoza and Leibniz's traditional relation between the subject and object. Instead of emphasizing the subject revolving around the objects in an attempt to understand it, the objects are made to turn around the rational subject. Despite this modification to the rationalist epistemology Kant like Descartes, Spinoza and Leibniz assume a dualistic ontology. Albeit a peculiar dualism which holds that science gives the truth about phenomena, while reserving a noumenal, or supersensible, sphere for moral agency (Metaphysics, 2007). Despite Kant's significant contributions to modern philosophy he was convinced of the necessity of accepting an empirical dualism of mind and body; and it was left to Hegel and the Idealists to look at the problem afresh and to reveal a perspective from which mental life and bodily life are intimately bound together (Metaphysics, 2007).

2.1.1.5. Hegel (1807)

Hegel agrees with Kant's diagnosis of internally contradictory nature of pure reason, however, while for Kant this reveals the limits of going beyond "pure reason"; for Hegel it reveals the contradictory nature of reason's proper objects (Redding, 2006). In response to Kant challenge to the limits of "pure reason", Hegel set out to devise a very different ontology. Towards this end Hegel developed a radically new form of logic, which he called speculation, and which is today popularly called dialectics.

> *Thus while Kant had used the word 'dialectic' to refer to the propensity to fall into contradictions, Hegel used it to mean the propensity to transcend them. This process of transcendence is the true course of logic, and 'dialectics' is the name for the intellectual pursuit whose endpoint is not limited or partial, but on the contrary, absolute truth in itself. '… a deeper insight into the antinomies or, rather into dialectic nature of Reason shows us … that every concept is a unity of opposite moments, which could therefore be asserted in the shape of an antimony'(Logic, vol. 1, p.205)(Scruton, 1981).*

Kant erects a barrier between pure and practical reason: pure reason concerns the unknowable objective materiality, while practical reason concerns the moral decisions of our own lives (Karpatschof, 2000). Hegel extends Kant's "transcendental deduction" beyond the limits of his method, in which the conditions of thought and experience were regarded as merely subjective, towards a transcendental logic which becomes ontological (Redding, 2006). It is important to

recognize that the terms of Hegel's logic there are no true or false propositions or judgments; but rather concepts are evaluated according to their limitations and incompleteness vs. their wholeness and transcendence of limitation (Scruton, 1981). The German Idealists succeeding Kant intended a reunification of reality, a surmounting of ontological dualism, a unification of objectivity and subjectivity; however, Hegel's unique conception of unity is found in the conceptual essence of being and becoming (Karpatschof, 2000).

> *"Being" seems to be both "immediate" and simple, but reflection reveals that it itself is, in fact, only meaningful in opposition to another concept, "nothing." In fact, the attempt to think "being" as immediate, and so as not mediated by its opposing concept "nothing," has so deprived it of any determinacy or meaning at all that it effectively becomes nothing. That is, on reflection it is grasped as having passed over into its "negation". Thus, while "being" and "nothing" seem both absolutely distinct and opposed, from another point of view they appear the same as no criterion can be invoked which differentiates them. The only way out of this paradox is to posit a third category, "becoming," which seems to save thinking from paralysis because it accommodates both concepts: "becoming" contains "being" and "nothing" since when something "becomes" it passes, as it were, between nothingness and being (Redding, 2006).*

This ontology of becoming tracing back to Heraclitus thus becomes fully articulated in the works of Hegel (Overton & Michelle, 2006). For Hegel, the dialectic process is inscribed at all levels of the social and natural worlds, forming a single yet internally differentiated process that expressed and embodied the larger evolution of "Spirit" (Calhoun, 2002). According to Hegel the development of mind, self consciousness and knowledge is inextricably part of the dialectical (contradictory yet unified) relationship between mind (spirit) and the world. Hegel uses "das Bewusstsein" (consciousness) to refer not only an individual's consciousness but also to the conscious person himself as opposed to the object which he is conscious of (Inwood, 1992). Consciousness is the dialectic between knower and known.

Hegel's analysis therefore addresses both the construction of knowledge (and its justification) and the construction of the knower; i.e. the human person advances from immediate sensuous experience (of the present here and now), to self-consciousness, consciousness of others, consciousness of society as an objective reality, consciousness that society is the product of human activity, and consciousness of how society is produced through human activity (Packer & Goicoehea, 2000). Hegel did not assume the existence of the individual knowing and learning self, unlike his

immediate philosophical predecessors (Kant, Locke, Descartes) (Packer & Goicoehea, 2000). For Hegel the pressing issue is not so much overcoming the dualism of Descartes, but moving beyond his exclusive focus on the individual as thinker (the mental cogito as seat of cognition and meaning); and to show how consciousness emerges through activity in the social and physical world (Hegel, 1967; Stahl, 2003b, 2006c). Although Hegel described the mutual constitution of person and social context, and the dynamic of contradiction in both; his account of these transformations unfold in a somewhat mysterious way (Packer & Goicoehea, 2000). Karl Marx and Martin Heidegger extended Hegel's perspective to illustrate how meaning is socially produced and situationally interpreted (Stahl, 2003b, 2006c).

2.1.1.6. Heidegger (1927)

Heidegger building on the works of Hegel's dialectics found himself at odds with Descartes conception of human beings as essentially thinking things. Heidegger conceded that Descartes reasoning may prove human existence, however, it said nothing about the nature of human existence, i.e. what it means to be human (Zahorik & Jenison, 1998). According to Heidegger human understanding is based on a tacit background pre-understanding of one's world as a cultural situation consisting of a totality of meaningful artifacts and therefore people have a unique situated pre-understanding (primordial human experience), from which they interpret their world and features of their on-going activity (Stahl, 2003b, 2006c). The division between the thinking subject and world of objects only emerge in the event of some discontinuity in our interaction with the world of objects (Coyne, 1994). Heidegger therefore concludes that "I am in the world" precedes "I think". This rational assumption of differentiating the object from the subject makes possible the distinction between the knower and what he knows; it is basis for the rational epistemology.

Heidegger criticizes the rational tendency to take "knowing" as our primary way of interacting with things. Heidegger suggests that "knowing" is determined by "Being in the world" (Dasein) (Heidegger, 1962). Heidegger claims because of *Dasein* we are thrown into situations which we continually interpret and in which we continually act. We are continually in a state of what Heidegger terms "throwness". Human existence is a lot like playing in a jazz band. Action is unavoidable: playing is action; and not playing effects (act on) the group's play. Detached reflection is not possible: Playing is improvising, it takes place immediately in order to respond to group; and it is therefore impossible to stop and analyze play during a performance. Action's effects are therefore unpredictable and stable representations of the situation impossible. Heidegger concludes from this

that all representation is interpretation. We are all continually acting and therefore unable to represent the situation in any objective fashion. (Zahorik & Jenison, 1998).

Heidegger critique of rationalist epistemology is subtle; he is questioning its underlying ontological assumptions. Heidegger is not explicitly denying that we can know anything rationally. According to Heidegger knowing something rationally is but one way of knowing and one way of seeing the world. Rational truth based on the division between object and subject, is but one of the stable representations we can project on the *throwness* of *Dasein*. *Dasein* is our primary mode of experience and precludes all representation of it. According to Heidegger knowledge and meaning derives from the division of this unity. Knowledge and meaning therefore derives from differentiation and can never be considered in absolute terms. Heidegger's ideas have been of great influence and can be traced to some of the most prominent postmodern thinkers Merleau-Ponty, Gadamer, Habermas, Sartre, Foucault and Derrida. Of his contemporaries Derrida makes maximum play on the nature of difference, even to the extent of creating a new word (differance) that implies (in relation to language) "that meaning is always deferred, perhaps to the point of an endless supplementary, by the play of signification" (Coyne, 1994; Norris, 1991).

Like Heidegger, this text acknowledges that it is possible to know reality rationally; however, this is not the only way of knowing and seeing the world. Furthermore, if Descartes dualism and resulting rationalist epistemology comes to dominate, as it has in western thought, there are clear consequences. It is important to emphasize that this text is not proposing a radical shift to the other pole (non-dualistic). Such a dichotomy would be indicative of essentialism. *This text is striving for an integrative perspective that illuminates the dialectic between dualist and non-dualist perspectives. Understanding learning in terms of this dialectical process ties together what is often regarded as loose strands of educational theory into a unified theory of learning and human development.*

Developing such a perspective requires mapping out the historical path of Western philosophical thought, relating prominent philosophers to one another and charting their influences on contemporary learning theories. This is no simple task. This text greatly benefits from the work of Gary Stahl in his book entitled "Group Cognition: Computer Support for Building Collaborative Knowledge" (Stahl, 2006c). Stahl develops a map of the "Philosophic influences on individual and social theories of learning" and eloquently describes the development of these theories based on the significant philosophers and their influences of one another. His work illuminates the relationship between philosophers, their philosophies and learning theories. Stahl's map was taken as inspiration to develop Figure 2.

Figure 2. **Philosophical influences on individualistic and social learning theories**

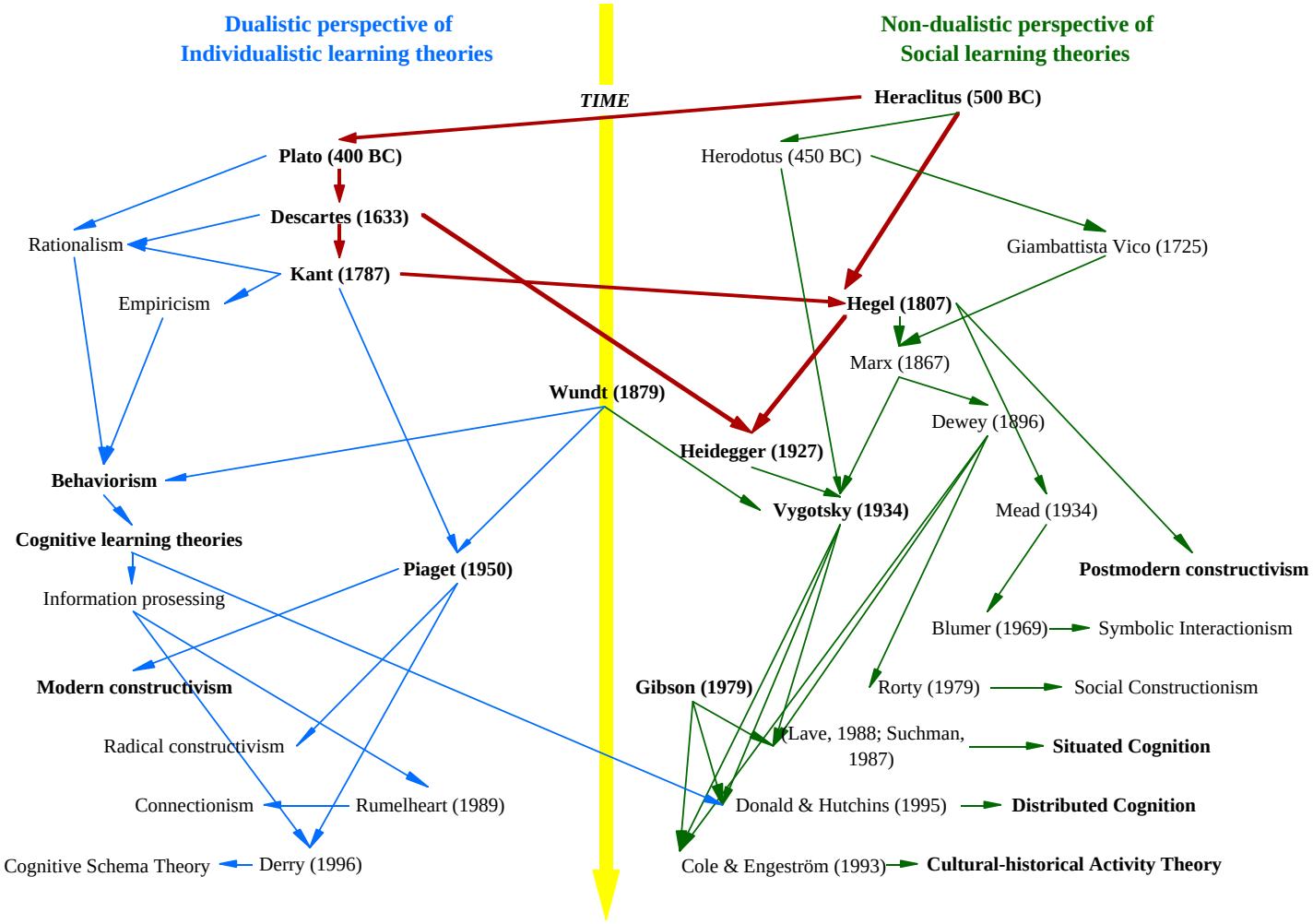


Figure 2 expands Figure 1's representation of the philosophical influences on the ontological development of Western thought, with arrows pointing towards the respective learning theories, which are supported by the different ontological perspectives. As with all representations the map is not the territory. The philosophers, their relationships (arrows) to the learning theories and one another are not all encompassing. The two competing paradigms are indicated left by the **blue** (Dualistic) and right **green** (Non-dualistic) arrows respectively. The arrangement is pragmatically optimized for space and not according to time scale. *The aim of Figure 2 is elucidating the ontological assumptions underlying our contemporary theories of learning and overcoming the ontological short sightedness of learning theories and theorists which typically focus on the left.* Cognitive Science in particular emphasizes its epistemological roots at the expense of ontological

considerations. Howard Gardner (1985) in his seminal work "The Minds New Science: A History of the Cognitive Revolution" acknowledges the contributions made by Plato, Descartes and Kant in laying the philosophical foundations of cognitive science, however, little or no mention is made of the significant contributions of Heraclitus, Hegel and Heidegger. The dominant paradigm of individualistic learning theories based on the dualistic ontological heritage of Plato, Descartes and Kant will be considered first.

2.1.2. Dualistic perspective of individualistic learning theories

The dualistic ontological perspective in Western philosophy has been traced back to Plato (400 BC) (2.1.1. History of the ontological perspectives underlying learning). Plato in his dialogue "Phaedo" (Plato, 1995) formulates his famous "Theory of Forms"; and the dualistic ontology inherent in Plato's philosophy becomes even more explicit in his allegory of the Cave in the *Republic* (Plato, 360 BC) and its "Two Worlds Doctrine" (philosophical anthropology, 2007). Descartes was the first to formulate the dualistic ontological perspective explicitly and so provide a philosophical framework for the natural sciences. Descartes posits a strict division between the thinking subject and the world of objects outside of our minds. Accordingly, reason reveals objective reality through the application of science based on the axiomatic premises of mathematics and the mechanistic interpretation of the physical world and human action. Descartes philosophical ideas were to have important implications for the later development of psychology and theories of learning.

> *Not only is philosophy the oldest of the cognitive sciences, but its epistemological branch has supplied the initial agenda – the list of issues and topics which empirically oriented cognitive scientists are working today… René Descartes is perhaps the prototypical philosophical antecedent of cognitive science (Gardner, 1985, p. 49-50).*

The relationship between Descartes and modern psychology is well documented (Bakhurst, 1991; Cole, 1996; Gardner, 1985). Since Descartes formulated his rationalist epistemology, dualism has prevailed as the dominant world view in the West. It underscores much of our western thinking and in particular our conception of knowledge, learning, cognition and science. Dualism as all ontological perspectives is not agnostic and has ideological implications. This becomes particularly evident when we consider Individualism. Indeed Descartes conception of human beings as essentially thinking things (I think therefore I am) opitimizes the individualistic perspective. The individual is the essence of what it means to be human and this motivates the other duality of emphasizing the individual over group and society; and the individual mind as the seat of cognition. Dualism

consequently through the ideology of individualism has an important influence on the individualistic learning theories which dominate western contemporary education.

> *Prevalent enlightened thinking about learning owes much to Descartes' (1633/1999) theory of ideas as existing in individual minds isolated from the material and social world. Thorndikian educational theories, which still dominate schooling, go back to this philosophic position (Stahl, 2004, 2006c).*

This text will start its explication of the history of educational theory with Wilhelm Wundt, considered by many as the father of psychology. Wundt exhibits both ontological perspectives respectively in his "two psychologies". He is included here, however, as the continuing history of psychology resulted in the emphasis of Wundt's "Physiological Psychology", based on the dualistic ontology, at the expense of his "Folk Psychology" based on the non-dualistic ontology.

2.1.2.1. Wundt

Wundt's "Physiological Psychology" aimed to study simple (lower) psychological functions, such as the qualities of sensory experience and the components of simple reactions; and although called *physiological*, Wundt's experiments utilized the method of introspection rather than physiological measures (Cole, 1996). Wundt's "Folk Psychology" (Völkerpsychologie) aimed at investigating complex (higher) psychological functions, developing from uniting simple (lower) psychological functions (Cole, 1996). Folk Psychology was intended to unite "into a unified whole the various results concerning the mental development of many as several viewed by language, religion and custom" (Wundt, 1921, p. 2). Wundt sought to synthesize his two psychologies. He regarded the historical development of human cognition as central in this pursuit. Only from the historical-developmental perspective of his Folk Psychology can we "reveal well-defined primitive conditions, with transitions leading through an almost continuous series of intermediate steps to the more developed and higher civilizations" (Wundt, 1921, p. 2). Wundt unfortunately provides little detail for how the "two psychologies" can be united.

The problem of Wundt's "two psychologies" remains today on account of his "Folk psychology" and historically descriptive methodology being marginalized within the historical development of psychology, particularly in the West. Psychology required a unified methodology and the model of the natural sciences was adopted rather than developing a dialectical approach. It is therefore not surprising that the only part of Wundt's scientific system that won wide approval was his emphasis on experimentation as the legitimate method for studying psychological phenomena.

This approval was ironically turned against him and used to discredit his claims regarding the relationship between higher and lower psychological functions; despite Wundt's explicit warning that his experimental method should be used only to investigate lower functions. Wundt's claims about the features of mind were transformed into claims about laws by which elements of behavior combine according to reflex principles by the behaviorists (Cole, 1996).

2.1.2.2. Behaviorism

Behaviorism underlies the educational theory which has dominated the West for the first half of the twentieth century (P. L. Smith & Ragan, 1999; Wilson & Myers, 2000). Behaviorism developed in response to the then "New" psychology of Wundt. Behaviorism opposed the rationalism of "New" psychology and rejected the method of introspection. Behaviorism subscribes to an educational philosophy of extreme empiricism (P. L. Smith & Ragan, 1999). Empiricists postulate that knowledge is acquired through experience and not reason. We find clear evidence of the underlying empiricist philosophy in behaviorism's research methods and particularly their criterion for measurement, i.e. observation. According to behaviorists the only phenomenon worth studying was those which could be observed directly, i.e. behaviors. Although most behaviorists would not deny the existence of mental activity, they did not think it prudent to consider unobservable phenomena such as mental states, feelings, intentions, ideas, etc. (P. L. Smith & Ragan, 1999). Behaviorists regarded human behavior, like other animal behaviors, as observable systematic reactions to stimuli in the environment. Behaviorists aimed to uncover these basic stimulus-response episodes, leading them to a generalized theory of human behavior (Patraglia, 1998b).

Learning according to behaviorists had occurred when learners produce appropriate response behaviors to particular stimulus. The development of stimulus-response episodes through conditioning is what behaviorist educators aimed to exploit in an attempt to facilitate learning. To evaluate learning behaviorists had a clear and objective measure, i.e. the appropriate behavioral response. Behaviorism has subsequently been severely criticized for being reductionistic and for casting people in a passive role, receiving stimuli from the environment and behaving as they were conditioned. Although behavioral theory emphasized the influence of the environment on learning (P. L. Smith & Ragan, 1999), the "environment" is reduced and only comprises a particular physical stimulus delivered by an experimenter within controlled conditions of the laboratory. Despite these serious flaws inherent in behaviorism, remnants of it survive in contemporary education and pedagogy. Behaviorism continues to exert its influence in education and training (Wilson & Myers,

2000). In particular in the reinforcement procedures found in the practice of discipline at schools and the fixation on "objectively" observable behavioral measurements of learning.

Today the empiricists' legacy of behaviorism is most evident in the empirical tests and objective measures used to evaluate learners. Like most educational theories the ontological assumptions underlying behaviorism went largely unnoticed (Packer & Goicoehea, 2000). Although behaviorism criticized rationalism's idealism, the rational subject can be found at the heart of behaviorist methodology. The subject position is essential to making any observation. The dualistic division between subject and object is clear. Behaviorism is the first psychological theory to actively attempt to understand, predict and facilitate the learning process; however, its over-emphasis of methodological empiricism reduced the environment to the controlled laboratory and humans to animals, severely limiting its contribution to the understanding of human nature.

2.1.2.3. Cognitive learning theories

Disillusionment with behaviorism in the 1950's and 1960's urged psychologists to consider alternative perspectives to provide insight into the obvious limits of behaviorism. This new perspective was found in the metaphor of computation and information processing (Bruner, 1990). The advent of the computer heralded a new and exciting tool and metaphor for psychologist to use to experiment and think about human cognition. This new technology enabled psychologists not only to use the computational metaphor to describe and hypothesize human cognition. They were also now able to build computational models to simulate these processes and so "prove" the validity of their ideas. Cognitive psychology was therefore not a comprehensive refutation of behaviorism, but rather an expansion on mental states previously ignored by the behaviorists, since they had no means of objective measurement. Cognitive learning theories has become the dominant force in psychology and learning theory in the second half of the twentieth century in the West (Fox, 1997; P. L. Smith & Ragan, 1999).

Cognitive learning theories aims to understand, explain, predict and facilitate the cognitive processes of humans typically assumed to be occurring in the brain. Cognitive learning theories are largely based on the information processing paradigm, which proposes that much like a computer the human brain is an information processing system. The brain holds memories in interrelated symbol structures that are connected to the external environment via sensory and motor connections that send and receive encoded symbols. The input-output model of computers is also a useful analogy to consider how humans interact with the environment. Humans receive encoded information from the

sense organs, processing the information in the symbol representation and transformation systems in the brain; and outputting the resulting information to the muscle systems to act. The brain accomplishes thinking by copying and reorganizing symbols in memory, receiving and outputting symbols, and comparing symbol structures for identity and difference. The brain solves problems by defining a symbolic representation of the problem space that is capable of expressing initial, intermediate, and final problem situations (Langley *et al.*, 1987). Cognition according to the information processing metaphor equates to the symbolic processing done by computers.

In strong contrast to behavioral theories the cognitive information processing theories described learning as a series of transformations of information (encoded in symbols and processed) through postulated structures within the brain. These theories typically aim to identify specific structures within the brain and find strategies for facilitating their processing and function. For example one of the most critical parts of the learning process according to information processing theory is the transfer of information into long term memory. It is claimed that for information to be stored in long term memory it has to be meaningful; and integrated with prior knowledge (P. L. Smith & Ragan, 1999). Postulating the structures and organizational aspects of cognition have consequently become of major importance to information processing theorists. Various concepts and hypotheses have been developed in attempt to describe the underlying structures of cognition.

The cognitive paradigm utilizes primarily empirical and quasi-empirical methods to conduct research. Empirical research is typically concerned with low level cognitive processes that form part of the cognitive system, like memory and perception. Measurements are usually quantitative in nature measuring response times, memory tasks, psychophysical responses, eye tracking etc. Quasi empirical methods utilize computers to simulate and evaluate models of learning and task performance. Like behaviorism, Cognitive learning theories has been criticized for being reductionistic. Cognitive learning theories have in effect reduced people to symbol manipulating machines, i.e. computers. This myopic focus of the computer metaphor has elicited much criticism. In particular from psychologists who recognize that for many information processing researchers, theoretical questions about cognition has become less important than questions about the hardware and programming issues generated by attempts to construct simulations of tasks (Coulter, 1983). These quasi-empirical methods introduce artificial technical constraints through the limitations of hardware and software. Limits in computation become limits to understanding cognition. It has been argued that the rise of cognitive learning theories was a byproduct of the advent of the computer rather than the other way around (Papert, 1979). In recent years connectionism has attempted to

describe cognition at the neuron level by modeling cognitive processes in computational neural networks. Connectionism aims to replace the computer metaphor with the brain metaphor (Rumelheart, 1989). This is an interesting inversion of the traditional information processing metaphor; however, it still offers impetus to the dualistic world view.

> *"Information-processing (IP) theory, it should be clear by now, represents dualism in a different guise: Information processors turn the "Eye of the Mind" outward, to use Rorty's (1979, p. 159) expression, toward the real world of objects and events. IP theory represents a mind-WORLD approach. Structures built up in the head are judged valid to the extent to which they map onto whatever structures are present in and extractable from the world" (Prawat, 1996).*

Instead of situating truth in the rational and objective world outside of us as Descartes had. Information processing proposes that truth is ultimately constructed inside our heads and the criterion for its validity is how closely these schematic constructions maps to our experiential world. This notion is strongly reminiscent of the Kantian perspective (See 2.1.1.4) and signals the source of Constructivism.

2.1.2.4. Modern constructivism

Constructivism was the label used for the departure from the objectivistic model of education (Barab & Duffy, 2000). Constructivism moves away from such passive conceptions of learning and essentialist notions of knowledge toward a conception of learning, wherein knowledge is actively constructed by the learner from experience. Most constructivists will generally agree with this statement. However, the exact details of how this "knowledge" is constructed and from what "experience", is where the different constituents of constructivism start to diverge. Even among those who call themselves "constructivists" there are different perspectives and different sets of assumptions (Barab & Duffy, 2000; Cobb, 1994, 1995; Phillips, 1995). Constructivism represents a heterogeneous body of theoretical approaches across different disciplines that has forged diverse alliances, as well as both attracted and antagonized vast audiences within these disciplines, including psychology and education (Vianna & Stetsenko, 2006).

Constructivism is therefore not a unified theory regarding cognition and human development, but described as metatheory (Patraglia, 1998a), i.e. a theoretical framework composed of different mediating theories that share common themes (Patraglia, 1998b). Some of the differences are quite subtle; while others are more fundamental. *Making sense of these subtleties within constructivism*

and developing a coherent picture of the diversity of meanings of constructivism poses a challenge which this text that had to overcome. The accessibility of constructivism as an educational theory is hampered by the fact that theorists and researchers from both the Dualistic and Non-dualistic perspectives use the term indifferently. They do not explicate the implications of their ontological assumptions for their conception of learning theory. The epistemological differences underlying the different manifestations of constructivism have been noted (Cobb, 1994; Derry, 1996; Phillips, 1995; Steffe & Gale, 1995); however, the more fundamental ontological assumptions underlying the different mediating theories are largely avoided and ignored (Packer & Goicoehea, 2000) and deliberately so (von Glasersfeld, 1985).

This text concurs with Prawat (1996) and Packer & Goicoehea (2000) that illuminating these assumptions are fundamental for understanding the more subtle aspects differentiating the different mediating theories of constructivism, particularly since epistemology is always an aspect of ontology (Packer & Goicoehea, 2000). Prawat (1996) makes the valuable distinction between "Modern Constructivism" and "Postmodern Constructivism" based on these respective category's fundamental different underlying ontological assumptions. It is important to consider the philosophical histories tracing back to Kant and Hegel when making the distinction between modern and postmodern constructivism. Modern constructivism assumes a dualistic ontology and includes the terms: Piagetian -, Individual -, Radical -, Rational -, Strong -, Cognitive -, Schema-driven constructivism. Jean Piaget is generally regarded as the foundational figure for constructivism and many constructivists trace the roots of constructivism to him (Cobb, 1994; Derry, 1996; Packer & Goicoehea, 2000; Phillips, 1995; P. L. Smith & Ragan, 1999).

2.1.2.5. Piaget

Piaget focused his research on the constructive processes within the individual. Accordingly, learning is the result of the constructive reorganization of knowledge structures. Piaget consequently took a more mentalistic approach to cognition and his views are therefore regarded by some as more compatible with the information processing paradigm. Derry (1996) makes this explicit through his proposal to blend Cognitive schema theory and Piaget's Strong Constructivism together; and so building a bridge between information processing and the radical constructivist perspective. The bridge linking information processing and Piaget's Strong Constructivism is, however, built on their shared dualistic ontology and not their epistemological correspondence. Information processing is the epistemological antithesis of Piaget's Strong constructivism (Prawat, 1996).

Piaget was greatly influenced by the philosopher Immanuel Kant (Pea, 1993; Prawat, 1996); and indirectly by Descartes through his influence on Kant (Packer & Goicoehea, 2000). John Dewey (1988) explained that Kant's intent was not to evolve a brand new theory but rather "edit" a new and improved version of the prevailing rationalist doctrine (Prawat, 1996). Constructivism is consequently regarded as rationalistic by many theorist (Phillips, 1995; Prawat, 1996; P. L. Smith & Ragan, 1999). Piaget “assimilated” the basic insight that the knowledge is actively constructed from Kant and added a developmental dimension to this (Piaget, 1988). Kant’s "categories of the understanding" (Kant, 1965) became the basic concepts whose genesis Piaget traced through infancy and beyond. Kant insisted and Piaget implied that these universal cognitive structures shape our experience of reality, both ascribe to distinction between mind and matter, the thinking subject and independent world; and consequently both assume the dualist ontology (Packer & Goicoehea, 2000).

Piaget’s work is important for constructivism since it emphasizes the centrality of the constructive (active) processes in thinking. Piaget’s notion of *schema* in particular has played an important role in the formulation of constructivism. A schema is hypothesized to be a memory structure that represents information in associated webs. These structures assist cognition by providing an expectation framework by which new information can be filtered for relevance. If these memory structures are abstracted from our everyday experience, like Piaget suggested, this means that memory, thinking and learning are squarely placed in context of everyday experience. Piaget’s ideas develop from the vantage point of evolution and biology, wherefrom human development is the result of adaptation to the environment. Learning according to Piaget is adaptation through action and aimed to better “fit in” the environment as a whole. Cognition is consequently made up of the goals and processes that develop out of the activity of adapting to the world. Piaget’s concepts of “assimilation” and “accommodation” are most noteworthy in this regard. Piaget largely omits society and culture from his theories regarding human development. This lack of consideration regarding the social dimension has been aptly termed ‘a weak image of the role of social life’ in the Piagetian framework (Lerman, 2000). Piaget, Kant and Descartes all considered the human individual as essentially a thinking thing (cogito), an epistemic person fundamentally unchanged by the construction of knowledge (Piaget, 1988); and distinct from the material world. Dualism poses all sorts of problems for a coherent theory of human knowledge, learning, and action (Packer & Goicoehea, 2000).

The problematic dualism on which contemporary Western education is built has been voiced for years by prominent educational theorists. Dewey argues that dualism carries with it a host of

insidious contrasts almost too numerous to itemize: that between experience and nature; subject and object; mind and matter; cognition and affect; “higher” and “lower” forms of knowledge; process and content; logic and methodology; the universal and the particular; analysis and synthesis; and the closely related notion of the processes of justification and discovery in science. The effects of the mind-world split has been particularly problematic in education (Dewey, 1989; Prawat, 1996). Prawat (1995) goes as far as to state that the persistence of this dualist problem accounts for the vexing cycles of educational reform, wherein reaction and a return to basics has followed every reform with great regularity since the turn of the century. Seven decades ago Lev Semenovich Vygotsky had spoken out against the very same divisions. Vygotsky noted that (educational) psychology is in a state of crisis because of the “atomistic and functional modes of analysis . . . that treated psychic processes in isolation” (Vygotsky, 1986, p. 1). More recently we find the dualistic ontological assumption identified as culprit when facing contemporary education’s “epistemological crisis” (Patraglia, 1998b), “conceptual upheaval” (Sfard, 1998); and the “The Theory-Practice Gap” (Roth & Tobin, 2000). Both Dewey and Vygotsky are representatives of social learning theories based on the non-dualistic ontological perspective, which will be considered next.

2.1.3. Non-dualistic perspective of social learning theories

The non-dualistic ontological perspective in Western philosophy has been traced back 2500 years to Heraclitus (500 BC) and his notion of the “unity of opposites” (See 2.1.1. History of the ontological perspectives underlying learning and Figure 2). Some of the earliest evidence for the cultural-historical approach can be found in the histories of the Greek Herodotus (450 BC) of Halicarnassus (Cole, 1996). Herodotus is considered the Western "Father of History" (van Wees, 2002). He is not regarded as a philosopher, but rather the first Western ethnographer (Willis, 2002). Herodotus’ project of tracing the cultural and historical origins of the Greek-Persian conflict, however, reveals his intellectual likeness to Heraclitus (Gould, 1989; Thomas, 2002). The Platonic ontological view serves to underpin the “natural” science of mind, while the cultural-historical theories of mind followed the path of Herodotus (Cole, 1996). Descartes had formulated dualism and the rationalist epistemology explicitly, supporting the mechanical conception of nature and man of the Enlightenment. The same methodologies used successfully to determine the natural laws of the physical world were used to define the laws of humanity. Giambattista Vico strongly opposed the use of natural science’s models and methods to study human nature. In his “Scienza Nuova” (The New Science, 1725/1968) Vico accepts that human nature and history are qualitatively distinct; however,

contrary to Descartes he concludes that the science of human nature must be based on specifically human forms of interaction and understanding; i.e. a distinctive historical science (Cole, 1996).

The Non-dualistic perspective, however, took some time to take root in the West; and was first explicitly formulated in Western philosophy by Hegel (Hegel, 1967) 200 years ago. Hegel's alternative ontology had a great influence on his contemporaries Marx, Vygotsky, Ilyenkov, as well as postmodernists as Derrida, Foucault, Deleuze, and Lacan; poststructuralists such as Bourdieu and Latour, as well as phenomenologists including Heidegger and Merleau-Ponty (Packer & Goicoehea, 2000). Hegel laid the foundations for his contemporaries to build on and develop their respective responses to dualism and so reclaim the importance of the historical, developmental and descriptive approaches. Although their responses vary subtly, they share strong relations to one another, and back to Hegel. These responses were taken up by learning theorists and incorporated in their theories, which this text subsumes under the label Postmodern constructivism (See Figure 2).

2.1.3.1. Postmodern constructivism

Postmodern constructivism assumes a non-dualistic ontology and includes the terms: Situated, Symbolic Interactionism, Sociocultural Constructivism, Social Constructionism and Social Constructivism. As mentioned above Hegel is one of the central philosophical figures responsible for the development of Postmodernism constructivism, through the formulation of his non-dualistic ontology of becoming (See 2.1.1.5). Hegel's legacy was then further developed by Marx and Heidegger and their successors, each applying Hegel's dialectical approach to their own domains to overcome many of the modernist dualities. Where Hegel considers how two phenomena constitute each other dialectically, Marx illustrates how the relationships arise in concrete socio-economic history; for example the rise of conflict between the capitalist class and the working class, with the establishment of commodity exchange and wage labor (Stahl, 2006c). Heidegger's contribution towards constructivism is often understated. Heidegger's philosophical writings provide an alternative way of understanding our existence in the world. As opposed to the rational object/subject dichotomy, "Dasein" (being-in-the-world) is an existence wherein mind is intimately related with situation, context, environment and world. We exist quite literally in the world; we cannot exist apart from it. This primary mode of existence provides us with an alternative view on knowledge and what we can know. Knowledge is stable, yet temporary projections (constructions) that result form detached analysis or "break-down" of our unavoidable action (throwness) of Being-in-the-world.

One of the central tenets of constructivism is the absolute necessity of action for learning to take place.

> *At first blush, it may seem strange to label Vygotsky's theory postmodern. I do this with some trepidation, encouraged in this regard by two thoughtful recent treatments of the postmodern turn in psychology (Morss, 1996; Shatter, 1993), both of which highlighted Vygotsky's pivotal role in this important event (Prawat, 1996, p. 217).*

Lev Semyonovich Vygotsky (Vygotsky, 1978, 1986) supplements Marx's social theory with a psychology of mediated cognition, a dialectical perspective of the individual intertwined with the social (Stahl, 2002, 2006c). Vygotsky's socio-cultural psychology can therefore be seen as an expansion of Heidegger's critique of Western assumptions, illustrating that individual learning is reliant upon collaborative learning (Stahl, 2006b). Adapting the philosophic critique of individualism in Hegel and Marx to his pragmatist viewpoint, John Dewey draws out the consequences for education (Stahl, 2006b). Dewey argues that knowing and doing are tightly coupled and thus learning needs to take place in the context of activity (Dewey, 1915; Menand, 2001; Shaffer, 2004); and in so doing he overcomes the dualistic distinction between knowing and doing which has plagued educators for years (Prawat, 1996). Richard McKay Rorty develops his own radical pragmatism incorporating the ideas of Dewey, Heidegger and Ludwig Wittgenstein in an attempt to overcome the *representational view of mind* (Rorty, 1979). Rorty is the philosopher most associated with social constructionism (Prawat, 1996). George Herbert Mead, one of the founding pragmatists along with Dewey, drawing from Hegelian dialectics overcomes the dualistic division between society and the individual. The individual mind can exist only in relation to other minds with shared meanings (Mead, 1982). Blumer first coined the term "Symbolic Interactionism" to describe the view that the meaning of objects arise from social interaction; however, he credits Mead with the origination of these ideas (Prawat, 1996).

Contemporary postmodernist constructivist theories clearly incorporate various threads of cross influence (indicated by green arrows in Figure 2) and it is therefore difficult to draw strict boundaries between these social learning theories. Instead this text will trace the trajectories of three movements, in the developing conceptualization of learning and cognition as *Distributed*, *Situated* and *Social*; which follow from Hegel's dialectics and are essential when considering learning in a virtual world. These trajectories will lead us to the social learning theories of Situated cognition (Lave, 1988; Suchman, 1987), Distributed Cognition (E. Hutchins, 1995; D. A. Norman, 1993) and

Cultural-historical Activity Theory (CHAT or Activity Theory) (Cole & Engeström, 1993). The differences between these social learning theories are not their content but rather where they place their emphasis. This text will argue that Activity theory is the most appropriate and productive framework from which to consider learning in a virtual world. However, before expounding these theories and their differences, this text provides further information about Gibson and Vygotsky in addition to Heidegger (See 2.1.1.6), since all three these theorists are important contributors to the formulation of these social learning theories and will also contribute to our understanding of VR in the next section.

2.1.3.2. Gibson

The perceptual theory of James Jerome Gibson shares much with Heidegger's ontological orientation (Zahorik & Jenison, 1998). The work of Gibson also played a pivotal role in the move to situate cognition. Gibson's work illuminated the dialectical relationship between our perceptual system and our situated environment. Gibson challenged the then dominant view in perceptual psychology, that perception was a rather passive affair of mentally representing the world of the senses outside, inside our heads. According to this theory of sensory channels, the act of perceiving is a mixture of sensing and imagining. The theory of sensory channels is firmly based in the dualistic ontology in that the atomistic quantifiable parameters of the "objective" world are represented mentally in the form of a mental image. Gibson theorized that far from the mental images in our heads, perception is the process of active selection of information from the perceptual array.

> *…the perception of an object does not depend on a series of percepts, each of one image of the object, that is, perceptions of its forms or perspectives, but depends instead on the invariant features of the forms or perspectives over time. Object-perception does not depend on form-perception but on invariant-detection (J. J. Gibson, 1973).*

Gibson's experiments suggested to him that object perception is dependant on invariant features detected over time rather than mental images corresponding to an "objective" world perceived. He affirms Heidegger's radical epistemology of "Difference", whereby our worlds is revealed to us through invariance, i.e. difference. However, Gibson illustrates that this mechanism runs as deep as our perceptual system. Animals in the environment are mobile and actively seek information vital to their survival. The environment provides what Gibson came to call *affordances* for the animals inhabiting it. Affordances are properties of the environment taken with reference to the creatures that live in it (Pick *et al., 1982*). Gibson's unique insight rests with the notion that the

perceiving organism and the environment are intimately related, i.e. the environment provides conditions commensurate with the organism's evolution (Zahorik & Jenison, 1998). Gibson's perceptual theory acknowledges that the environment also includes other organisms, places, and events; however, he was primarily interested in the perceptual system of individual organisms and the relationship between them and the environment. Heidegger also failed to take advantage of the understanding of social phenomena in the tradition of Marx (Nancy, 2000; Stahl, 1975a, 1975b, 2003b, 2006c). We can fortunately take advantage of the hindsight history affords us and turn to Vygotsky who took up Marx's tradition of dialectical materialism to situate cognition in society, culture and history.

2.1.3.3. Vygotsky

Vygotsky and his collaborators Alexander Luria and Alexei Leontiev established the Sociohistorical School of psychology, with the aim of studying the cultural and historical situated activities of thinking and learning. Their approach focuses on cognition in context, with all its complexity and ambiguity of everyday life. Embedding cognition and learning in everyday cultural practice is the single greatest contribution the Sociohistorical School made to constructivism. According to Vygotsky thought is based on three general assumptions: 1) The developmental approach is required to understand learning and cognition. 2) Cognition is the result of the internalization of social practices. 3) These social practices are mediated through physical and mental tools and symbols (Wertsch, 1985). Vygotsky anchors cognition firmly within the context of our everyday social interactions with people.

> *Any function in the child's cultural development appears twice, or on two planes. First, it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intrapsychological category…Social relations or relations among people underlie all higher functions and their relationships (Vygotsky, 1981).*

According to Vygotsky's "general genetic law of cultural development" quoted above, the cognitive functioning of children develops in two interrelated planes or levels, namely interpsychological (between people) and intrapsychological (inside the child). He postulates these levels by making the principle distinction between "lower", natural mental functions, for example perception, attention, memory and will; and the "higher", or cultural functions, which are exclusively human and develop gradually through the course of the radical transformation of lower functions

(Kozulin, 1986). The higher level of mental functioning develops as result of interpsychological or social interaction. The higher mental functions are then later internalized within the child and linked to lower mental functions through mediation of physical and mental tools (Patraglia, 1998b). Tool and thought therefore become inextricably bound together (Shaffer & Clinton, 2006).

> *Initially, this gesture is nothing more than an unsuccessful attempt to grasp something, a movement aimed at a certain object which designates forthcoming activity. . . When the mother comes to the child's aid and realizes this movement indicates something, the situation changes fundamentally. Pointing becomes a gesture for others. The child's unsuccessful attempt engenders a reaction not from the object he seeks but from another person. Consequently, the primary meaning of that unsuccessful grasping movement is established by others. . . The grasping movement changes to the act of pointing. As a result of this change, the movement itself is then physically simplified, and what results is the form of pointing that we may call a true gesture (Vygotsky, 1978, p. 56).*

The "pointing gesture" is a tool. Despite the fact that the "pointing gesture" is formed by the hand, the hand is used as a tool to embody and externalize meaning in the material world, much like language. The meaning of the "pointing gesture" is reference to the object which is pointed at. The meaning of the pointing gesture is created intersubjectively between the child and the mother and draws its meaning from their social interaction. Only after this intersubjective meaning has been established can the "pointing gesture" be internalized by the child for future use and understanding. The mother can in turn then use the "pointing gesture" to associate names with the objects pointed at. Language so grows out of gesture (Stahl, 2003a, 2006c).

> *Mind is not a pre-given cognitive capability (Descartes), a universal schema for structuring reality (Kant), or a biologically developing set of facilities (Piaget), but the result of internalizing and transforming artifacts that arise in social interaction (Stahl, 2003a, 2006c).*

Vygotsky's notion of tool mediation consequently overcame two of Descartes' dualities, namely the duality between mind and matter; and the duality between the individual and society. The mind is the result of the internalization of tools that develop intersubjectively through our social interaction with others. In retrospect, Vygotsky's work in offer a valuable extension on the work of Heidegger. Vygotsky's conception of cognition as a result of interacting and being-in-the-social-world is legitimated through Heidegger's philosophy of "Dasein". Thinking, understanding and knowing can also be firmly contextualized within being-in-the-social-world. Furthermore, Vygotsky's notion of social practices (ways of seeing and knowing) mediated through physical and

mental tools and symbols can be assimilated with Heidegger's concept of circumspection. Through interaction with mental and symbolic tools, stable representations of our social existence become apparent in the world. Although these pioneers of postmodern constructivism had made a significant contribution to psychology by drawing attention to the constructive, active and socio-cultural nature of cognition; they had not offered much resistance to the then dominant views of behaviorism and information processing. The real thrust of Postmodern constructivism only came about the second half of the twentieth century with the movement to "situate" cognition in cognitive psychology.

2.1.3.4. Situated cognition

The movement to situate cognition picked up momentum the last two decades of the twentieth centaury. Disillusionment with cognitive learning theories, the information processing paradigm and the dualistic ontological perspective - caging cognition in the cranium - has provided much impetus in the search for alternative conceptions of cognition and learning. It is not surprising that some theorists contend that situated cognition comes into clearer focus when contrasted against traditional information-processing views of cognitive learning theories (See 2.1.2.3)(Wilson & Myers, 2000).

> *A central tenet of the situated action approach is that the structuring of activity is not something that precedes it but can only grow directly out of the immediacy of the situation (Suchman 1987; Lave 1988). The insistence on the exigencies of particular situations and the emergent, contingent character of action is a reaction to years of influential work in artificial intelligence and cognitive science in which "problem solving"' was seen as a "series of objective, rational pre-specified means to ends" (Lave 1988) and work that overemphasized the importance of plans in shaping behavior (Suchman 1987) (Nardi, 1995b, p. 36).*

Situated cognition, also called "embodied cognition" (Cole, 1997) or "situated action" (Wilson & Myers, 2000), disputes the prevalent view that cognition is based in explicit mental representations; and although the manipulation of such representations can facilitate activities, there is a more basic primordial understanding, which cannot be fully captured in these representations (Stahl, 1993, 2006c). Human behavior and cognition are prior to the rational analysis of these actions. The resulting goals and plans are therefore secondary and usually occurring after the action has started (Suchman, 1987). Clearly, situated cognition draws most strongly on Heidegger's (See 2.1.1.6) philosophical exposition regarding the situated nature of our primordial understanding of "Dasein" (being-in-the-world) and the improvisational, emergent nature of cognition and learning.

Situated cognition emphasizes the emergent, contingent nature of human activity, the way activity grows directly out of the particularities of a given situation (Salomon, 1993). Ethnomethodological inquiry is regarded as an important source for such information and an important methodology utilized for doing research within the situated cognition domain.

Situated cognition acknowledges the sociality of human situations and the import role of mediating artifacts; however, the emphasis and focus of inquiry is the “everyday activity of persons acting in setting" (Lave, 1988). Consequently, the most appropriate unit of analysis for situated cognition is the intimate relationship between individual and setting. The setting can be thought of as Gibson’s environment imbued with Vygotsky’s artifacts and social relations. The situation constitutes a network of significance in terms of which each part of the situation is already meaningful (Stahl, 1975b). This network of significance is already tacitly understood and does not need to be an object of rational thought and the manipulation of symbolic representations; and therefore knowledge of the world does not consist primarily in mental models that represent an objective reality, but rather our understanding of things presupposes a tacit pre-understanding of our situation (Stahl, 2006c). An important aspect of person acting in setting, as a unit of analysis, is that it focuses attention on the flux of the ongoing activity, i.e. the unfolding of the activity in a setting. It is important to note that situated cognition is not interested in attempting to identify the structural elements of these activities. This would be a rational abstraction (representations) of the activity. Situated cognition focuses is the improvisatory nature of human activity (Lave, 1988). “In emphasizing improvisation and response to contingency, situated action deemphasizes study of more durable, stable phenomena that persist across situations” (Nardi, 1995b, p. 36). Through this myopic focus, situated cognition omits: human intentionality, the larger situational contexts and the more complex activities which give rise to the situation and which follow it.

Indeed, before the jazz player (See 2.1.1.6) that improvises his play, and would be unable to rationally analyze this without “breaking-down” the activity of play, could play; the jazz player had to consciously practice various notes and melodies with the goal in mind to become a jazz player. Only once the jazz player had moved from playing as a conscious action, to playing as an automatic operation (See 2.1.4.3), could the jazz player play jazz and improvise. Activity theory and Distributed cognition in contrast to situated cognition recognize that emphasizing the more stable structures of activities, which can span situations, make possible the understanding of more complex activities and higher level cognitive functions. As an alternative Distributed cognition will be considered next.

2.1.3.5. Distributed cognition

Distributed cognition parallel to situated cognition offers an alternative perspective to the purely mentalistic notion of cognition. However, unlike situated cognition, it does not completely reject the cognitive science conception of cognition as a representation, but rather extends the scope of these representations to outside the individuals head.

> *The distributed cognition approach is a new branch of cognitive science devoted to the study of: the representation of knowledge both inside the heads of individuals and in the world ...; the propagation of knowledge between different individuals and artifacts ...; and the transformations which external structures undergo when operated on by individuals and artifacts.... By studying cognitive phenomena in this fashion it is hoped that an understanding of how intelligence is manifested at the systems level, as opposed to the individual cognitive level, will be obtained (Flor & Hutchins, 1991).*

According to distributed cognition the most appropriate unit of analysis is the cognitive system composed of individuals and the artifacts they use (Flor & Hutchins, 1991; Nardi, 1995b). This is a systems view on activity, human behavior and cognition which takes into account not only the individual but also the artifacts used. The focus and emphasis of distributed cognition is the unifying relationship of interaction between people and the artifacts they use when performing a task or participating in an activity. The coordination between the participants, and participants and artifacts are also emphasized in the description of these "functional systems". These cognitive systems are the structures which distributed cognition aims to describe and includes the representations inside and outside of the participant's heads. The transformations of these representations, both inside and outside of the participants, are also regarded as significant components to understanding cognitive systems and therefore included in the analysis. However, unlike situated cognition's emphasis on improvisation, the emphasis is on stable elements such as system artifacts, goals and plans; which facilitate the coordination and transformation of the functional system.

Artifacts are regarded as stable external representations, interacting and reflecting human internal representations. Distributed cognition therefore tends to provide finely detailed analyses of the use of particular artifacts (Nardi, 1995b; D. A. Norman, 1988). Distributed cognition identifies a special kind of artifact, which not only extend our actions but also our cognitive abilities, namely "cognitive artifacts". Donald Norman (1993) introduces cognitive artifacts as a special class of artifact which affords the operation, representation and maintenance of information. Cognitive

artifacts are perceived to offload human cognitive functioning unto a device or artifact. Indeed, artifacts are regarded as conceptually equivalent to people with respect to their role in functional systems, i.e. both people and artifacts are "agents" of the system. This is a similar view as proposed by Actor Network Theory, wherein technologies become key actors in the network. Unfortunately, these theories again fall into the trap of equating humans to machines; and ignoring the crucial character of human intentionality and agency. Machines and artifacts do not have intentions. If they sometimes behave as if they do, this is because people have designed their human motives, intentions and goals into these technological agents. Equating humans and artifacts in functional systems, become particularly problematic when these systems are required to make ethical decisions.

> *Activity theory instructs us to treat people as sentient, moral beings (Tikhomirov 1972), a stance not required in relation to a machine and often treated as optional with respect to people when they are viewed simply as nodes in a system. The activity theory position would seem to hold greater potential for leading to a more responsible technology design in which people are viewed as active beings in control of their tools for creative purposes rather than as automatons whose operations are to be automated away, or nodes whose rights to privacy and dignity are not guaranteed (Nardi, 1995b, p. 43).*

Activity theory is therefore proposed by this text as the most appropriate framework from which to consider learning. Furthermore, Activity theory has been elaborated from its origin with the specific task to unite the individualistic and social perspectives.

2.1.4. Cultural-historical activity theory

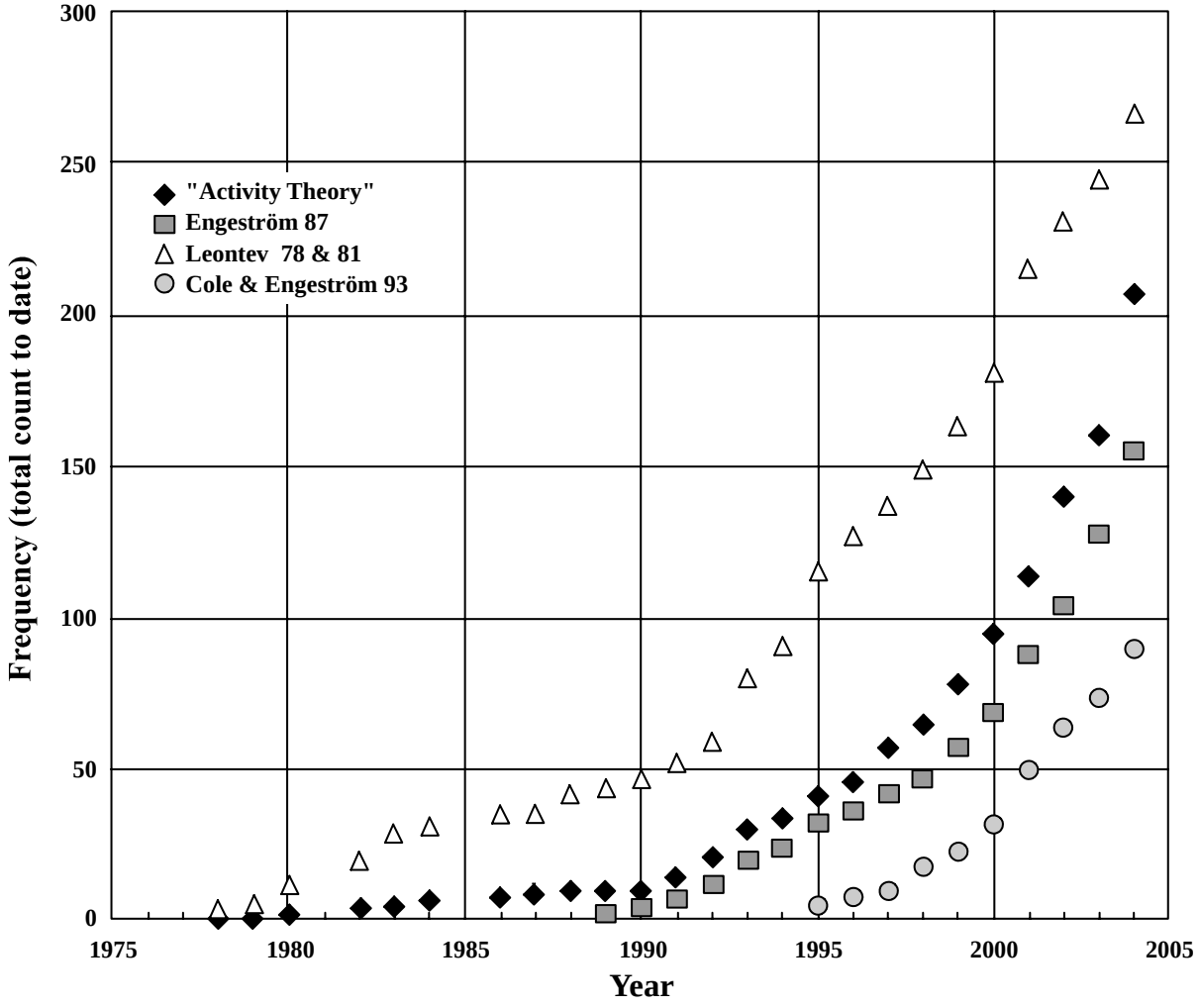
Activity Theory, formally referred to as Cultural-historical Activity Theory, is an evolving theoretical framework established firmly in dialectical materialism. As such it is a reflexive "theory" that posits a dialectical relationship between theory and practice emerging in context of history and culture. Activity Theory theorists practice what they preach. Activity Theory offers us a unique lens to look at human development through our activities as they unfold in social and material contexts. As such it is not a theory which aims to evaluate the "objective" truth of the social and physical world, aiming to empirically prove or falsify testable hypotheses. Activity Theory is closer to ethnomethodology's notion of theory, as it attempts to make concrete sociology's theoretical constructs with reference to the social world (Halverson, 2002).

Activity Theory has evolved over the last approximately 80 years to develop unique characteristics to transcend dualism and its dichotomies from a transformative, dialectical materialist, cultural-historical, reflexive, object-oriented perspective. Activity Theory takes human activity as the unit of analysis for context and cognition, which is constituted through the enactment of the activity by its subjects and the objects they use to perform their actions (Nardi, 1995b). This object relatedness is one of Activity theory's most distinctive characteristics (Stetsenko, 2005) and can be traced to Lev Vygotsky's original proposal that human cognitive development result from the internalization of social interactions and is mediated through cultural tools and symbols (See 2.1.4.2)(Wertsch, 1985). Alexei Leontiev (or Leont'ev) expanded on Vygotsky's proposal focusing on how material practical forms of activity are transformed into cognitive processes (See 2.1.4.3). Yrjö Engeström's extended triangle of mediation graphically extends Leontiev's extension of Vygotsky's original model into a model of a collective activity system (See 2.1.4.4) (Center for Activity Theory and Developmental Work Research, 2003b; Engeström, 1987).

> *Because CHAT addresses the troubling divides between individual and collective, material and mental, biography and history, and praxis and theory (Cole, 1988), we believe that it is deserving of wider currency among the educational community… what is educationally relevant: its inherently dialectical unit of analysis allows for an embodied mind, itself an aspect of the material world, stretching across social and material environments (Roth & Lee, 2007).*

Activity Theory entered into Anglo-Saxon academia rather late and it has only risen to prominence in the West in the last two decades of the twentieth century; some theorists even go as far as to say it is "the best kept secret of academia" (Engeström, 1993b); however, there is no denying the exponentially rising appeal of Activity theory as indicated by various citation-related factors (Roth, 2004; Roth & Lee, 2007):

Figure 3. **Four indicators of the increasing interest shown in CHAT (Roth & Lee, 2007)**



Activity Theory is typically traced to the original proposals of Vygotsky, which his students and followers then substantially developed to constitute much expanded forms in its second and third generation (Roth & Lee, 2007). The prehistory of Activity Theory can be traced back to Hegel (Karpatschof, 2000) and it can be argued that Activity Theory's historical roots can be traced back even further, to the dialectical philosopher Heraclitus' "unity of opposites".

2.1.4.1. Dialectics

Dialectics is generally regarded as the philosophy of process, transformation and change; for example Heraclitus' doctrine of "Flux" (See 2.1.1.1). The heart of dialectics is the notion that all "things" are actually processes, that these processes are in constant transformation, which is driven

by the tension created by two interrelated opposites acting in contradiction with one another (Au, 2007; Gadotti, 1996; Ollman, 2003; Sayers, 1990). The nucleus of dialectics is the unity of mutually exclusive opposites (Ilyenkov, 1977). The dialectical approach to science attempts to understand reality as a process, not by isolating constituting elements, but by recognizing the interrelationships and contradictions between "elements" as central part of this process in all its complexity (Bidell, 1988). This contradiction of opposition, and yet uniting relationship, is the creative force that drives the process' transformation (Allman, 1999; Au, 2007). Transformation is key to understanding dialectics and consequently also Activity theory (Davydov, 1999). The dialectical perspective also regards the world as a layered, interrelated system, a totality, a chain of relationships and processes (Au, 2007; Gadotti, 1996; Ollman, 2003; Sayers, 1990). It is believed that the least understood and most violated tenet in Western interpretations of Activity Theory is the dialectical nature of consciousness (Roth & Lee, 2007).

Hegel articulates the human development of "spirit" in his "The Phenomenology of Mind" (Hegel, 1967). Central to this dialectical process is the relationships of contradiction, mediation (sublimation) and historical development. Hegel's preferred method for surmounting philosophical problems is to accept problems as an expression of a contradiction; which becomes the impetus for an ontological jump to a higher level and so-called 'sublation', in which the primary negation is followed by a negation of the negation (Karpatschof, 2000). Contradictions are inherent tensions in the state of affairs and are the very dynamic of any history, no matter whether it is the history of nature, political history or the history of ideas (Karpatschof, 2000). Marx was opposed Hegel's idealism and aimed to "put Hegel's dialectics back on its feet" by arguing that history is not the product of the "Spirit" but the effect of material class struggle in society. Marx (1845/1967) opposed the idealistic "head in the clouds" conception of reality as the development of "spirit", abstract and unable to know sensuous reality. However, he also found the mechanical materialist's conception of reality objectionable, i.e. considered purely in the form of objective contemplation, devoid of sensuous human activity and not subjectively (Marx, 1845/1967). For Marx an objective external world clearly does exist. The objective practice of humanity not only proves this, but provides increasingly dependable knowledge of the external world (Jackson, 1971).

Reality is an approximation produced through human praxis; it is pluralistic, i.e. relative to the perspective taken. There are neither ultimate truths nor knowledge, but there is also no absolutely relative truth and knowledge either. Knowledge is related to the context revealed through human activity. Dialectical materialism, as Marx's philosophy later came to be known and its dialectical

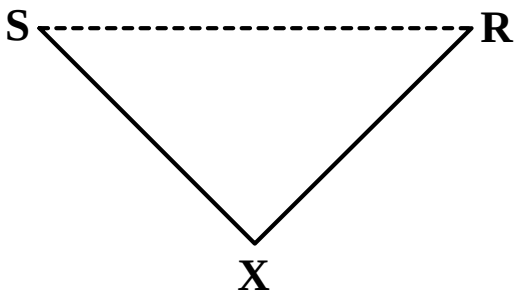
materialist epistemology played a constitutive role in the formulation of the first generation of Activity Theory by Vygotsky.

2.1.4.2. Mediation

> *For Marx and Engels, labour is the basic form of human activity. It lies at the foundation of any explanation of socialcultural history and of the psychological characteristics of the individual. Their analysis stresses that in carrying out labour activity, humans do not simply transform nature: they themselves are also transformed in the process (Vygotsky, 1981, p. 134).*

Vygotsky's great contributions towards the development of Activity Theory are: Firstly, his "general genetic law of cultural development", which like Wundt proposed two levels of cognition; i.e. natural "lower" cognitive functions and "higher" cultural cognitive functions. Secondly, that "higher" functions develop from intersubjective interactions mediated by cultural artifacts. Thirdly, his historical approach to the development of "higher" cognitive functions. Vygotsky opposed the stimulus–response behaviorist psychology prevalent in his day, in particular the reductionistic conception of consciousness as atomic structures that reside in the brain itself. Vygotsky represents the "lower" unmediated behavior typical of the stimulus(S)-response(R) relationship as S → R (Vygotsky, 1981, p. 38). In an attempt to expand the basic S → R relationship, to represent "higher" mediated human behavior (R), Vygotsky introduces "an intermediate link between the stimulus and the response", as represented by the X in Figure 4:

Figure 4. **The structure of the mediated act (Vygotsky, 1978, p. 40)**



According to Vygotsky's structure of the mediated act (Figure 4), human interaction with their environment differ from other animals. They do not interact directly (stimulus-response) with their environment, but indirectly mediated by tools and signs (X). The human mind is therefore

revealed through the cultural artifacts (tools and signs) which mediate between the environment and the person's internal mental reflections (Vygotsky, 1978).

> *A key idea in activity theory is the notion of mediation by artifacts (Kuutti 1991). Artifacts, broadly defined to include instruments, signs, language, and machines, mediate activity and are created by people to control their own behavior. Artifacts carry with them a particular culture and history (Kuutti 1991) and are persistent structures that stretch across activities through time and space (Nardi, 1995b, p. 38).*

Tools and signs enable people to more effectively interact with objects (which can be other people) and thus gain greater control over their environment. The "higher" mediated functions are internalized within the person and linked to "lower" functions through mediation of physical and mental tools (Patraglia, 1998b). These internalized artifacts provide the person with mechanisms to control their own behavior. Tool and thought are inextricably bound together (Shaffer & Clinton, 2006). Tools and signs are also externalized as products of social interaction and cultural-historical development. Central to Vygotsky's historical approach (See 3.1) to the study of human cognition is the observation, analysis and description of the dialectical process of transformation of cultural artifacts and practices, which facilitate the mediation of human cognition through the processes of internalization and externalization.

Figure 5. **Common reformulation of Figure 4 (Center for Activity Theory and Developmental Work Research, 2003b)**

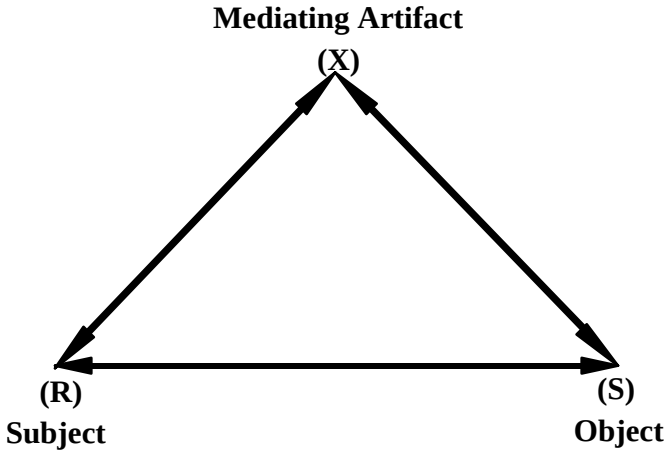


Figure 5 represents the common reformulation of Vygotsky's structure of the mediated act. For example a person (Subject) building a chair (Object) using a hammer (Mediating Artifact). This

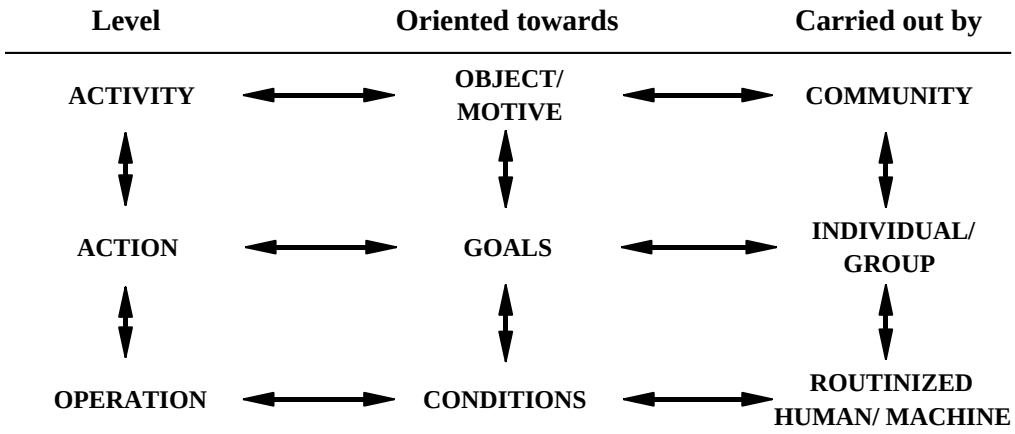
reformulation is primarily inspired by the view of activity as a mediated "subject–object" interaction (Leontiev, 1978, 1981). Leontiev, one of Vygotsky's students, contributed to the development of the understanding of the difference between mediated and non-mediated activities, by introducing the distinction between activity, action, and operation (Roth, 2007).

2.1.4.3. Activity, action and operation

> *The term activity is related to work, trade, and professions—A. N. Leont'ev (1978, p. 46) likens it to the German term Tätigkeit (which has the synonyms work, job, function, business, trade, and doing) and distinguishes it from Aktivität (which has the synonyms effort, eagerness, engagement, diligence, and restlessness). The activity concept therefore differs from the kind of events educators usually denote by "activity," which are structures that allow children to become engaged, involved, and busy that one might better refer to as tasks (Roth & Lee, 2007).*

Leontiev, like Vygotsky, shares a common interest in the analysis of how the individual's response emerges from the forms of collective life. Leontiev's framework was specifically developed for individual activities in a "narrow sense" (Leontiev, 1978, p. 50) and within the context of his psychological approach is understood as activities of concrete individuals, even when they are carried out by the individuals collectively in collaboration with other individuals (Kaptelinin, 2005). Activities are oriented toward conscious object/motives, which themselves have developed in cultural history as the result of the division of labor, and which serve to sustain the collective life conditions (Roth, 2007). Marx's concept of the production of use values was the paradigmatic model of human object-oriented activity for Leontiev (Center for Activity Theory and Developmental Work Research, 2003b). Activities are object-oriented, i.e. directed toward something that objectively exists in the world, i.e. an object. The object of an activity can be referred to as a "objectified motive" (Christiansen, 1995), it is the target which orients the activity (Nardi, 1995b). Activities are consequently identified according to their objects. Activities identified by their motive/object can further be described as a complex hierarchy consisting of three dialectically interrelated levels, as represented in Figure 6:

Figure 6. **Hierarchical model of activity (Center for Activity Theory and Developmental Work Research, 2003a)**



The hierarchical model of activity (Figure 6) represents the 3 dialectically interrelated levels of analysis: object/motive-oriented activities, goal-oriented actions, and conditioned operations (Roth & Lee, 2007). Activities are undertaken in order to fulfill motives behind which there always stands a need or a desire to which the activity always answers (Kaptelinin et al., 1999; Leontiev, 1978). The activity is then realized through concrete actions, which are therefore goal directed. Actions are comparable to tasks, as referred to in the Human Computer Interaction (HCI) literature (D. Norman, 1991). As one holds a goal in mind, actions are conscious, and different actions can be taken to achieve the same goal (Nardi, 1995b). These concrete goals determine the conditions for sequencing the unconscious elements which realize them, i.e. operations. Each of the operations is shaped "not by the goal in itself but by the objective-object conditions of its achievement" (Leontiev, 1978, p. 65).

Taking the example of the activity of learning to drive a car, the shifting of the gears is an action with an explicit goal that must be consciously attended to, later shifting gears becomes operational and can no longer be picked out as a special goal-directed process, gear shifting psychologically ceases to exist; conversely, an operation can become an action when the conditions impede an action's execution through previously formed operations (Kaptelinin et al., 1999; Leontiev, 1978). The operations of the activity depend on the conditions under which the action is being carried out and therefore if a goal remains the same while the conditions under which it is to be carried out change, then only the operational structure of the action will be changed (Leontiev, 1978; Nardi, 1995b). Activities are flexible structures and although they are identified according to an

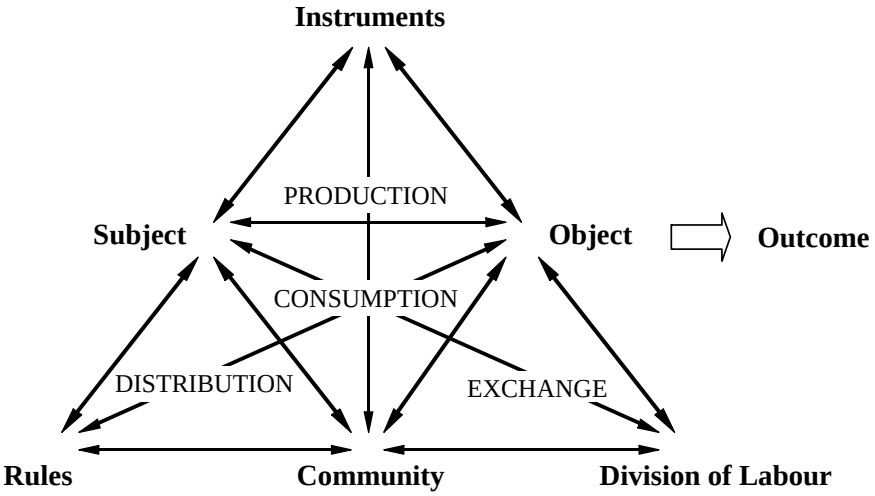
object, the components of the activity (actions and operations) can change as the conditions change. All levels of the activity hierarchy can therefore move both up and down (Leontiev, 1978).

2.1.4.4. Activity system

> *Activity system as a unit of analysis calls for complementarity of the system view and the participant's view. The analyst constructs the activity system as if looking at it from above. At the same time, the analyst must select a participant, a member (or better yet, multiple different members) of the local activity, through whose eyes and interpretations the activity is constructed. This dialectic between the systemic and subjective-partisan views brings the researcher into a dialogical relationship with the local activity under investigation. The study of an activity system becomes a collective, multivoiced construction of its past, present, and future zones of proximal development (Y Engeström & Miettinen, 1999, p. 10).*

Leontiev (1978) originally took as his unit of analysis almost exclusively individual activities; however, there have been several attempts to extend Activity theory to cover activities of supra-individual entities, the most well known being made by Engeström (1987, 1999), who developed the notion of the activity system that includes not only individual subjects interacting with objects, but communities as well (Kaptelinin, 2005; Kaptelinin & Cole, 1997). The activity system as unit of analysis for collective activities provides a dynamic systems approach to examining individual and social transformations. The unit of analysis of the activity system is defined as the object-oriented, collective, and culturally mediated human activity; which elements minimally include the object, subject, mediating artifacts (signs and tools), rules, community, and division of labor (Y Engeström & Miettinen, 1999). Taking Leontiev's (1978, 1981) perspective on activity as a mediated "subject-object" as a point of departure, and drawing from diverse sources, including biology, anthropology, and philosophy; Engeström introduces the third component of the community and adds it to his model in a three-way interaction between subjects, objects, and community (Kaptelinin, 2005). His model is then further elaborated by postulating that each of these three elements are further mediated by instruments, rules, and the division of labor (Kaptelinin, 2005). The resulting model is represented as a triangular diagram describing the relationship between these components in Figure 7:

Figure 7. **The structure of human activity (Yrjö Engeström, 1987, p. 78)**



In Engeström's triangular model of the activity system (Figure 7) the subject of an activity is the individual or group who are engaged in the activity and provide the participant view. The object of the activity is the physical (raw material) or mental (problem space) product at which the activity is directed; and which is constrained and motivated by the activity's outcome. The production or transformation of the object is mediated by the instruments of activity, which can be physical or mental. The community of the activity is the stakeholders who share in the general object of the activity. They constitute the larger cultural context in which the subject participates. The rules of the activity mediate between its subject and community, while the division of labor mediates between the community and the production of the object. The four dominant aspects of human activity (production, consumption, distribution and exchange) are also represented in the model.

The activity system is a dialectical system in tension, internal contradictions are the driving force of change and development in activity systems (Ilyenkov, 1977, 1982). These tensions are represented in Figure 7 by the arrows pointing between the elements of the activity system. These contradictions manifest themselves as problems, ruptures, breakdowns, clashes; and activities are virtually always in the process of working through these contradictions (Kuutti, 1995). Engeström places lightening-shaped arrows between the central components of the activity system to emphasize these contradictions explicitly (See, e.g. Engeström 1999, p. 31). Notwithstanding, these graphical indicators for contradiction and tension, the activity system's triangular representation remains a static representation. This becomes particularly evident when considering the temporal development of an activity or the developmental processes of internalization and externalization. In response to

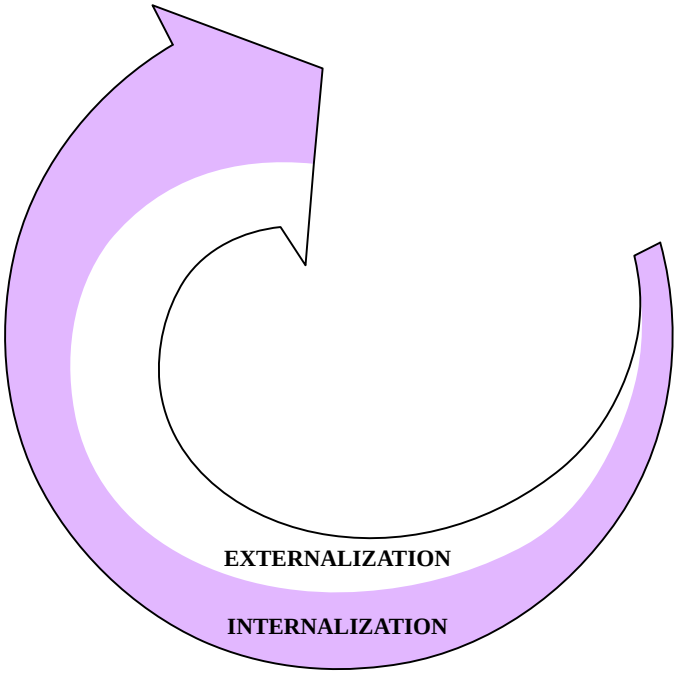
this limitation, Engeström extends Leontiev's concept of "activity cycles" to formulate the "expansive cycle".

2.1.4.5. Expansive cycle

> *An activity system is by definition a multivoiced formation. An expansive cycle is a reorchestration of those voices, of different viewpoints and approaches of the various participants (Yrjö Engeström, 1999, p. 35).*

The expansive cycle (represented in Figure 8) of an activity system is the iterative formulation and resolution of the internal contradictions of an activity system, driving the transformation of the activity through the developmental processes of internalization and externalization.

Figure 8. **The expansive cycle (Yrjö Engeström, 1999, p. 34)**



The expansive cycle of an activity system starts with an emphasis on internalization, through socializing and teaching the novice becomes a competent participant in the activity; this is then followed by the phase of creative externalization in the form of discrete individual innovations, which cause disruptions and contradictions in the activity; and finally culminates in the critical self-reflection and re-creation of the activity, again becoming the norm and being internalized in the next

cycle (Yrjö Engeström, 1999). The expansive cycle as the evolving activity system lies at the heart of Engeström's (1987) concept of "Learning by expanding". The concept of a learning activity proposed by Engeström's may be crystallized as learning by expanding.

2.1.4.6. Learning activity

> *The object of expansive learning activity is the entire activity system in which the learners are engaged. Expansive learning activity produces culturally new patterns of activity. Expansive learning at work produces new forms of work activity (Yrjö Engeström, 2001, p. 78).*

The essence of a learning activity is the production of a new activity structure (which would include new objects, instruments, etc.). The new activity emerges out of actions manifesting through the inner contradictions of the preceding form of the activity in question. The learning activity is the mastery of the expansion from actions to a new activity. Expansive learning is essentially a collective endeavor (Yrjö Engeström, 2001). This idea of learning as an activity system is rejected by some scholars (Holzkamp, 1983). Holzkamp (1983) suggests that individual and collective learning should be linked by "transgressing the boundaries of individual subjectivity through immediate cooperation toward the realization of common interests of collective self-determination against dominant partial interests—intersubjective relations in a definite sense reflect collective or rather societal subjectivity" (Holzkamp, 1983, p. 373, Roth & Lee, 2007 translation). Indeed, one of the *challenges facing second generation Activity theory is that in its reaction to the mentalistic notion of cognition, the pendulum might have been swung to far towards the collective side of the dialectic*, marginalizing human subjectivity, which is endowed with the capacity to generate new cycles of activity (Stetsenko, 2005). Learning activities are therefore dialectical processes which unite the individual and the social structure in mutual transformation. Furthermore, Engeström's representation of the activity system appears to prioritize a unidirectional form of artifact-mediated, object-oriented action; and therefore it is difficult to recognize the reciprocal influences that participants in a dialogue have on one another through the text that they co-construct (Wells, 2002).

> *Engeström (1999) posed the question: "Can we have sufficient shared understanding of the idea of activity to make it the cell of an evolving multivoiced activity theory?" (p. 20). While the ambitions of this theoretical stance are very impressive, its claim towards a full resolution of how different traditions can be integrated into a single theoretical system seems unrealistic. Our preference would*

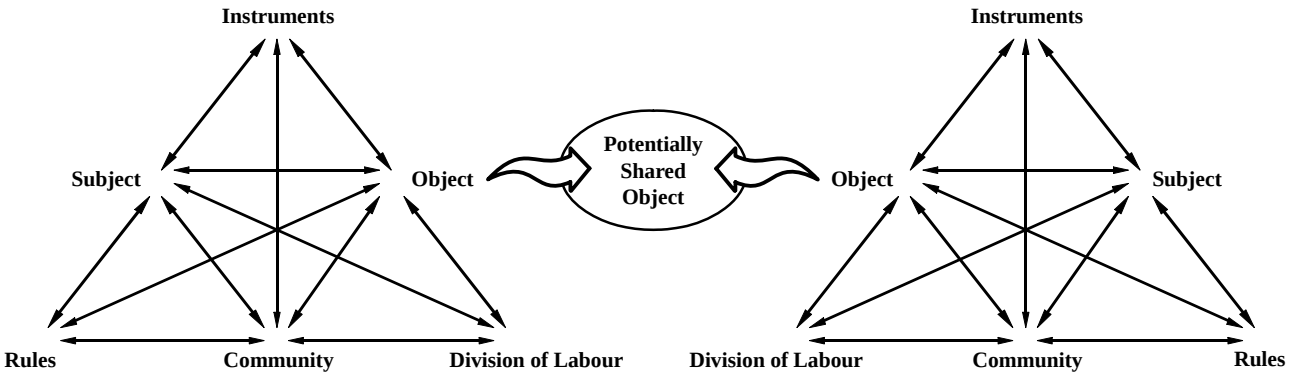
be to construct a set of interrelated theories which reveal richness at different levels of analysis (Minnis & John-Steiner, 2001, p. 310).

Engeström seems to anticipate these limitations of his activity system's triangular representation: "There are other kinds of communicative relations, typically those in which representatives of different activity systems interact. Those relations need further elaborations of the model, perhaps entirely new models" (Engeström, 1999, p. 32). Engeström suggests using multiple triangles to represent activities in networks and so address the above mentioned challenges facing his triangular representation.

2.1.4.7. Activity networks

When activity theory went international, questions of diversity and dialogue between different traditions or perspectives became increasingly serious challenges. It is these challenges that the third generation of activity theory must deal with. The third generation of activity theory needs to develop conceptual tools to understand dialogue, multiple perspectives and voices, and networks of interacting activity systems. In this mode of research, the basic model is expanded to include minimally two interacting activity systems (Center for Activity Theory and Developmental Work Research, 2003b).

Figure 9. **Two interacting activity systems as minimal model for the third generation of Activity theory (Yrjö Engeström, 2001, p. 136; Center for Activity Theory and Developmental Work Research, 2003b)**



In Figure 9, the object moves from an initial state of unreflected, situationally given 'raw material' to a collectively meaningful object constructed by the activity system; and then to a potentially shared or jointly constructed object (Yrjö Engeström, 2001). An activity system does not

exist in a vacuum, it interacts with a network of other activity systems (Center for Activity Theory and Developmental Work Research, 2003a). Figure 10 represents a central activity "broken up" in its constituting network of activity systems, revealing four levels of contradictions:

Figure 10. **Four levels of contradictions in a network of human activity systems (Center for Activity Theory and Developmental Work Research, 2003a; Yrjö Engeström, 1987)**

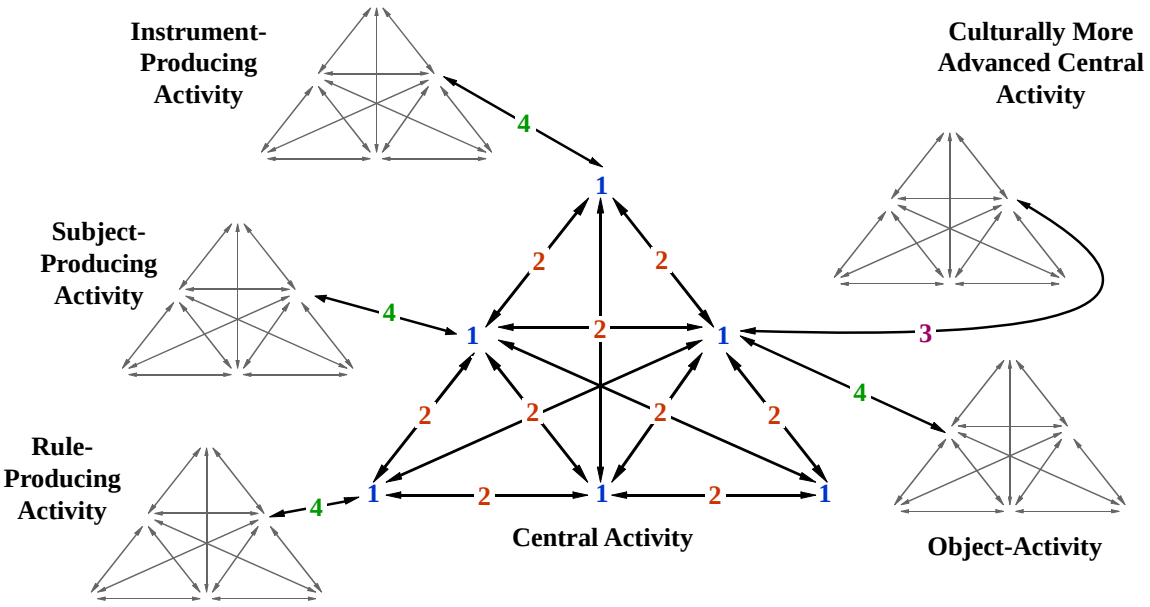


Figure 10 represents: Primary inner contradictions (1) within each constituent component of the central activity, Secondary contradictions (2) between the constituents of the central activity, Tertiary contradiction (3) between the object/motive of the dominant form of the central activity and the object/motive of a culturally more advanced form of the central activity; and Quaternary contradictions (4) between the central activity and its neighbor activities (Center for Activity Theory and Developmental Work Research, 2003a; Yrjö Engeström, 1987). Indeed, the consideration of the contradictions between activity systems drives the development of contemporary Activity theory. The most challenging of Activity theory's own contradictions is reconciling the view of human development as being a profoundly social process, with the view of individual subjectivity and agency making the process of human development and social life possible (Stetsenko, 2005); however, this has been Activity theory's object since its first conception. "More than ever before, there is a need for an approach that can dialectically link the individual and social structure. From its very beginnings, the cultural-historical theory of activity has been elaborated with this task in mind" (Yrjö Engeström, 1999, p. 19).

It is clear that Activity theory cannot be viewed as a master theory or quick fix, for true to its origins, it is subject to its own contradictions; and is compelled to update, transform, and renew itself constantly, so as to become a reflection of its own object (Roth & Lee, 2007). This reflexivity provides Activity theory with a critical advantage over all the other approaches and perspectives considered in this text. This text has explicated the ontological perspectives underlying learning, to reveal postmodern constructivism and the social learning theories, as an alternative to the rational objectivistic model of learning, which has been dominant in the West. Considering Activity theory in light of the other social learning theories, this text has shown that Activity theory provides a stable yet flexible framework for understanding human activity and practice. Activity theory overcomes the myopic focus of situated cognition by identifying the relatively persistent structure of the activity as unit of analysis, which can span situations. Activities are identified by their object, yet provide flexibility through its constituent actions and operations, which enable activities to dynamically change and transform according to the situation (Nardi, 1995b). Activity theory also overcomes the critical omission of human intentionality made by distributed cognition, by identifying activities according to their "objectified motives", i.e. object-relatedness.

Learning, defined as learning activity, is clearly a dialectical process which unites the individual and the social structure in mutual transformation. Activity theory has the potential to unite individual learning and social-cultural development, in a unified theory of mind, from a historical perspective. However, this remains the target and object/motive of the practice of Activity theory. For this reason Activity theory still remains on the right side of the two ontological perspectives represented in Figure 2. Notwithstanding, Activity theory provides the most developed and productive framework from which to analyze, describe and evaluate learning as process. Activity theory achieves this by virtue of its unique conception of cognition as object-related (Stetsenko, 2005). Activities are identified by their object, whilst actions and operations can change according to the activity's situation (Nardi, 1995b). Activity theory's unique conception of object-relatedness enables the analysis and comparison of a learning activity occurring in different situations. By using Activity theory, this text is able to compare a learning activity, which occurs in the classroom to a learning activity which occurs in a virtual world, on the basis that these two activity's objects are the same. From the perspective of Activity theory if the object of two learning activities is the same, the comparison is of the same activity occurring in two situations. However, before this text can attempt such an analysis and comparative evaluation, it needs to explicate what it means by a virtual world and the larger cultural phenomenon of Virtual Reality.

2.2. Virtual reality

The domain of computation has also been caught up in the postmodernity of the last century. The computer has been transformed from a linear, logical, hierarchical, command driven calculating machine to a fluid, decentred, nonlinear and opaque system (Turkle, 1995). Virtual reality, worlds and simulations epitomize this new paradigm of computing and embody the central themes of postmodernism. It is not surprising that Turkle (1995) suggests that they are helpful *objects-to-think-with* about postmodernism. The encompassing concept VR will be considered before its more specific embodiment in virtual worlds; as utilized in the research for this text. Virtual Reality (VR) like learning is inherently multidimensional (Bricken, 1990) and therefore inherently complex. VR consequently means a great many things to a great many people. VR is a fantasy, a technology, an experience, a medium and a social construct. VR exist between these dimensions and is shaped by the myriad of influences these dimensions contribute.

> *Virtual Reality is an assemblage of technical developments and social practices. The technology and what it allows users to do inflects their grasp of embodied perceptual processes, what we mean by experience, and how users make meaning of the world around them within cultural contexts that necessarily impinge upon sense-making and its component physiological processes (Hillis, 2006, p. 347).*

Coming up with a concise definition of VR is challenging and at times it seems that it is hard to describe what VR is not (Kommers & Zhiming, 1998). What makes defining VR even more difficult is that VR is still evolving. As with all bleeding edge constructs it is difficult to predict, control and understand the full impact of VR (Lauria, 1997). The full impact of VR on society and our thinking will only become apparent once VR has become a fully integrated part of our culture. We are starting to see signs of this happening in the proliferation of video games, massively multiplayer online games (MMOG) and virtual worlds in our popular culture. VR has taken hold of our cultural imagination through fantasy books like “Neuromancer” (W. Gibson, 1984) and “Snow Crash” (Stephenson, 1992), comics and films, like “The Matrix” (Wachowski & Wachowski, 1999) and “The Thirteenth Floor” (Rusnak, 1999); which blur the distinction between virtuality and reality. Although it is difficult to predict where the VR phenomenon is heading, we do have a good idea where it all started. VR starts with a fantasy.

2.2.1. VR as fantasy

The movie "The Matrix" (Wachowski & Wachowski, 1999), probably the most famous film to popularize VR, provides telling clues to the origins of the fantasy of VR. The movie echoes deep metaphysical themes and questions haunting theories of perception and epistemology from the time of antiquity. In the film, when Neo is released from his prison and made to grasp the truth of his life and the world, this account captures the turning point in the 1999 film, and yet it is drawn from an image crafted almost 2500 years ago by the Greek philosopher, Plato (400 BC) in his allegory of the cave (See 2.1.1.2) (Partridge, 2007). When Morpheus is preparing Neo for his exit from the Matrix, he asks him: "Have you ever had a dream, Neo, that you were so sure was real? What if you were unable to wake from that dream? How would you know the difference between the dream world and the real world?" This very argument was used by Descartes in his First mediation (See 2.1.1.3). Descartes performed a similar thought experiment; however, relying on his imagination, conjuring a malicious deceiver tricking the senses rather than through the technological wizardry imagined by the Wachowski brothers. Jean Baudrillard's classic metaphor "the desert of the real" (Baudrillard, 1998) is also exploited in the movie to represent a empty reality where the map of the landscape (the simulacra) has replaced the original territory and all that remains of it is a empty desert.

VR is part of the rationalist fantasy of capturing and representing reality. It can be traced to Plato's "Theory of Forms" (See 2.1.1.2), which is ultimately the desire and fantasy of revealing the true "form" (representation) of reality, revealed through the metaphor of sun illuminating the world, i.e. reason (light) revealing truth. This rationalist metaphor of light is resurrected today, in the light shining from computer displays and HMD's, revealing the fantasy of a new cyborg transcendence and enlightenment (Hillis, 2006). VR like countless media before it attempts to get past the limitations of representation to achieve the real. The age old metaphysical desire for "direct unmediated perception" also emerges in HCI in the notion of a "transparent" interface (Winograd & Flores, 1986). The notion of "direct manipulation" also suggests that the goal of good HCI is to develop of applications which renders the interface cognitively imperceptible (E. L. Hutchins *et al.*, 1985). Matthew Lombard and Theresa Ditton (1997) explicitly define the aim of VR as presence, the "perceptual illusion of nonmediation". VR is the clearest example of the logic of transparent immediacy and has become a cultural metaphor for the ideal of perfect mediation (Bolter & Grusin, 1999). Although VR starts as a technological innovation, aimed to fulfill the age old rationalist fantasy of representing reality, it does not remain here. VR has clearly evolved into a cultural object. This text will however start its exposition with VR as technology.

2.2.2. VR as technology

VR is typically defined as a computer technology that presents sensory information and feedback with the intention of producing a convincing illusion that the user is immersed in an artificial world inside of the computer (Rheingold, 1991). Virtual reality is therefore sometimes termed "immersion technology", a highly sophisticated level of human- computer interaction. Special stereoptic helmets or Head Mounted Displays (HMD), produce binocular images before the eyes of the participant and allow the position of the participant's head to be tracked so that the images of a three-dimensional scene can change according to his or her movements (Coyne, 1994). Various devices such as the magic wand (control pointer), three-dimensional mouse, data glove and haptic devices simulate the touching, moving and feeling of virtual objects; and with this technology one can move through and manipulate the 3D environment (Brand, 1987).

Reputedly the term “Virtual Reality” had first been coined by Jaron Lanier (Burbles, 2004), CEO of Virtual Programming Language, Inc. Lanier’s company produces and sells HMD’s data gloves, VR software and authoring tools (Krueger, 1991). It is not surprising that early VR research had predominantly focused on the peripherals and technology. In an attempting to engineer the most efficient and realistic interfaces and displays. Proponents of the view of VR as technology stress the criterion for VR should be stereoscopic technologies that simulate binocular 3D; i.e. HMD or polarized projection walls. These systems are very expensive, difficult to operate and often plagued by technical problems. However, without these technological innovations VR would have stayed within the domain of fantasy and thought experiment. However, there exists folly in defining VR purely in terms of technology (Steuer, 1992). In quite practical terms, in our world of rapid innovation and technological development only one thing is constant, namely change. Today’s VR technology, software and hardware are bound to be innovated and changed.

Defining VR in terms of stereo technologies is particularly problematic for this research project since it has political implications, namely that of access. One of the aims of the Collaborative African Virtual Environment Systems (CAVES) projects was to research and develop VR for the general public. If VR is defined in terms of expensive stereo hardware it is placed out of reach of the general public and even more critically researchers doing research in the context of South Africa. Interestingly the researchers that promote this definition of VR are largely from universities and research institutions from the more affluent countries, which have access to the technology they define VR by. *It is the contention of this text that the South African context offers a unique perspective on VR, in particular the importance of defining VR in cost effective and accessible terms.*

The South African context forces researchers to be innovative and find solutions to enhance the VR experience using other means than expensive interfaces. This becomes advantageous particularly when the aim of the research goes beyond the purely technical dimension of VR. If the aim is to explore the application of VR for learning and collaboration, providing access to multiple users through low cost VR becomes even more essential. VR systems need to be cost effective and accessible for use in collaborative (multiple systems) and educational settings.

The restrictive technological definition of VR has lead to much disillusionment and even led some researchers to conclude that despite much excitement VR research and development it has delivered far less than it has promised (Bryson *et al.*, 1994; Oliveira *et al.*, 2001). It is the aim of this exposition of VR to show that this pessimism can be attributable to the restrictive definition of VR as only a technology. It will be conceded that the preoccupation with the technology of VR was necessary for practical innovations to take place, so that the technology can disseminate through to researchers who might seek more than technical fidelity from VR. For these people the purely technological definition of VR is restrictive and does not capture the meaning or potential of VR (Latta & Oberg, 1994; Riva, 1999; Steuer, 1992). VR as technology might not live up to our rationalistic fantasies; yet still surprise us when considered from the perspective of VR as experience.

2.2.3. VR as experience

According to the phenomenology of VR what is key is the inclusive relationship between the participant and the virtual environment, where direct experience of the immersive environment constitutes communication (Bricken, 1990; Lauria, 1997). Presence, the feeling of "being there" is considered central to teleoperation and VR endeavors, and has been since its conception (Minsky, 1980; Zahorik & Jenison, 1998). Film critic André Bazin used the term *presence*, in his landmark book "Qu'est-ce que le Cinéma" (What is Cinema?) (Bazin, 1958), to describe the film viewer's sense that he is within the spatial/temporal continuum as the screen (Katz, 1991). Presence, the "perceptual illusion of nonmediation" (Lombard & Ditton, 1997), has become a important criterion whereby many researchers define VR (Steuer, 1992). The term presence offers some reprieve from the limitations of defining VR in purely technological terms. The term presence emphasizes the more experiential human side of VR. However, the term presence has far from clarified our understanding of VR. Instead of asking what constitutes VR and how is it evaluated we are now asking what determines presence and how can it be measured.

> *What determines presence? How may presence be measured? In the examination of these questions, comparison is made, often implicitly, to the notion of presence in real-world situations: the feeling of, as well as the physical facts of "being here". Though such comparison may at first glance seem to plant examinations of presence in teleoperation and virtual reality systems on firm theoretical ground, this is in fact far from true. Philosophers have toiled with just such questions as to the nature of existence in the world for centuries (Zahorik & Jenison, 1998).*

Presence, clearly relates to the ontological question of being (See 1.1.2), i.e. what is the nature of being and existence? It is therefore not surprising that the very same ontological and epistemological tensions explicated underlying learning, prevail in debates regarding presence. Again two camps emerge from their related ontological and epistemological commitments: “Rationalistic presence” based on the dualistic ontological perspective and “Dialectical presence” based on the non-dualistic ontological perspective.

2.2.3.1. Rationalistic presence

Current research in presence and VR subscribes, in one way or another to the rationalistic tradition (Hayles, 1993; Morse, 1996; Schuemie *et al.*, 2001; Zahorik & Jenison, 1998). This text earlier elucidated the ontological perspective of dualism which underlies the rationalist epistemology implied by Plato (See 2.1.1.2) and explicated by Descartes (See 2.1.1.3). In current presence research two types of measures have been proposed, namely subjective and objective measures (Schuemie et al., 2001; Zahorik & Jenison, 1998). Subjective measures aim to evaluate the subjective experiential dimension of presence, typically using rating scale questionnaires to collect and measure the presence experience. Objective measures in contrast aim to evaluate more “objective” measures of presence by observing the performance of some kind of task. This distinction between subjective and objective measures clearly stems from the dualistic orientation to differentiate between the subjective experience of mind and the objective world outside. In addition much of the current research in VR posits that presence is facilitated when the VR environment closely match the participants’ mental models and schemata. The rationalistic view that the objective world outside is internally represented in mental models is significant for VR formulation and evaluation. In order to construct and evaluate VR environments we need a description of these environments. Current VR environments are developed using the “language” of geometry and kinematics. Space is defined in terms of Euclidean geometry and the Cartesian coordinate system (*n-Space*). These descriptions have atomistic quantifiable parameters. Presence therefore depends on the transfer of enough information to

properly specify the geometry and kinematics of the particular environment being modeled (Zahorik & Jenison, 1998). This “correspondence view” of representation generates certain research interests, such as developing models (computer algorithms) to produce greater photorealism and techniques for storing, processing and presenting more detailed data. In this light, VR is a literal enactment of Cartesian ontology, cocooning a person as an isolated subject within a field of sensations and claiming that everything is there, presented to the subject (Coyne, 1994). For VR researchers and theorists who subscribe to the rationalistic worldview the quality of the VR environment and the evaluation of presence depends on the faithfulness of the reproduction of the characteristics of the objective world outside, i.e. technological fidelity.

This criterion however introduces an interesting problem regarding the existence of mental models and internal worlds. VR is not only utilized to give form to our understandings of the real world outside of ourselves, but also to represent and share imagined worlds. What about painterly aesthetic environments such as Ephémère and Osmose (Davies, 2003) whose aim is to communicate subjective experiences of intermingling: interior self and external world, of body and nature; purposefully blurring the Cartesian distinction between subject and object, mind, world and body. Participants in these environments responded surprisingly in terms of their emotionality, including euphoria and tears of loss (Davies, 2003). Such emotional responses are clear indications of presence. It would be difficult to account for these responses in an environment someone did not experience as “real” and were immersed in. How is it possible for people to experience presence in imagined and surreal environments such as Ephémère and Osmose if presence is constituted by closing the gap to the objective world?

Cyberphilosophy offer the only rational, yet peculiar explanation. The distance separating the objective world and the virtual world, marks a gap opening between "real" things and the simulated things, which although not really “real”, is still in some way real. Most supporters of the cyber movement accept the principles of ingenuous realism and merely ask that VR objects may be granted the same (ontological) rights of citizenship in "reality" that ingenuous realism grants to "natural" objects (Riva & Mantovani, 1999). These problems are the result of taking the rationalistic perspective of VR technology and presence to its logical conclusion. However, these problems can be addressed when VR technology and presence is considered from the more inclusive and relational perspective of dialectical presence based on the non-dualistic ontology.

2.2.3.2. Dialectical presence

The term VR only has meaning in a world where a true and objective reality exists and can be differentiated from its representation in a synthetic environment. For many VR researchers and theorist who do not hold the rationalist world view, the term VR is a misnomer (Burbles, 2004; Riva & Mantovani, 1999). In an attempt to come to a more inclusive definition of VR and measurements of presence, which does not fall into the restrictions imposed by the rationalist view, researchers have found the ontological treatise of Heidegger and the perceptual theory of Gibson invaluable (Riva & Mantovani, 1999). Heidegger (See 2.1.1.6) and Gibson (See 2.1.3.2) are considered in the exposition of this text as proponents of the non-dualistic ontological perspective. These theorists contributed to the cultural-historical perspective on learning and the dialectical materialist epistemology. Heidegger investigates knowing in terms of its ontological basis. Heidegger discards the rational atomistic descriptions of material things of Descartes (with weight, color, shape etc.), instead he insists that the nearest kind of association is not mere perceptual cognition; but rather, handling, using, and a taking care of things which has its own kind of `knowledge' (Heidegger, 1996). This knowledge, unique to our normal proficiency over everyday situations and activities is called by Heidegger: circumspection (Hayward, 2002).

Circumspection is Heidegger's term for the way in which "Dasein" (being-in-the-world) comports itself (acts) in its world (Schwartz, 2001). Through circumspection objects as tools can be conceived of according to their usefulness in relation to the action being performed. Heidegger terms this type of usefulness "readiness-to-hand" and shows how this term illustrates how equipment exists relative to the user and how use is determined by circumspection. When using a hammer under normal conditions, to hammer a nail for example, the hammer is "ready-to-hand". The action of hammering prohibits the user from having a stable representation of the tools use in action and so renders the tool transparent to the user. The tool only becomes represented to the user once "break-down" occurs in the situation of use, i.e. when the hammer slips or breaks. The tool then ceases to be "ready-at-hand" and becomes "presen-at-hand" (Zahorik & Jenison, 1998). Heidegger therefore identifies action as precluding yet central to our stable representations of "Dasein" (being-in-the-world). Action is therefore necessary prior to knowledge. The temporary yet stable representations (knowledge) therefore become apparent, from the detached analysis of our condition of "throwness", or "break-downs" of tools previously "ready-at-hand". Contrary to rationalistic presence, sought by attempting to truthfully represent reality through correspondence, dialectical presence surface through action.

Gibson like Heidegger identified action as central to understanding the relationship between the organism and its environment. According to Gibson, the (natural) environment provides all the information necessary for the organism's ordinary activities. The environment is central, it affords to guide or prevent action through various levels and dimensions of information. The interaction is represented by a bipolar model incorporating the active organism and the environment. Gibson suggested "... the so-called feeling of reality that accompanies a percept is actually a result of the tests for reality that go along with active perception. Actually, they are tests for the existence of an external source of stimulation" (J. J. Gibson, 1970, p. 426). According to this suggestion presence, the feeling of "being there" or the "perceptual illusion of nonmediation" (Lombard & Ditton, 1997), is the epiphenomenon of successful action in the environment. Presence is a by-product of successfully perceiving and acting on the affordances in the environment. This then lead Zahorik and Jenison to their unexpectedly simple working definition of presence: "Presence is tantamount to successfully supported action in the environment" (Zahorik & Jenison, 1998).

The key for developing VR environments that facilitate the inclusive relationship between the environment and participant (presence) is action. Dialectical presence can therefore also be called relational presence. We can think of this relationship as a feedback loop between the participant and the environment. When the participant interacts with the virtual world and the feedback the participant receives back from this environment is consistent with the participant's evolved perceptual system, the participant experiences presence. According to dialectical presence the ecological perception-action coupling is thus the key to understanding presence and designing efficient VR environments. VR systems should accordingly be described and specified in terms of perception-action couplings. Since our perceptual systems have evolved in the "real world" it is a good benchmark for evaluating perception-action couplings in virtual worlds. The "real world" here should not be confused with the "objective" real world of the rationalists. Relational or ecological presence depends on questions like: "Can users accomplish the tasks they accept? Can they acquire the necessary information? Do they have the necessary control authority? Can they correctly sequence their subtasks?" (Ellis, 1996). Instead of focusing our attention on the quality of image and other measures of evaluating the fidelity of our VR environments, the attention shifts toward facilitating the actions of the participants in them. For a dramatic example of the potential, action has as a motive force when interacting in a virtual world, we have just to look at the economic success of the Nintendo Wii, the top selling games console world wide (P. Miller, 2007b; Snow, 2007):

> *"Thumb candy for dummies". That's how, in 2003, Time magazine described Nintendo President Satoru Iwata's conviction that what consumers really wanted out of video games was simpler, more accessible entertainment -- not the photorealistic graphics and massive online worlds that the company's competitors were chasing. Less than four years later, the machine that Iwata built around his controversial strategy is the world's top-selling game console (Kohler, 2007).*

Physical movement is the major method of interacting with the virtual world generated by the Wii console. The Wiimote is the motion-sensing remote of the Wii console. Its movement is tracked by the console and translates to objects that users can manipulate in the virtual world; for example to swing a bat or sword. This method of interaction closely matches the evolved human perception-action coupling for such activities. Researchers are already exploring the possibility of utilizing the Wiimote for building training simulators in the MMOG Second life (Mollman, 2007). Indeed, what makes VR unique in respect to other older media is that the user needs to act to be able experience of the virtual space.

> *Film theorists have taken this immobility to be the essential feature of the institution of cinema. Anne Friedberg wrote: "As everyone from Baudry (who compares cinematic spectation to the prisoners in Plato's cave) to Musser points out, the cinema relies on the immobility of the spectator, seated in an auditorium"...On the one hand, VR does constitute a fundamental break with this tradition. It establishes a radically new type of relationship between the body of a viewer and an image. In contrast to cinema, where the mobile camera moves independent of the immobile spectator, now the spectator has to actually move around the physical space in order to experience the movement in virtual space (Manovich, 2001, p. 108-9).*

The aim of VR according to dialectical presence is not to get VR to represent objective reality, but rather to facilitate activities and human praxis. The aim is therefore not explicitly to hide the mediation of the activity and engender the experience of presence, but to facilitate the mediation between the user, other participants and the virtual world. Presence, the “perceptual illusion of nonmediation” (Lombard & Ditton, 1997), is a useful subjective indicator of the success of this mediation; however, this is an effect (Gibson’s epiphenomenon) and should not be the explicit goal. With use, all tools that successfully mediate our action will become “ready-at-hand” creating the “perceptual illusion of nonmediation”. Gibson’s perceptual theory acknowledges that the environment also includes other organisms, places, and events; however, he was primarily interested in the perceptual system of individual organisms and the relationship between them and the

environment. When considering human existence we have to acknowledge that things become somewhat more complicated. People exist in, interact with and construct their social and physical environments. Humans go far beyond the simple interaction between organism and environment as described by Gibson in his perceptual theory.

2.2.4. VR as culture

In order to consider VR and presence in terms of the culturally mediated environment, the valuable insights afforded by Gibson and Heidegger need to be expanded. Socialized action does not consist simply of the interaction between individuals in the environment. Social action is a complicated web of diverse actors, interacting on a shared environment, using shared objects both physical and conceptual, in an attempt to negotiate their individual and often competing needs. Shared reality, both natural and computer generated, is produced by the encounter between specific contexts and specific, structured, human communities equipped with their own cultural tools, representational systems, artifacts, media, roles, rules, myths, rites, values, etc. (Riva & Mantovani, 1999). How can we expand the ecological conception of presence, as successfully supported action in the environment, to include this socio-cultural context?

In our shared environment of multiple actors cultural reality is inherently ambiguous. Not only do the needs of individual actors differ, they are often in conflict and vary over time, even within the actors. What is real for one person is not the same for another and even the individual's notion of reality can change. The resources and information offered to us through the environment also transforms over time and are influenced by the interaction of multiple actors. The reason for the ambiguity of everyday situations therefore is the result of both the changing interests of the person and the equally changing affordances offered by the environment. How is it then possible that humans perceive and successfully interact with one another and the environment? According to cultural psychology the way we perceive and experience our environment (physical and social) is sustained by a framework that preexist individual interactions and make them consistent, namely Culture (Cole, 1996). As with learning, Cultural-historical Activity Theory (See 2.1.4) offer the oldest and most developed framework for considering human activities in contexts of virtual worlds. Activity theory's dialectical materialist epistemology is inherently pluralistic.

According to this text, all human reality is a cultural construction and hence also virtual, i.e. not rational objective reality. Virtual reality is therefore another cultural context, albeit computer generated and mediated. Learning in VR is consequently as legitimate as learning in any other

cultural context. Culture enables us to reduce the ambiguity of everyday situations by providing us with a shared cultural framework mediating our interactions with one another and the environment through shared artifacts (both physical and conceptual). The ambiguity of reality is reduced by the opportunities for social negotiation of these cultural tools, norms, conventions, roles, etc. Like Gibson's concept of affordance, these shared frames or contexts make a more concrete and meaningful social reality (environment) available to us. However, unlike Gibson's ecological approach this text recognizes that all of human experience is culturally mediated, always immersed in social contexts, ambiguous and changing; and only given continuity and stability through cultural constructs (artifacts, etc.) which mediate human practices, for example communication, negotiation and the construction of shared representational systems (Riva & Mantovani, 1999). Lev Manovich (2001) in his seminal book entitled "The Language of New Media" refers to these shared representational systems as cultural interfaces. Manovich (2001) argues that as the production and distribution of all forms of culture become computer based, people increasingly have to "interface" with culturally encoded data (photographs, films, virtual worlds, etc.) and not simply the computer. Cultural interfaces enable the representation and manipulation of cultural data and they are fundamentally fused components of older, already familiar cultural forms (Manovich, 2001):

> *Another feature of cinematic perception which persists in cultural interfaces is a rectangular framing of represented reality. Cinema itself inherited this framing from Western painting. Since the Renaissance, the frame acted as a window onto a larger space which was assumed to extend beyond the frame. This space was cut by the frame's rectangle into two parts: "onscreen space," the part which is inside the frame, and the part which is outside... Just as a rectangular frame of painting and photography presents a part of a larger space outside it, a window in HCI presents a partial view of a larger document. But if in painting (and later in photography), the framing chosen by an artist was final, computer interface benefits from a new invention introduced by cinema: the mobility of the frame (Manovich, 2001, p. 80-81).*

VR can be defined as a representational system or cultural interface, which aims to afford new opportunities for human praxis and meaning making, by mediating activities and actions. Presence consequently is tantamount to successfully supported action in the socio-cultural context of VR. VR is thus defined as a cultural construct, artifact and representational system which mediate social reality. VR and presence can be evaluated on the merit of supporting human praxis (cultural practices). What is of cardinal importance is to make VR accessible to large communities. Only then will VR fall into the right hands and applications. Defining VR in accessible terms is therefore of

great importance to the future of VR. Virtual worlds such as Second Life, with "31,000,000,000 registered users" (Arrington, 2007) and counting, clearly represent the technology with the greatest potential for realizing accessible VR at this moment in time. *This text consequently views learning in a virtual world in cultural-historical terms, from a non-dualistic ontological perspective.*

2.3. Learning in virtual worlds

This text started by explicating the concept of learning by examining the ontological development of western thought over the last 2500 years to illuminate two competing perspectives of learning: individualistic learning (mental representations) based on the dualistic ontology and social learning (human development) based on the non-dualistic ontology. This historical view reflexively led to Cultural-historical Activity Theory, which was identified as the most appropriate framework for considering learning as a developmental process, dialectically reciprocating between the individual and society. This text further illustrated that the same ontological tensions underlying learning, underlie two different views on VR. Indeed, ontology as the study of being considers the nature underlying reality and ontology is therefore key to understanding VR. The two ontological perspectives support two fundamentally different views of VR: Rationalistic VR based on the dualistic perspective and Dialectical or Relational VR based on the non-dualistic perspective. This text does not define VR as a technology which aims to fulfill the rationalist fantasy of representing the world, by seeking presence through VR's correspondence to objective reality. Rather, VR is understood to be a representational system, like film; which aims to afford new opportunities for human praxis, by relating people to a shared cultural interface and so mediating human meaning, activities and actions.

From the perspective of the individualistic theories of learning and cognition, VR enables the externalization and manipulation of mental models and so the objectification of reasoning; however, this perspective is based on the rationalistic assumption of the isomorphism of mental representations and operations with external visual transformations (Manovich, 2001). From the social learning theories perspective, VR is a cultural artifact which facilitates social interaction. Higher psychological functions result from the internalization of such interpsychological or social interaction (Vygotsky, 1981). *This text aims to unite these two perspectives by transcending their oppositions through the dialectical notion of activity theory's learning as an expansive cycle, i.e. the learning activity. For the practical purposes of the research for this text the collaborative group will be presented as the most productive unit of analysis for the learning activity.* Indeed, VR is an object

which mediates between the individual and society, both externalizing cognition and internalizing human practice. *Activity theory is clearly the most appropriate and productive framework for understanding and evaluating learning in a virtual world.*

Despite many authors illuminating the educational and research potential of virtual worlds, educational research involving the use and effectiveness of these innovative technologies is in its infancy (Baum *et al.*, 2004; Hansen, 2008; Kirriemuir & McFarlane, 2004; Steinkuehler, 2004). As noted at the beginning of this chapter, one of the challenges facing the nacescent research field of virtual learning is that it lacks clear definitions, frameworks, approaches and methods. Defining the learning component is notoriously difficult as there is a wide range of perspectives on learning and consequently theories of how learning occurs (Roussou *et al.*, 2008). This complicates the search for relevant related research, as the search terms “learning”, “virtual” and “world” produces a large number of diverse results. However, having identified “activity theory” as the most appropriate framework, and using it as search filter, significantly contributed to improving the accuracy of finding relevant research. The most relevant research papers found will be briefly discussed.

In their paper Kaptelinin & Cole (1997) employs the conceptual system of Activity Theory to explore the nature of learning in the “Zone of Proximal Development”. In their analysis they draw on empirical evidence from the "Fifth Dimension", an after school setting where collaborative learning is organized around computer game play. They propose that learning is determined by the interplay between individual and collective activities and that the mechanisms underlying the influence of social context on learning and development are mutual transformations between these levels of activity. This perspective is associated with Vygotskian notions of "inter-psychological" functions and the "Zone of Proximal Development" (Kaptelinin & Cole, 1997). Although this paper credibly illustrates how games and simulations mediate between the individual and group learning activities, it focuses on existing leisure games as do the majority of educational studies focusing on virtual worlds (de Freitas & Oliver, 2006; Gee, 2003; Squire, 2005).

Marsh’s (1999, 2001) paper adopts Activity Theory as framework to devise a model of evaluating interactions within VR. He also introduces the concept of “breakdown in illusion” to categorize contradictions in interactions within VR leading to a reduction in presence. This research paper focuses on Leontiev’s (1978) hierarchical model of activities, to develop evaluation guidelines for VR. Evaluation guidelines for the design of the “perceptual illusion of nonmediation” experience are proposed and applied to usability problems detected in an empirical study of a head-mounted display (HMD) VR system. This study shows that the guidelines devised from activity theory are

effective for the usability evaluation of VR. However, the evaluation is aimed at evaluating usability of the VR system and it does not evaluate the activity within the virtual world nor learning taking place. The evaluation furthermore only utilizes Leontiev's (1978) hierarchical model of activities and does not utilize the full scope of Activity theory in its application, i.e. the activity system, etc.

In their article Barab et al. (2002) use activity theory to illuminate how their Virtual Solar System course supported the emergence of actions that transformed objects through which students developed astronomical understanding. The transformative objects utilized in the course are 3-D models of different aspects of the solar system produced by the students on average desktop personal computers using CosmoWorlds a virtual reality modeling language (VRML) editor (Barab *et al.*, 2002). Their research demonstrates the usefulness of activity theory for understanding learning activities with virtual objects; however, the learning activity was still taking place in the classroom, despite being supported by the activity of constructing virtual objects.

The Mwanza, D., & Engeström, Y. (2003) paper illustrates how theoretical and pedagogical perspectives can be incorporated into the systems development process, of abstracting design requirements for an e-learning environment by applying activity theory to the Lab@Future project. Lab@Future focuses on leveraging educational use of ICT by exploiting advancements in virtual reality, 3D and mobile technologies to produce innovative tools to support teaching and learning activities in participating European high schools (D Mwanza & Engeström, 2003). This research illustrates how activity theory can be productively used in the specification of requirements for virtual worlds aiming to facilitate learning; however, it does not provide any insight into using activity theory to meet these requirements in a design, nor how to evaluate the learning taking place in virtual worlds.

Sara de Freitas & Oliver (2006) develop an evaluation framework based on activity theory to help address this gap in the current research literature. They argue that despite it being established that it is possible to learn from games and simulations, there is still the question of how such resources can form part of curricula. Their paper aims to address this shortcoming by introducing a framework for helping tutors to evaluate the potential of using games- and simulation-based learning in their practice. Their aim is to support more self-directed and differentiated learning by developing more critical approaches to this form of interactive content. The benefits are illustrated in two case studies, including *MediaStage* a simulation software tool that allows learners to write text, choose characters, build 3D stage sets and direct action, including gesture, speech and movement of the characters or avatars. This paper highlights the need for a framework to evaluate learning in virtual

worlds. The authors acknowledge the relationship between their framework and Activity Theory; and illustrate how their framework can be mapped onto the triangular representation of an activity system (de Freitas & Oliver, 2006).

Nardi et al. (2007) examines the learning culture in a popular online game "World of Warcraft" by analyzing the way players learn this complex game through chat conversations with peers. The paper further investigates learning in the zone of proximal development as specified in cultural-historical activity theory. The paper reports to find evidence of a zone of proximal development in conversations of the participants of the MMOG "World of Warcraft" (Nardi et al., 2007). However, Nardi et al. (2007), like Marsh's (2001) does not consider the full scope of Activity theory in her analysis of the online interactions. She does not make use of the activity system to provide a detailed account of the learning activity and as most of the educational studies in the virtual world domain; the study focuses on an existing leisure game.

Sherlock's (2007) article also considers applying activity theory to the popular online game, "World of Warcraft". However, he focuses his analysis on the activity of "grouping". "Groups are formed through specific interfaces in the game that enact social networking processes and can be examined comparatively alongside web-based social networking technologies" (Sherlock, 2007). By looking at these interfaces through the lens of activity theory, the article identifies how grouping as an activity is mediated, and what social expectations are put in place when players participate in groups. This is an insightful analysis illustrating how activity theory and activity systems can be used to understand and communicate how activities are mediated through a virtual world; however, the activity considered is not a learning activity.

In the work of Barr *et al.* (2006) the activity system and hierarchy are utilized to analyze the structures of a game play activity, as well as decomposing it into actions and operations. They argue that a central feature of video games is that they contain value systems and activity theory is thus linked with concepts of value. They use activity as their primary means for describing conduct in video games, i.e. applying activity theoretic concepts and models to game play in order to decompose it and examine the relations present. This result in a detailed description of the user-interface of a particular game, culminating in assessments of the kinds of values the activity supports and promotes through its structure (Barr *et al.*, 2006). The paper focuses on studying contemporary single-player leisure games, to illuminate the role of values emerging from interacting with a video game and its interface specifically, rather than players playing the same game together. Furthermore, the study

observes the results of learning, rather than the learning process itself, which Barr *et al.* (2006) regards as extremely time consuming.

Roussou's (2004a, 2004b, 2008) exploration of children's interaction in immersive Virtual Environments (VEs), focuses on the role and the effect of interactivity on learning and conceptual change. Her intention is to examine how interaction and conceptual learning are related in the context of virtual environments, developed primarily for informal educational settings. She utilized activity theory for the evaluation of user behavior in immersive virtual environments. A set of exploratory studies was carried out with children in an immersive stereoscopic VE. Roussou (2008) describes the analysis of these exploratory case studies from an activity theoretical perspective and reports that the main contribution of this analysis is the formulation of the understanding that learning occurs through particular types of interaction. Although this study demonstrates the usefulness of activity theory, to identify manifestations of learning through the examination of critical incidents or contradictions; Roussou's (2008) suggests that the data gathering methods requires enhancement to include a range of methods to provide evidence of task learning and conceptual change (Roussou *et al.*, 2008). This is understandable as activity theory has been developed to understand human practice in context, rather than conceptual change.

These relevant research papers demonstrate the usefulness of activity theory as a descriptive framework for facilitating our understanding of learning and other activities in virtual worlds (Barab et al., 2002; Kaptelinin & Cole, 1997; Nardi et al., 2007; Roussou, 2004a, 2004b; Roussou et al., 2008; Sherlock, 2007); and how it can be used productively in the design (D Mwanza & Engeström, 2003) and evaluation (de Freitas & Oliver, 2006; Timothy Marsh, 1999; Tim Marsh *et al.*, 2001) of virtual worlds to facilitate learning and other activities. Despite the growing interest and research in learning in virtual worlds their still remains a great deal to be done. There are no established methods for the study of learning in virtual worlds from the theoretical perspectives of activity theory and constructivism (Roussou *et al.*, 2008). The research methodology that emerged from the research studies explicated in this text have much in common with the research methods employed in the studies of Barab et al. (2002) and Roussou's (2004a, 2004b, 2008). This text does not claim to develop an established method, as this would be a major project and beyond the scope of this text. However, this text acknowledges that such methods need to be more systematically formulated and standardized and hope to be making a small contribution in this direction (See 4.3.3.4 and 5.4.4).

Having established that it is possible to learn from existing games, there is still the question of how learning can be designed as to recognize particular contexts and the value systems that shape

them (de Freitas & Oliver, 2006). There is a need for virtual worlds specifically developed for custom educational contexts and consequently frameworks for the design and evaluation of such virtual worlds. *The research explicated in this text aims to contribute to this growing body of research by developing a methodology for the design and evaluation of learning activities as processes within virtual worlds.* The relevant research papers also do not explicate the deep ceded theoretical basis for considering Activity theory as framework for the evaluation and understanding of learning in virtual worlds; nor do they *address the deep seeded evaluation challenge of the relativity of dialectical materialist epistemology underlying activity theory*. Indeed, how is learning evaluated from Activity theory's dialectical materialist position, which regards reality, truth and knowledge as pluralistic and relative in relation to the perspective taken? In the emerging culture of simulation it is impossible to unpack the overlapping simulations that are contemporary society in their totality, as the complexity of our organizations drive the need for simulations these very simulations create further complexity (Turkle, 1995).

> *The basic cognitive engine of virtual culture is the externalization of symbolic processing. Simulations function as virtual worlds in which students can "read" concepts experientially (Gee, 2004; Norman, 1993). In a theoretic culture it is possible to conceive of literacy as an interaction between tool and person: between the text and the reader or writer. However, new forms of reading and writing such as we find in videogames and other simulations require a degree of projection (or inhabitance) that makes it increasingly difficult to analytically separate person from tool (Shaffer & Clinton, 2006).*

In our contemporary virtual world we construct micro worlds, simulations and models to manage the complexity of the pluralistic reality. Virtual worlds which aim to facilitate learning activities can simulate cultural practices and so mediate between the individual and society, both externalizing cognition and internalizing human practice. We can use virtual worlds to raise our consciousness about the assumptions underlying the simulations and virtual worlds of our pluralistic reality (Turkle, 1995). *This text therefore proposes to conduct the comparative evaluation of a learning activity occurring in two situations, one in the classroom and one in the virtual world.* Activity theory affords this comparative evaluation, on the basis that an activity is identified by its object; and although the actions and operations will vary between these two situations, the activity occurring in different situations can be compared on the basis of its object. Activity theory further provides the necessary conceptual and representational tools to describe and comparatively evaluate the activity systems of the two situations. Learning will consequently be evaluated in the virtual

world by describing the learning activity system and comparing how it facilitates the learning activity in comparison to the same activity (same object) in the classroom (See 3.3.6). *This is a novel approach that aims to synthesize and expand on Vygotsky's historical approach and Engeström's (1987) expansive method; and so develop the novel dialectical method for designing and evaluating learning in a virtual world (See 3.3).* However, this development is the subject of the next chapter.

3. Dialectical approach

In the previous chapter, this text developed its Meta-theoretical framework by explicating the dualistic and non-dualistic ontological perspectives; and their respective epistemological systems: rationalist and dialectical materialist. This text further illustrated the impact of these philosophical tensions on contemporary learning theories and debates regarding virtual reality and virtual worlds. Cultural-historical Activity theory was then proposed as the most appropriate framework to understand learning in a virtual world. Following from the non-dualistic paradigm and dialectical materialist epistemology promoted in this text, Activity theory frames learning as a dialectical transformation between the individual, society and world; albeit virtual as in this text.

Choosing an alternative ontological and epistemological perspective to that, which has been dominant in the West for the last century, does not come without its consequences. Indeed, much of contemporary science and methodologies derive from rational assumptions seeking validity and objective knowledge about phenomena through the quantification, categorization and the elimination of alternate hypotheses. The dialectical materialist epistemology proposes a radically different understanding of truth and consequently science. *Clearly, the first methodological challenge is finding the appropriate methods for conducting research from a dialectical approach to science.* Dialectics is the philosophy of process, change and transformation and can be traced to Heraclitus' "doctrine of flux" (See 2.1.1.1), whereby the nature of reality is regarded as flowing, transforming and complex. Indeed, complexity is regarded an essential aspect of the process of reality's transformation (Bidell, 1988). This is a stark contrast to the "two world" nature of reality proposed by Plato (See 2.1.1.2) and explicated by Descartes (See 2.1.1.3) in his dichotomy between mind and matter. Descartes' rationalist epistemology posits that knowledge is derived from this division, since the true and unchanging form of the changing material world of appearance can only be revealed through the rational mind.

The Cartesian and Baconian traditions of the 17th century, referred to as the methodology of Cartesian reductionism (Levins & Lewontin, 1985), clearly extends Descartes divisions to the separation of all natural processes into their isolable parts for individual study. A growing number of natural scientists (Bohr, 1934; Levins & Lewontin, 1985), social scientists (Cole, 1996; Wertsch, 1985), and philosophers (Blumer, 1969; Rorty, 1979) are recognizing the limitations of scientific methods, which divide complex phenomenon into categories, while ignoring the relations between the artificially isolated parts. However, Cartesian reductionism continues to be the dominant

approach to scientific methodology; and at the heart of its success is the artificial division of processes into elements for out of context inquiry, which avoids dealing with the complex contradictory interrelationships inherent in them (Bidell, 1988). Such reductionism might be sufficient for the elucidation of general categories and laws of a Newtonian universe, however, when we are trying to understand more complex relational phenomena such as quantum physics and human nature we require an alternative methodology to science.

The dialectical approach to science therefore aims to overcome reductionistic approaches by accounting for complex phenomena as processes. Phenomena as processes are not regarded as static objects, they are constantly in motion, driven by the tension of opposing forces uniting the process through transformation (Allman, 1999; Au, 2007). The nucleus of dialectics is the unity of mutually exclusive opposites (Ilyenkov, 1977). This is clearly a contradiction from the perspective of formal logic; however, the dialectical approach offers its own logic. Hegel's systemization of dialectics (See 2.1.1.5) formulates a radical alternative to formal logic (Tolman, 1983). Formal logic abides by the "Law of Non-contradiction", whereby identity is based on the premise that no two things can be partaking in the same being. Clearly, this contradiction lies at the heart of dialectics; it presupposes the identity of processes from the contradictory relationship of their internal division, i.e. difference. Where formal logic is logic of stasis and reduces the world to a simplified picture; dialectical logic is logic of change and transformation and reveals the complexity of the word. Dialectical logic offers an alternative method for science. Human development is inherently complex and offers an excellent opportunity for the development of such a dialectical science and methodology.

> *There is no better example of the increased need to represent complex relationships than the recent history of developmental psychology. The dichotomies of continuous versus stage models, structural versus functional interpretations, domain-specific versus universal approaches, and vying metaphors, have led to increasing interest in finding ways to integrate various descriptions. The dialectical perspective offers a scientific approach to understanding phenomena in their complexity and in their relationship to one another, rather than isolated and competing phenomena (Bidell, 1988, p. 330).*

Giambattista Vico laid the foundation for this dialectical science 300 years ago with his "New Science" (Scienza Nuova, 1725/1968). Vico contested the Cartesian extension of the model and methods of natural science to studying human nature. He proposed that the study of humanity should be based on specifically human forms of interaction and understanding; i.e. a distinctive historical science (Cole, 1996). Hegel systematically devised dialectical logic, Marx placed Hegel

"back on his feet" with the articulation of the dialectical materialist epistemology and Vygotsky formulated his historical approach on these foundations preparing the way for Activity theory.

This chapter aims to develop a method for the design and evaluation of learning in a virtual world from the perspective of the non-dualistic paradigm, dialectical materialist epistemology and congruent with the dialectical approach to science. This is a challenging endeavor and this text will thus consider how Vygotsky had approached this challenge by taking into account his historical approach, unit of analysis and methods; in particular his double stimulation method. At the end of this exposition on Vygotsky's historical approach, insufficiencies in his approach will be identified and Engeström's expansive method will be explicated to overcome some of these challenges. *This text will then contribute a synthesis and expansion on Vygotsky's historical approach and Engeström's expansive method, to develop the novel dialectical method for designing and evaluating learning in a virtual world (See 3.3).*

3.1. Vygotsky's historical approach

Central to the science of dialectics is the study of "phenomena in movement", like a river is defined by the movement of water, dialectical science accounts for phenomena by their transformation. Since phenomena transform over time, the history of these transformations is key to the dialectical approach. *This text, like Vygotsky's historical approach, aims to utilize the dialectical approach to understand the complex phenomenon of human behavior, cognition and learning; and therefore: "the historical research of behavior is not an addition or auxiliary aspect of theoretical study but forms the very basis of the latter" (Vygotsky, 1966, p. 105).*

Vygotsky develops his dialectical materialist approach to the development of higher cognitive functions in response to the limitations of the then contemporary psychological theories and methodologies. The empirical psychology of Vygotsky's day regarded human behavior from the perspective of mechanical materialism and focused primarily on lower psychological functioning. The methodologies for studying psychological functions were extended from natural science to the study of humans. This approach is exemplified in the behaviorist stimulus response model of behavior and their reductionistic experimental methods. Where empirical psychology did consider the higher mental functioning of humans, this was assumed as quantitatively more complex than the lower functions but not qualitatively different. The idealistic psychology, also prevalent at this time in opposition to the empirical perspective, regarded the higher psychological functions as qualitatively different to other natural phenomenon. Human cognitive development could therefore

not be explicated by the naturalistic scientific methods, nor regulated by deterministic laws, and was therefore regarded unfathomable. Contemporary psychology at the time of Vygotsky could therefore not account for the development of complex behaviors and mental functions such as language acquisition, self-regulatory functions, etc.

Vygotsky's historical approach to the development of higher mental functions, provided not only a viable explanation for the development of complex higher cognitive processes, but also transcends the two opposing psychological perspectives of empiricism and idealism. Vygotsky agreed with the idealistic perspective that higher mental functioning in humans cannot be explained through "natural laws", however, he did not regard the development of these functions as inexplicable. Vygotsky (1966) comports: "Neither the eternal laws of nature nor the eternal laws of the sprit" reveal the development of higher mental functioning. He proposes another level of exposition for the development of these cognitive functioning based on the "historical laws". History is the key to the dialectical approach and Vygotsky's explication of the development of higher psychological processes.

> *Human behavior differs from animal behavior in the same qualitative manner as the entire type of adaptability and historical development of man differs from the adaptability and development of animals, because the process of man's development is part of the general historical development of mankind (Vygotsky, 1966, p. 95-96).*

Vygotsky is clearly expanding on the key notion of dialectical materialism developed by Marx and Frederick Engels: "that the human species differ from all others because, through its manipulation of nature, it frees itself from biological determinism and begins to fashion its own nature" (Scribner, 1997b, p. 244). How is it that the human species is able to manipulate nature and through this process produce itself? Unlike all other species humans do not interact directly with their environment (Vygotsky, 1978, 1981). Humans regulate their interaction with the environment, including other humans, through systems of objects, which stand in-between, or mediate human interaction with the world (Scribner, 1997a). Vygotsky expands Marx's (1977) description of the prototypical human activity of labor, mediated by tools and instruments, to the human intellect and behavioral processes. According to Vygotsky, human cognition is mediated by signs, just as human labour and behavior is mediated by tools. The development of cultural sign systems is the crucial historical moment when "lower" cognitive functions are transformed into "higher" cognitive functions. These "higher" psychological processes are qualitatively different, they are cultural

functions. According to Vygotsky this unique capability is the result of purposeful social activities and practices which develop historically giving rise to new resources and forms of culture. Human activities are culturally mediated through tools and symbols (See 2.1.4.2). These tools, symbols and practices develop over time, can span many generations and consequently have histories. Definitions of human nature and cognitive functioning cannot therefore be considered, without considering the cultural and historical development which produces these very definitions. Through cultural practices humans transform their environment, develop tools and signs and ultimately redefine their own human nature. Vygotsky introduces the term "cultural development" in his discussions regarding the development of higher cognitive functions (Scribner, 1997b). Cultural development is understood in historical terms and therefore implies a radical new unit of analysis for the exposition of psychology.

3.1.1. Vygotsky's unit of analysis

In a broad historical sense higher cognitive functions have their own origins and stages of development; however, in a more specific sense this history is embedded in the histories of real people and is therefore realized on two levels, namely individual and cultural histories (Scribner, 1997b). In the individual both natural (biological) developmental processes and social (cultural) developmental processes are conflated and occur together. Vygotsky preserves the term "ontogeny" from biology to describe this individual level of history; while reserving the term "phylogenesis" to refer to the more general cultural-historical developmental process, which displaces the biological (Scribner, 1997b). Vygotsky's historical approach to the development of higher mental processes aims to transcend the "nature" versus "culture" dichotomy, typical of the reductionistic approaches of natural science, by dialectically linking biology and culture through his cultural-historical developmental perspective and so reveal the transformative relationship between these two levels of historical development.

Vygotsky proposes a unit of analysis, which unites the two levels (ontogenetic and phylogenetic) of development, rather than isolating them in opposition. Importantly, Vygotsky is not proposing a unit of analysis of unmanageable scope. The Vygotskian concept of unit of analysis focuses on the elements of which the interrelationship and polar contradictions are most visible; and therefore it would be a mistake to debate the merit of one unit over another, since the nature of the unit is related to the content of the investigation (Bidell, 1988). Of crucial significance is that the unit of analysis includes a dialectical unity of opposing opposites, driving the transformation and development of the cultural-historical process under consideration. Vygotsky focused a large part of

his research on the unit of analysis of word meaning (Wertsch, 1985), since this process accommodates important sets of relations and contradictions including: action-meaning, internal-external and social-individual relations (Bidell, 1988). The natural and the cultural developmental processes are clearly united in a "common although complex process" (Vygotsky, 1966, p. 37) of mutual transformation. Although it is possible to rationally extricate these two levels of development through abstractions, this would reduce the substance of the relationship between the two processes. What is important about Vygotsky's unit of analysis is that it provides a base for a dialectical approach to science (Bidell, 1988). However, this radical approach requires new methods for doing research and the development of theory.

3.1.2. Vygotsky's historical method

Vygotsky's dialectical approach proposes the unit of analysis of processes rather than things or objects. With his historical approach to higher mental functioning, Vygotsky introduces a genetic perspective, with the aim of revealing the origins of human cognitive functioning and lying bare the causal, dynamic links of cognitive phenomena. Vygotsky like his contemporaries assumed that ontogenesis ends at adolescence, and therefore focused his attention on the early stages of the individual's cognitive development, i.e. child development. Vygotsky posited that higher cognitive functioning consist of the two interrelated developmental processes of ontogenesis and phylogenesis. Vygotsky aimed to reveal the development of higher mental functioning by utilizing both ontogenetic and phylogenetic histories; and illustrating how the development of these functions can be called forth in the laboratory.

> *The search for method becomes one of the most important problems of the entire enterprise of understanding the uniquely human forms of psychological activity. In this case, the method is simultaneously prerequisite and product, the tool and the result of the study (Vygotsky, 1978).*

Congruent with the dialectical approach Vygotsky's historical methodology does not regard theory and practice as dichotomous; rather these "oppositions" are united in the inclusive transformative analysis of higher mental functions. Vygotsky's historical method reciprocates between theory and practice. Sylvia Scribner (1997b) describes Vygotsky's method of theory generation by identifying four stages within its process. These stages will be explicated in the next four sub-headings.

3.1.2.1. Observe ontogenetic behavior

Vygotsky observed that within human behavior we find what he referred to as fossilized behaviors, i.e. behaviors which have become automated and do not change (Van der Veer, 2001). These "rudimentary forms" he regarded as remnants of behavior developed early in cultural history now operating as "living fossils" detached from the contexts that provided them with social meaning but valuable as prototypes for study (Scribner, 1997b). Vygotsky regarded these prototypes significant and suggested the need to go back to their earlier stages of development, to "liquefy" them in order to understand the true nature of their processes (Van der Veer, 2001). Vygotsky himself identified three such fossilized behaviors for analysis, namely: tying knots, casting lots and counting fingers. Each of which reveals the tripartite structure of cultural-historical behaviors, consisting of environmental stimulus-response and the cultural mediating object. Vygotsky regards these rudimentary behaviors as "key to higher behavior" (Vygotsky, 1966, p. 129), as they reveal the transformation of human nature through the development of symbolic means of self-regulating behavior. In the first stage of Vygotsky's method, the focus is on the ontogenetic level. Although these rudimentary behaviors are useful in elucidating the structural elements of higher cognitive functions and their primary symbolic mediation, these behaviors have been surpassed in modern societies through different symbolic mediational means; and these fossilized forms are therefore unable to reveal their own future (Scribner, 1997b). To discover how these rudimentary forms transform into new forms requires a phylogenetic level of analysis.

3.1.2.2. Develop a model of the phylogenesis of behavior

Vygotsky introduces evidence from ethnopsychology, revealing that from the more general cultural-historical perspective a recurring pattern of transformation of higher psychological processes becomes evident. External means of regulating behavior, such as tying knots and counting fingers become internalized through a series of stages, culminating with the person being able to regulate their behavior without these external means. Vygotsky hypothesized that this pattern of internalization could be a model for the development of higher cognitive functioning and could be applied to the formulation of cultural-historical theory at both ontogenetic and phylogenetic levels. Vygotsky makes the brilliant deduction that if this hypothesis is true the phylogenetic model could serve as a model to artificially elicit the development of higher psychological processes in the laboratory. Vygotsky (1978) sets out to reveal the transformation of rudimentary to higher psychological functions, by developing the experimental-genetic method (Scribner, 1997b), which he

refers to as “the functional method of double stimulation”. Vygotsky’s (1978) method of double stimulation aims to reveal the dialectical development of higher cognitive functions by altering “the automatic, mechanized, fossilized character of the higher forms of behavior” (p.64), i.e. ontogeny; “and turn it back to its source” (p.64), i.e. phylogeny.

3.1.2.3. Produce the behavior experimentally using the double stimulation method

The method of double stimulation was developed to aid the reconstruction of the developmental process (Van der Veer, 2001). In this method, the participant is typically placed in a problem-solving situation, i.e. presented with a simple stimulus. The task facing the participant in the experimental context is, as a rule, beyond their present capabilities and cannot be solved by existing skills (Vygotsky, 1978). The participant is then presented with a second stimulus (a mediatory object) which role is to help the participant organize their response and provides the means to resolve the problem. The second stimulus is neutral to the problem, i.e. it is not connected to the solution. Frequently it is possible to observe how the neutral stimulus is drawn into the situation and takes on the function of a sign (Vygotsky, 1978). When the participant selects and converts this neutral stimulus into a stimulus-means for resolving the problem, this semiotic uptake (Wertsch & Stone, 1989), reveals the developmental process of the higher cognitive function. Vygotsky regarded the double stimulation method as most fruitful, as it provides the richest and most essential evidence (Scribner, 1997b). The double stimulation method is aimed at uncovering the development of new psychological capabilities as these are transformed from the interpsychological plane to the intrapsychological (Van der Veer & Valsiner, 1994); and therefore is significant because "it creates the conditions under which a subject's course of action toward an experimentally given goal makes explicit the psychological processes involved in that action" (Valsiner, 1990, p. 66).

> *We regard our method as important because it helps to objectify inner psychological processes; stimulus-response methods are objective, but they are limited to the study of external responses that are usually in the subject's repertoire to begin with. We believe that our approach to objectifying inner psychological processes is much more adequate, where the goals of psychological research are concerned, than the method of studying preexisting, objective responses. Only the objectification of the inner process guarantees access to specific forms of higher behavior as opposed to subordinate forms (Vygotsky, 1978).*

Vygotsky (1978) does not limit himself to the usual method of offering the subject a simple stimulus to which a direct response is expected; rather in his method the participant is offered a

second stimulus that enable them to accomplishing the task by the aid of specific auxiliary means; and thus reveal the inner structure and development of the higher psychological processes. This is a radical innovation over the traditional reductionistic laboratory experiment of behaviorist psychology. The research question considered within context of the double stimulation method is also radically different. It requires a focus on the change process itself, i.e. how the person constructs a new understanding of the problem and comes to employ a new (semiotic) tool in dealing with it (Moran & John-Steiner, 2003). The dependent variable of Vygotsky's method is not an outcome, but rather the action sequence, that leads to such an outcome (Valsiner, 1990). Vygotsky's double stimulation method provides a way to provoke the developmental processes of higher cognitive functioning to occur right "before one's eyes" (Vygotsky, 1978, p. 61). However, Vygotsky did not assume that this success in the laboratory was conclusive evidence for proof of his experimental modeling of higher psychological processes. Vygotsky believed that the models revealed through experimental studies are of necessity schematic and simplified (Vygotsky, 1966, p. 221), as the experiment fails to mirror the genetic development as it occurs in life (Vygotsky, 1986, p. 69). It does not therefore reveal the actual development of higher systems (Scribner, 1997b). Vygotsky's historical method therefore returns to observations of daily life, to test the models of the development of higher psychological processes, exposed through the dual stimulation method.

3.1.2.4. Observe the real life ontogenetic development of behavior

The hypothesized model developed (See 3.1.2.2) is evaluated by comparing it to the observation of the real life ontogenetic development of the behavior. Vygotsky therefore returns to the ontogenetic level to corroborate or correct the model and finally disclose how higher cognitive functions are transformed through everyday activities (Vygotsky, 1966, p. 222). Scribner (1997b), however, points to certain inadequacies in Vygotsky's historical method, which may limit its applicability:

> *In Vygotsky's theory, this history appears as a single unidirectional course of sociocultural change. It is a world process that informs us of the genesis of specifically human forms of behavior and their changing structures and functions in the past… But for purposes of concrete research, and for theory development in the present, such a view seems inadequate. Societies and cultural groups participate in world history at different tempos and in different ways… Individual societal histories are not independent of the world process, but neither are they reducible to it. To take account of this*

plurality, the Vygotskian framework needs to be expanded to incorporate a "fourth level" of history - the history of individual societies (Scribner, 1997b, p. 259-260).

Michael Cole (1988) also acknowledges these deficiencies in Vygotsky's historical method, and proposes an elaboration of the cultural-historical methodology based on the analysis of research carried out by the Soviet cultural-historical school, himself and his American colleagues:

Overall, I see current progress in the development of the socio-historical school growing out of its cross-cultural research program as a process of combining the American emphasis on cultural context and the study of concrete activity systems with the Soviet emphasis on the mediated structure of higher psychological functions and the importance of history and political economy (Cole, 1988, p. 148).

In addition to her suggestion for extending Vygotsky's method to incorporate a "fourth level" of history, Scribner (1997b) proposes that "child history" be replaced with "life history" (p. 260). Vygotsky, as other developmental scholars of his time assumed ontogeny stops at adolescence; and so there exists a valuable opportunity for extending Vygotsky's method to conduct research which spans the "entire life span" (Scribner, 1997b, p. 260). Vygotsky focused his research and the application of his historical method on the explication of higher psychological processes. Although he utilized phylogenetic cultural history, this was with the aim of understanding and reconstructing the development of cognitive functions on the ontogenetic level. This development of psychological forms in ontogenesis is largely understood in terms of internalization, i.e. the direction of transformation occurs from stable *priori* phylogenetic level (cultural-historical structures) to ontogenetic level (acquired and internalized cognitive structures). The papers of Scribner (1997b) and Cole (1988) are considered consistent with this basic direction (Yrjö Engeström, 1987).

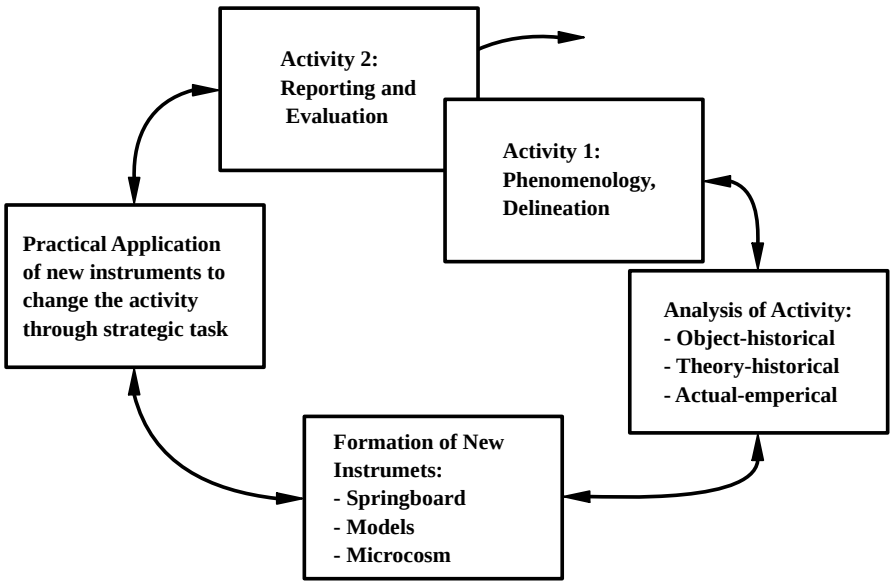
What is left unexplained is how the socio-culturally mediated forms of behavior, or the activity settings, or even societies, are generated or created in the first place. The fourth moment in Vygotsky's cycle provides for variation but not for creation (Yrjö Engeström, 1987).

Engeström (1987) argues that the development of higher psychological processes should acknowledge both histories of internalization and externalization; and although the expansive transition was not foreign to Vygotsky, it remained un-integrated into his general methodology. *Engeström therefore makes the explication of this cyclical transition from the ontogenetic level to the phylogenetic level the explicit aim of his expansive method.*

3.2. Engeström's expansive method

Vygotsky's developmental-experimental methodology is often regarded as the most adequate research method and characteristic of Activity theory (Yrjö Engeström, 1999). Engeström (1987) aims to trace the generation of socio-culturally new activity systems by focusing on the externalization process of his expansive cycle (See 2.1.4.5). Engeström (1999) regards Vygotsky's method as a cyclical methodology for understanding the internalization process of cultural higher cognitive functions at the ontogenetic level; however, he suggests that people do not only face the challenge of acquiring established culture, but also are required to formulate new desired cultures. This is particularly evident in and relevant for our contemporary world of high technological and social transformation. Engeström (1999) suggests that what is required for understanding such transformations occurring in human activity systems is a methodology for studying expansive cycles. However, such a methodology does not easily fit into the frameworks of sociology, psychology or any other disciplinary frame; neither is he suggesting the return to naïve forms of action research (Yrjö Engeström, 1999). What Engeström (1999) is suggesting, is that Activity theory be put to the acid test of practical validity and relevance, by developing interventions which aim to construct new models of activity with local participants. Engeström (1987) transforms the expansive cycle into a cycle of expansive developmental research, which he graphically illustrates as represented in Figure 11:

Figure 11. **The methodological cycle of expansive developmental research (Yrjö Engeström, 1987)**



The first step in Engeström's (1987) methodological cycle of expansive developmental research is the identification of a contradiction or problem situation (Activity 1) which will drive the development of the new model of activity.

3.2.1. Activity 1: Phenomenology and delineation

Activity 1 is identified by acquiring a preliminary phenomenological insight into the nature of its discourse and problems as experienced by those involved in the activity and by delineating the activity system under investigation.

3.2.2. Analysis of activity

The second step consists of the rigorous analyses of the activity system. This is done through object-historical, theory-historical and actual-empirical analyses. Object-historical analysis identifies and analyzes the successive developmental phases of the activity system (Activity 1) with the help of the general models of Activity theory (See 2.1.4.4), as well as techniques for describing the sequential structure of transitions (See 2.1.4.5). The main aim of the theory-historical analysis is to identify and trace the formation of the secondary contradictions (See the number 2's in Figure 10) initiated by or connected to the secondary instruments of the successive developmental periods. Object-historical and theory-historical analysis reveals objectified instruments which are powerful constraints. However, these are generalizations and what is further required is the actual-empirical analysis of the internalized and invented models professed and used by the participants of the activity.

3.2.3. Formation of new instruments

The third step in the expansive methodology encourages the participants of the activity system to formulate qualitatively new models as guides to resolving the activity (Activity 1) contradiction. Creative design such as this lies somewhere between art and science; and there are therefore no foolproof prescriptive formulas for success. Engeström (1987) suggest using "Creativity as an exact science" (Altshuller, 1984) to formulate an alternative conception of models for the new activity system, i.e. springboard. These methods are therefore aimed at "springboarding" the development of the new general models of the activity; however, this transformation is seldom mechanical and uni-directional (See double-headed arrows in Figures 11). The microcosm then is a prototype of the future culturally more advanced form of the activity system (Activity 2). However, the new cultural form cannot be prescribed, thus the microcosm functions as a vehicle for its

intersubjective development. The new models serve as instruments for transforming the new activity system through the microcosm.

3.2.4. Practical application of new instruments

Within the microcosm new instruments can only be implemented in selected strategic tasks. Implementations of the new instruments introduce new contradictions within the activity system and represent the points of probable breakthroughs into the qualitatively more advanced form of practice (Activity 2). The task of the researcher is to register and support this drama, as these contradictions are in actual fact producing practical solutions and new theories for the formation of the new activity system (Activity 2).

3.2.5. Activity 2: Reporting and Evaluation

The final step consists of the rigorous analyses of the newly developed activity system (Activity 2). Documenting, reporting and evaluating the results of the expansive research are therefore very important. Only through the detailed reporting and analysis of the development of the cultural form of the new activity system, will the transformation from Activity 1 to Activity 2 be accurately documented. This account is however complex and difficult to capture. Engeström (1987) therefore suggests the use of multiple methods, ranging from phenomenological and anthropological observation; and historical analysis to rigorous cognitive analysis of performances, conceptions and discourse processes.

3.3. Dialectical method for designing and evaluating learning in a virtual world

The Meta-theoretical framework developed in Chapter 2 delineates a frame from which to conduct practical research. The foundation on which this framework is built is the non-dualistic ontological perspective and dialectical materialist epistemology. From this perspective Activity theory is the most appropriate theoretical frame to understand and evaluate learning in a virtual world. As argued in the beginning of this chapter, this perspective clearly requires a dialectical approach to scientific inquiry. This text therefore does not aim to understand and evaluate learning as a purely mental (inside the head) process; and neither is evaluation explicitly concerned with typical Human Computer Interaction (HCI) usability. Learning in virtual worlds is to be understood and evaluated in terms of being cultural-historical processes, i.e. learning activities. This text proposes to conduct a comparative evaluation of a learning activity taking place in the classroom with the same learning activity taking place in the virtual world. Activity theory affords this comparative

evaluation, on the basis that an activity is identified by its object. Although the actions and operations can vary between the two situations, they can be compared on the basis of the activity's object being the same. Clearly, this comparative evaluation requires the design of a virtual world (See 3.3.3) for this comparative evaluation and hence the "design" within the dialectical methodology title. This requirement matches the need for research and methods focusing on developing virtual worlds specifically for custom educational contexts (See 2.2.5). *The research explicated in this text contributes to this emergent body of research, by developing a methodology for the design and evaluation of learning activities within virtual worlds.*

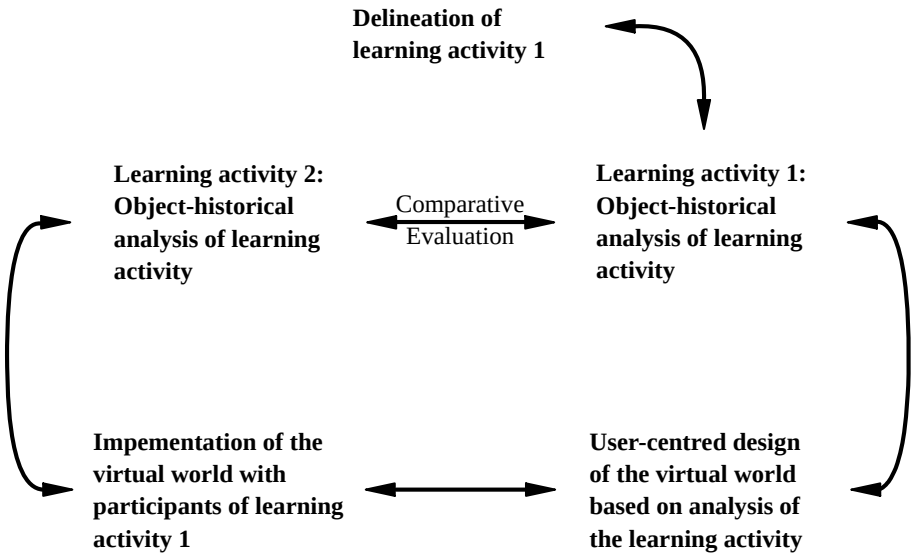
Developing a dialectical approach clearly should expand on Vygotsky's key notion of history as the source for understanding developmental processes. In this text the cultural process under investigation is learning activities in virtual worlds. Vygotsky focused his research on the unit of analysis of higher cognitive functioning, while this text will focus on the unit of analysis of the learning activity (See 2.1.4.6). *Congruent with Vygotsky's dialectical unit of analysis, this text therefore proposes the analytic unit of the group as the dialectical process of mutual transformation, uniting the individual and society within the virtual world.* The key historical focus is therefore not the development of higher psychological processes, but the historical development of the learning activity. Vygotsky's double stimulation method in particular offers a useful method for elucidating the developmental process of higher forms and will therefore utilized to reveal the development of the learning activity.

The double stimulation method will be expanded to reveal the development of the learning activity right "before one's eyes". Vygotsky achieves this by first presenting the participant with a simple stimulus; and then presenting a second (mediating) stimulus, which role is to help participants organize their responses. *The dialectical method developed in this text first analyses the learning activity in the classroom and then presents a virtual world as a second (mediating) artifact to organize the learning activity.* Vygotsky uses his method to discover how a sign can organize behavior. *The method developed in this text aims to discover how a representational system, such as a virtual world, can organize a learning activity.* This contribution from Vygotsky will form the foundation for the proposed methodology for designing and evaluating learning in a virtual world. However, Vygotsky method was primarily concerned with the process of internalization, i.e. transformation moving from phylogenetic history to the ontogenetic level. Engeström's expansive method on the other hand focuses on the opposite process of creative externalization. It builds on Vygotsky's foundation to provide the dialectical method with a means to trace the transformation of

learning activity systems. Engeström furthermore developed the conceptual tools and representations to describe activity systems (See 2.1.4.4) and expansive cycles (See 2.1.4.5) to support his expansive method. *This text therefore proposes uniting and transforming Vygotsky's historical method and Engeström's expansive method, to develop a dialectical method for designing and evaluating learning in a virtual world.*

The process of transformation that produced the dialectical method occurred intuitively, through trail and error, reciprocating between theory and practice. Only after the method emerged, could it be rationally analyzed and explicated in the most suited theoretical objects, borrowed from Vygotsky and Engeström. This is an example of the "bricolage" (Lévi-Strauss, 1968) style of this text and the research it explicates. Bricolage is a valid and valuable way of organizing scientific work, as ethnographers of science have shown that bench science often depends on a long and muddled process of trail and error, followed by a fanatic scramble to rationalize results and the successive drafts of the final scientific papers, which cover the tracks of messy bricoleurs (Turkle, 1995). *This text contributes an account of its "bricolage" style; it has been a very important part of the process of its formulation and should be promoted rather than concealed*. It is important to note further that although existing objects are combined in new ways in a bricolage, these new relationships transform and give novel meanings to these objects. This dialectical method's cycle for evaluating learning in a virtual world is represented graphically in Figure 12:

Figure 12. **The dialectical method's cycle for evaluating learning in a virtual world**



The dialectical method's cycle for evaluating learning in a virtual world, represented in Figure 12, maps the flow of the dialectic method graphically. It is a transformation of Engeström's methodological cycle of expansive developmental research (See Figure 11). The key difference between the dialectical methods cycle when compared to Engeström's methodological cycle is that the "Formation of new instruments" of Engeström (See Figure 11) is transformed into the purposeful "User-centred design of the virtual world" (See Figure 12). Furthermore the resulting implementation of the virtual world (learning activity 2) is evaluated by comparing it to the learning activity on which it was modeled (learning activity 1). The difference between Engeström's method and the dialectical method is subtle but profound. The dialectical method is clearly more direct in its focus of engineering a novel learning activity in a virtual world and provides a mechanism for evaluating this object of the cycle. In addition, the different aspects of the methodological cycle are not demarcated in boxes (as in Engeström's methodological cycle) to suggest that these categories should not be read as opposing or separate categories of the cycle. These categories are descriptions of aspects that make up the complex and reciprocal methodological cycle and are therefore aimed at facilitating the description and understanding of the methodological cycle in a systematic way. Subsequently the dichotomy inferred by the arrows of the graphical representation should be understood as indicating a relationship between different mechanisms (or forces) rather than strictly opposing categories. These different mechanisms interact reciprocally.

As this map or "view of flow" of the dialectic method (Figure 12) is not the territory, other maps or perspectives can be taken on the dialectical process. In 3.3.3 the user-centred design view of this dialectical process will be graphically illustrated in Figure 13 as the "star life cycle" (Hartson & Hix, 1989). This is an interactive systems design view of the user-centred design of the virtual world. The two maps or views provide different ways of looking at the same dialectical process. Some of the categories of the design cycle clearly overlap and will be merged within the larger methodological frame. However, the two views serve very different objectives. Figure 12 illustrates the cyclical methodology for evaluating learning in a virtual world, whilst Figure 13 will illustrate the user-centred design of the virtual world. The two processes are however intertwined, constituting the dialectical method for designing and evaluating learning in a virtual world. Figure 12 should be read clockwise starting with the delineation of learning activity 1.

3.3.1. Delineation of learning activity 1

As with Engeström's (1987) methodological cycle the first category is the delineation and the acquisition of preliminary phenomenological insights of the learning activity (See Figure 12). The aim is to describe the larger context of which the learning activity forms part (for example the curriculum, learning objectives, etc.) and the specific object of the learning activity that will be the focus of the dialectical method, i.e. "the 'raw material' or 'problem space' at which the activity is directed and which is molded and transformed into outcomes" (Center for Activity Theory and Developmental Work Research, 2003a).

3.3.2. Learning activity 1: Object-historical analysis

The second category (See Figure 12) consists of the rigorous analyses of the learning activity system. This is again done through object-historical analysis, by identifying and analyzing the successive developmental phases of the activity system (Learning activity 1) with the help of the general models of Activity theory (See 2.1.4.4); as well as techniques for describing the sequential structure of transitions (See 2.1.4.6). The aim of this analysis is to develop a model of the learning activity system which will inform the design of the virtual world (See 3.3.2) and provide a "base line" or "benchmark" for the comparative evaluation that will follow (See 3.3.5). The scope of the analysis is therefore constrained to the central learning activity (See Figure 10) and its primary contradictions, i.e. the learning activity outcome. Although secondary contradictions will be included in the analysis, the formation of these secondary contradictions and their connection to secondary instruments are beyond the scope of implementation in the virtual world. The theory-historical analysis will therefore be omitted. The actual-empirical analysis will be done through video analysis of the learning activity. What is important is that the dialectical unit of the group, as dialectical process uniting the individual and society in mutual transformation, be emphasized during the analysis. In particular with regard to the later comparative evaluation (See 3.3.6).

> *Thorndikian educational research tradition focus on pre- and post-test behaviors, inferring from changes what kinds of learning took place in between. Such a methodology is the direct consequence of viewing learning as an internal individual mental process that cannot directly be observed (Koschmann, 2002a). However, if we postulate learning to be a social process, then the conditions are very different. In fact, it is not only necessary for the participants in a collaboration to make their evolving understandings visible to each other, this is the very essence of collaborative interaction (Stahl, 2006c, p. 352).*

The learning activity is a dialectical process; it develops over time and through the interaction between participants and the cultural artifacts mediating the activity. The aim of the evaluation of learning is therefore not to attempt to measure learning as individual mental process, but to account for it as an intersubjective process constructed by the participants during the learning activity. Although individual learning (See 2.1.2) is an important perspective on learning, it has dominated over other equally valuable perspectives on learning; in particular the social aspect of learning (See 2.1.3) as developed in this text. *The analytical focus of this text is therefore on the interaction between the members of the group participating in the learning activity. The dialectical methodology developed in this text, aims to reveal the historical development of the learning activity right before one's eyes.* This dynamic process is highly iterative, complex and difficult to capture. This text therefore proposes utilizing Digital Video to record the reciprocal interactions between participants and the cultural artifacts mediating the learning activity.

> *Analysis needs a detailed transcript. Depending on the situation under analysis, the transcript may have to include in addition to the words spoken, indications of other sounds, intonations, pauses, gestures, gazes and other non-verbal cues that were visible in the tape. Digital video allows repeated and detailed viewing, as well as the ability to accurately time pauses, in order to produce a useful transcript (Stahl, 2006c, p. 357).*

The use of video for research within the humanities is probably most prominent and well developed in the fields of ethnomethodology (Garfinkel, 1967) and conversation analysis (Sacks, 1992). Ethnomethodology studies how people ("ethno-"), who are members of communities, construct ways ("method-ology") of making shared sense of their joint activities; while conversation analysis is an area of specialization within Ethnomethodology that focuses specifically on the procedures participants employ in competently producing conversation (Stahl, 2006c). Video analysis (Heath, 1986) is founded upon ethnomethodology and conversation analysis. The objective of video analysis is to analyze the activities through which the participants of these activities construct shared group practices, knowledge and meaning.

> *In video analysis, researchers look closely at traces of member activities to study the methods that the members use to achieve meaningful interactions. The meaning-making activities are generally only tacitly understood by the individual members who engage in them, but their meaningfulness is made visible to the group so that it can be shared. Researchers take advantage of this visibility to make the methods explicit. Activities are meaningful in the group perspective (Stahl, 2006c, p. 358).*

Clearly, the dialectical method can take advantage of video analysis to record and document the interactive meaning-making process occurring between the participants of the learning activity. The pioneers of video analysis in the fields of ethnomethodology and conversation analysis have focused on discovering the structures of communication (such as turn-taking), rather than applying their methods to practical ends, like evaluating learning and designing curricular innovations (Stahl, 2006c). *The dialectical method developed in this text expands the application of video analysis towards this very end, by using video analysis in the design and evaluation of learning activities in a virtual world.* However, Activity theory is utilized as framework for developing a more comprehensive unit of analysis for video analysis (Bødker, 1995).

> *Activity theory shares the commitment of the cultural–historical school of psychology because of its commitment to understanding how human activity unfolds over time in a historical frame. Activity theory takes the long view: we cannot understand activity if we do not watch it cycle, grow, change (Kaptelinin & Nardi, 2006).*

As a result of this long term view, Activity theory has traditionally emphasized analyzing activities over long timescales. Kari Kuutti (1995) concurs that "activities are longer-term formations and their objects cannot be transformed into outcomes at once, but through a process consisting often of several steps or phases" (p.15). This long term perspective is the result of emphasizing collective activities as the molders of individual actions. Second generation Activity Theory distinguished three timescales according to Leontiev's (1978) operations, actions, and activities; however, it would be a mistake to lump these different timescales together in analysis (Lemke, 2000).

> *…Michael Cole (1996) proposes including a much wider range of scales of analysis, from the microgenetic (event scale), meso-genetic (extended activity or project scale), and ontogenetic (developmental-biographical scale), to the historical and evolutionary scales. He has a particular interest in the emergence of sustainable institutions that persist over times longer than the participation of any one individual in them (Lemke, 2000).*

In her summary of the practical methodological implications of using Activity theory as analytical frame for Human Computer Interaction (HCI) studies, the first implication which Nardi (1995b) notes is: "A research time frame long enough to understand users' objects, including, where appropriate, changes in objects over time and their relation to the objects of others in the setting studied" (p.47). A central notion of Activity theory is object-relatedness. Activity systems are

identified according to their object. Activity systems, however, vary in complexity, the number of participants, time frame, etc. There is a need within Activity theory to construct a set of interrelated theories which reveal richness at different levels of analysis (Minnis & John-Steiner, 2001). Learning activities of small groups are typically shorter in duration, consisting of a lesson or a couple of lessons. The learning activity's object, the learning outcome, is usually well defined and modular within context of the curriculum. They offer Activity theory with the opportunity to develop approaches and models that reveal richness at the level of short term learning activities, rather than the traditional long term collective activity.

Activity theory is therefore challenged to make analyses on several levels, and different approaches are required depending on the focus of analysis (Bødker, 1995). Nardi (1995b) referring to Bødker's (1995) video analysis of episodes of computer use concurs that looking at smaller episodes can be useful, however, not in isolation. It is therefore important to consider the analysis of smaller, shorter time scale learning activities within context of the curriculum which the activity forms part. Video analysis therefore needs to be supplemented by interviews, observations and participation in the larger curricular context in which the learning activity takes place. However, the main focus of analysis for this text will be the learning activities of small groups and will be analyzed through the theoretical framework of Activity theory applied to its video analysis.

> *Human social activity goes by too quickly for us to remember its details. With video we can either slow it down or replay it again and again… We have learned a great deal from it, but the approach does fundamentally distort and limit our view of human social interaction... There are thousands of excellent analyses of 5 minute episodes in school classrooms, very few of whole 40 minute lessons, and almost none of either whole school days for individual pupils or teachers or a whole week (much less a whole year) in the life of one class (Lemke, 2007).*

Indeed, using video analysis for conducting research over longer timescales is problematic. Analyzing video takes time, typically much longer than that of the recorded video being analyzed. Furthermore, people move around, making full accounts over long periods difficult. Even though wearable computers, small digital cameras, streaming video and large hard drives enable "lifecasters" to broadcast and record their point of view on activities 24/7 (Coyle, 2007), analyzing all this video data is one of the major challenges facing video analysis. "Activity theory helps to structure an analysis of hours of videotape without totally prescribing what to look for" (Bødker, 1995, p. 147).

Exploring the synergy between Activity theory and video analysis is an exciting opportunity which this text exploits.

3.3.3. User-centred design of the virtual world as an interactive system

The third category (See Figure 12) in the dialectical method is the user-centred design of the virtual world as informed by the analysis of learning activity 1. *This is also the second methodological challenge this text identified whilst developing the dialectical method, i.e. the design challenge of developing the virtual world as an interactive system.* Design is a "wicked problem" (Rittel, 1984), design problems are "ill-defined" (Simon, 1981), and consequently design is as much science as it is art. Again, there are no sure prescriptive formulas for success. However, the science part is typically undertaken by the Computer Science field of HCI's interactive systems design and evaluation.

> *One of the more significant trends in HCI research and practice over the last decades has been the increasing influence of sociological perspectives in the design and evaluation of interactive systems (Dourish & Button, 1998, p. 395).*

This now two-decade trend is the result of the very same postmodern ontological shift explicated in this text's definitions of learning and virtual reality. Human computer interaction has been attempting to catch up with the development of technological innovation and its cultural appropriation. Initial command line interfaces gave way to the graphical interface, as this accessibility facilitated the use of computers for more general tasks, cultural interfaces developed for the mediation of such activities. Computers are increasingly mediators for human practice; and for these instances it might be better to talk about computer-mediated activity instead of human computer interaction (Kaptelinin, 1995). Interaction design then goes deeper than the interface of traditional HCI, to consider the entire computer mediated experience of the user. From this perspective the emphasis has shifted from the interaction between the user and the interface towards the users' directed interaction through the interface to the useful activity that lies behind it. Developing these computer mediated interactions requires the use of user-centred design approaches, which accepts the importance of involving users in the design process (Preece *et al.*, 1994); and is particularly relevant for the design of virtual worlds as *cultural interfaces*. Virtual Reality regarded as the cultural interface by par excellence.

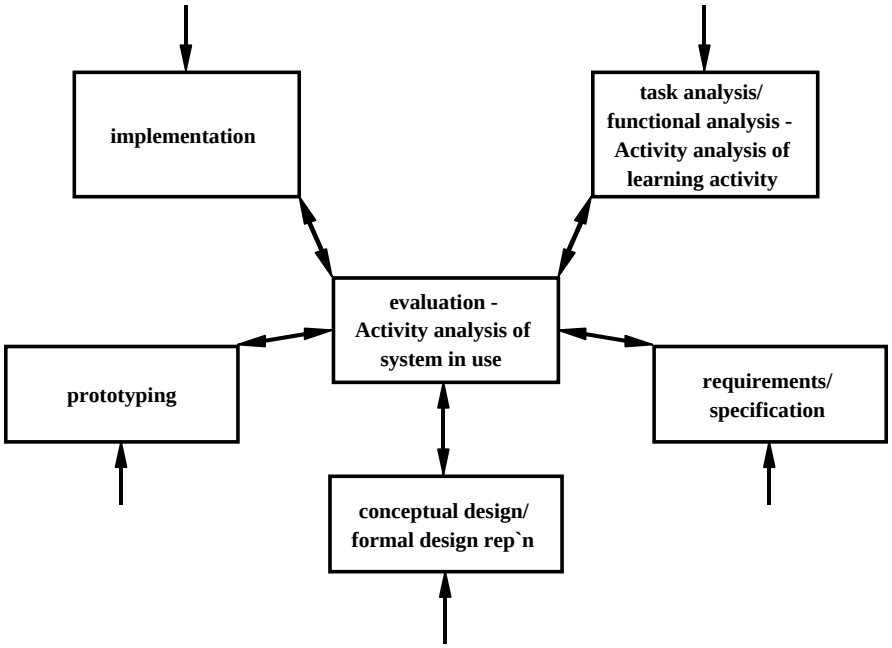
Lucy Suchman's (1987) seminal book "Plans and Situated Actions" provides a revealing and powerful critique of the then common HCI user analysis, modeling and design approaches. Suchman's work plays an important role in the formulation and continuing development of situated cognition (See 2.1.3.4). Suchman clearly emphasizes the perspective that purposeful human activity is situated within the context of particular activity settings. Her arguments and analysis draws strongly from the Ethnomethodological tradition and introduces it into HCI (Dourish & Button, 1998). Ethnomethodology has consequently become particularly fashionable in HCI, with the aim of designing systems which support social contexts, activities and processes (Button & Dourish, 1996). Great strides have been made employing ethnomethodological methods in HCI and particular systems design. However, challenges remain (Dourish & Button, 1998). One of the major problems facing HCI practitioners is the paradox which exists between ethnomethodologists and system designers' use of ethnomethodological methods (Button & Dourish, 1996). HCI comes from the engineering domain which is seeped in the positivist tradition, while Ethnomethodology has its roots in phenomenology. Ethnomethodologists therefore use ethnomethodology to capture unique social processes within situations and for descriptive purposes; while systems designers utilize these methods to prescribe, communicate and base their design decisions on. However, the generalizing and generative use of ethnomethodological methods goes against the very principles of phenomenology on which ethnomethodology is based. Ethnomethodology therefore rejects theories which react to problems by operationalizing sociology's theoretical constructs with reference to the observed world (Button, 1991; Halverson, 2002).

Ethnomethodology is, however, only one amongst a wide range of sociological perspectives (Dourish & Button, 1998). Consistent with the Meta-theoretical framework developed in Chapter 2, this text proposes Activity theory as the most productive framework for system designers to analyze, design and evaluate interactive systems from a sociological perspective. Activity theory provides a "working hypotheses" and model of the structure of cultural-historical activities, which facilitates understanding, communication and decisions making, to get the job done. Activity theory has risen in prominence as framework for the analysis and design of interactive systems in both HCI (Bannon & Bødker, 1991; Bødker, 1995; Kaptelinin, 1995; Korpela *et al.*, 2000; Kuutti, 1995; Nardi, 1995a; Uden & Willis, 2001) and Computer Supported Collaborative Work (CSCW) (Collins *et al.*, 2002; Miettinen & Hasu, 2002; Redmiles, 2002; Turner *et al.*, 1999). Activity theory has been suggested as task analysis framework for instructional design (Rohrer-Murphy, 1999) and for designing constructivist learning environments (Jonassen & Rohrer-Murphy, 1999). Activity theory is regarded

as valuable framework to inform the development of learning environments (M. Dobson *et al.*, 2004; D Mwanza & Engeström, 2003) and the understanding of the learning that occur in them (Barab *et al.*, 2002; Yrjö Engeström, 1987; Morrison, 2003). *However, the systematic integration of the "Star life cycle" (Hartson & Hix, 1989) and Activity theory, i.e. utilizing Activity theory as task analysis as well as evaluation framework within the star life cycle for the design of the virtual world as an interactive system, is one of the novel contributions of this text.*

The development of the "Star life cycle" (Hartson & Hix, 1989) was informed through the empirical observations of the qualitative investigation of interactive system design activities. These observations provided insights into both the procedural (life cycle) and notational (representation) aspects of the evolving methodology (Hartson & Hix, 1989). The star life cycle aims to categorize and represent various aspects that make up the complex and highly iterative process of designing interactive systems. The star life cycle model (Figure 13) does not specify the ordering of categories. You can move from any category to any other, provided that you go through evaluation (Preece *et al.*, 2002). In Figure 13 the conventional graphical representation of the "star life cycle" has been appended with the "Activity analysis of the learning activity" and the "Activity analysis of the system in use".

Figure 13. **The appended "star life cycle" (Hartson & Hix, 1989)**



Hartson and Hix (1989) identified two seemingly contrasting modes of activity at work in the life cycle of designing interactions, i.e. analytic and synthetic modes. The analytic mode was described by designers through notions such as: top-down, organizing, judicial, structural, general, abstract, modeling, and formal, i.e. reflecting the system's view and working towards the user's view. The synthetic mode in contrast was described by notions such as: bottom-up, free-thinking, creative, behavioral, specific, concrete, and empirical, i.e. reflecting the user's view and working towards the system's view. Indeed, the star life cycle is proposed for the user-centred design of virtual worlds because it promotes an 'alternating waves' approach to design, whereby the traditional waterfall, top-down approach is complemented by the synthetic mode.

The contrasting modes of analytic and synthetic activity are united within the dialectical process of design, clearly a "unity of opposites". The design of virtual worlds requires both these reciprocal modes. The Star life cycle life cycle also implies a high iteration of these alternating waves of analytic-synthetic activity; and hence rapid prototyping. The categories or aspects of the star life cycle of design should therefore not be considered as strictly separate or opposing modules. They are united in a dialectical process of mutual transformation. The categories are therefore aimed at enabling people to describe and understand the complex process of designing interactive systems in a systematic way. Subsequently the dichotomy inferred by some of the category titles are also to be seen as indicating the relationship between different mechanisms, rather than their opposition.

When following the star life cycle, development can start at any stage (indicated by single headed entry arrows in Figure 13). This is then followed by any of the other stages (indicated by double headed arrows in Figure 13), as long as the process passes through evaluation. Evaluation is central to the star life cycle, all aspects link through evaluation and are informed by it (Preece et al., 1994). It is important to note that this is an interactive systems design view of the user-centred design of the virtual world and therefore some of the categories of the design cycle (See Figure 13) clearly overlap and will be merged within the larger methodological frame (See Figure 12). The categories from the "Star life cycle" (See Figure 13) will be briefly described:

3.3.3.1. Task Analysis/ Functional analysis

Task analysis is the top-down design activity that produces a hierarchical organization of user and system tasks for the analyzed activity. This category clearly maps to "3.3.1. Learning activity 1: Object-historical analysis" of the dialectical method. Task analysis informs functional analysis, providing a hierarchical structure of what functions the system plays in the task analyzed. There are

various methods and frameworks one can utilize to analyze tasks depending on the purpose of the system to be designed. In the case of designing interactions in virtual worlds aimed at facilitating learning as process, Activity theory provides the most productive framework to use in the analysis of the dialectical process that is the learning activity.

3.3.3.2. Requirements/ Specification

Requirements are statements about what the intended software should be able to do or how it should perform (Preece et al., 2002). Specifications are formal documents or other representations that detail what the system will do (Preece et al., 1994). According to Hartson and Hix (1989) although the conventional life cycle concept demands that requirements and specification be completed before design begins, they observe a large amount of interaction between categories. The structuring of requirements and specifications strongly influenced the structure of subsequent designs. Hartson and Hix (1989) also observed the surfacing of design issues during the requirements process.

3.3.3.3. Conceptual Design/ Formal Design

Conceptual design is the process of transforming the users requirements into a conceptual model (Preece et al., 2002). Formal design is the process of representing that design in a physical medium. Preece (1994) therefore refers to “formal design” as “physical design”. This text will however use Hartson and Hix’s (1989) original term, as this text aims to use the original sources and terms explicated. According to Hartson and Hix (1989) there exists a tension between Conceptual and Formal design. The representation techniques of formal design are mostly based on a top-down hierarchical structure, which do not allow the development of details prior to the establishment of structures into which they will fit. This poorly matches the bottom-up process of experimentation, trail and error and the development of details, before developing the structure.

3.3.3.4. Prototyping

Prototyping is central to moving from conceptual to formal design. Prototyping entails developing an experimental, incomplete design of the system in order to test the design concepts (Preece et al., 1994). Part of or whole systems can be prototyped. Evaluation is the key to prototyping (See 3.3.3.6).

3.3.3.5. Implementation

Implementation refers to the actualization of the design in the context where it is intended to be used. Contextual issues raised during implementation can affect other aspects of the design process. This can be advantageous in highly iterative designs where subsequent stages of the design are implemented to identify contextual issues. This category maps to "3.3.4. Implementation of the virtual world" of the dialectical method.

3.3.3.6. Evaluation

According to Hartson and Hix (1989) evaluation is the very heart of the star life cycle. Evaluation is the key to all other aspects of the design process. It requires different evaluations depending on the particular preceding aspect. Evaluation is the process of determining the usefulness and usability of the system or design. It is measured in terms of a variety of criteria, i.e. the number of errors the users make using it, how appealing it is, how closely it matches the requirements, etc. (Preece et al., 2002). The virtual world as an interactive system will be formatively evaluated during the user-centred design process by having users use the system and provide feedback, while the summative evaluation will be mapped to "3.3.6. Comparative evaluation of learning activities" of the dialectical method.

3.3.4. Implementation of the virtual world

In the fourth category of the dialectical method's cycle (See Figure 12) the virtual world that was designed (See 3.3.3) is implemented with participants in a practical context. This implementation results in learning activity 2 (See 3.3.5). The aim of the virtual world is to facilitate the learning activity object which was delineated and analyzed within the original learning activity 1 (See 3.3.2). It is therefore important to structure the activity for the participants in the virtual world with this aim in mind. The virtual world provides a radically new means for participating in the learning activity and achieving its object. Participants' actions and operations will be transformed as the means of attaining the activity's object has changed. This will introduce contradictions and tensions in the activity system. It is the task of the researcher to document these contradictions and to note weather the virtual world has subverted the learning activity's object. These observations are essential for informing the comparative evaluation and making sure that learning activity 1 and learning activity 2 have the same object, as this will provide the basis for the comparative evaluation. This judgment can, however, only be made after the object-historical analysis of learning activity 2.

3.3.5. Learning activity 2: Object-historical analysis

The fifth category of the dialectical method's cycle (See Figure 12) is the object-historical analysis of learning activity 2. The analyses of the second learning activity within the virtual world, is again done through object-historical analysis applied to the actual-empirical video analysis. The successive developmental phases of the activity system (Learning activity 2) are identified and analyzed with the help of the general models of Activity theory (See 2.1.4.4) and techniques for describing the sequential structure of transitions (See 2.1.4.5). Special attention is given to the analysis of the learning activity's object and the actions and operations which provide the means for its transformation, as this will be the focus of the comparative evaluation.

3.3.6. Comparative evaluation of learning activities

The last category of the dialectical method's cycle (See Figure 12) is the comparative evaluation of the two learning activity systems analyzed in learning activity 1 (See 3.3.1) and learning activity 2 (See 3.3.5). The rigorous analyses of the two learning activities are very important, as only through the detailed account of the two learning activities can an accurate comparative evaluation be achieved. Video analysis was proposed as the most appropriate method for capturing the learning activity's meaning as implicitly understood by its participants and explicitly understood from the video researcher perspective (Stahl, 2006c).

> *The method we are recommending is an interpretive (hermeneutic) one. This does not make it subjective. On the contrary, we are interested in analyzing the intersubjective meanings that we find in the physical and visible video or chat record, rather than hypothesizing about what may have taken place in subjective individual minds (Stahl, 2006c, p. 354).*

Video analysis is fundamentally interpretive. Making reliable interpretations thus requires the researcher to themselves become a participant in the learning activity, to ensure that they have the proper understanding of the learning activity and know how to interpret the intersubjective meaning of the diverse actions exhibited by participants. This requirement is, however, already met by the dialectical method's user-centred design approach to the virtual world (See 3.3.3). The key to understanding and evaluating learning activities as a social process is the construction of shared group practices, knowledge and meaning.

> *As researchers, we can take advantage of what the participants made visible to each other to also see what was meant and learned as long as we stand within a shared interpretive horizon with them*

(Gadamer, 1960/1988; Stahl, 2006c). Methodologically, our access to these displays is ensured to the extent that we share membership in the culture of understanding that the participants themselves share (Stahl, 2006c, p. 352-353).

The meanings that are understood and taken for granted by participants of the learning activity are thus made implicitly visible through the group discourse, interactions and artifacts. The objective behavior of participants and the historical development of the learning activity can be observed and analyzed. However, making meaning from these observations is in itself an interpretive practice and evaluating the learning activity requires us to go beyond interpretation to judgment.

In this view, the video, the researcher, the camera, the playback apparatus, the transcript, the drafts of the article, etc. are all interdependent parts of a network, tied together by their roles in producing the ultimate chain (assuming it doesn't fall apart). This is saying more than simply that the researcher plays an inescapable role in interpreting the video. It is saying that it is only in relation to their roles in the chain (and in other chains) that any of these entities or "actants" has meaning (or even a determinable existence). Latour's ontology does not allow a view from outside, even for the purposes of taking a picture of our own activity in order to be reflexive about it (Lemke, 2007).

When evaluating learning activities the researcher's own activity of evaluation and judgment needs to be considered and held accountable. This is also a cultural practice and activity, based on assumptions and value judgments. The assumptions underlying the definition of learning and the criterion for evaluation should therefore be clear. Understanding the assumptions underlying the conceptual framework, models, concepts and methods used in evaluation and judgment is the only sure way to ensure its 'validity'. Developing a systematic framework, methods and models for this understanding and making these judgments is of central importance. *This text has developed the Meta-theoretical framework (See chapter 2), reflexively accounting for its assumptions and values (See 2.1.1 for philosophical basis of these). It is in the process of explicating the dialectical method for the design and evaluation of learning in virtual worlds; and will explicate its models in Chapter 6.*

The typical reductionistic criterion for evaluation, such as the measurement and comparison of task completion time the learning activity takes, test scores, etc. does not suffice. Activity theory provides the most appropriate frame for analyzing learning as process and interpreting the learning activity's participants discourse, interactions with artifacts and one another. However, Activity theory does not explicitly provide a criterion for evaluating learning. *The third methodological*

challenge stems from the relativity of dialectical materialist epistemology underlying activity theory. The entire process of transformation of the object through the learning activity system needs to therefore be taken into account. As the complete activity system of the learning activity needs to be taken into account, the implicit criterion of evaluation is the activity system itself. The learning activity occurring in the virtual world will therefore be comparatively evaluated with the same learning activity occurring in another situation. This is congruent with the Sociocultural approach, which places a premium on comparative methods and which searches for commonalities and differences among social practices and activities (Scribner, 1997a). This is then the additional motivation behind the delineation and analysis of learning activity 1 (See 3.3.1 and 3.3.2 respectively), i.e. for it to be used as the criterion by which learning activity 2 will be judged. It is important to note that learning activity 1 is not regarded as the "objective" or "true" activity; rather, it provides a normative base-line or benchmark from which to make a comparative evaluation. The evaluation of cultural practices and activities are always relative and never absolute.

This text therefore proposes to evaluate learning in the virtual world through the comparative evaluation of the two learning activities; i.e. evaluating learning activity 2 by comparing it to learning activity 1. Activity theory affords this comparative evaluation, on the basis that an activity is identified by its object. The validity of the comparative evaluation will therefore depend on the object of both learning activities being the same. If the two learning activity objects are different there would be no basis for a comparison; i.e. two different activities would be compared. *This is also the major limitation of the dialectical method, as it can only be applied to already existing learning activities.* Activity theory does however provide the necessary conceptual and representational tools to describe and comparatively evaluate the video analysis of the activity systems of the two learning activities. *Having developed the dialectical method for the design and evaluation of learning in a virtual world by synthesizing and expanding on Vygotsky's historical approach and Engeström's expansive method; this text will now move from theory to practice and put the dialectical method through the acid test of practical 'validity' by implementing it in two case studies.* This text initiated the implementation of its dialectical method for designing and evaluating learning in a virtual world, with the user-centred design of a virtual world (See 3.3.3) by prototyping (See 3.3.3.4) the visualization prototype in the next chapter.

4. Visualization prototype

This chapter describes the first of two implementations of the dialectical method. It starts by explicating the concept of visualization, which will become the object of the learning activity designed and evaluated in the prototype virtual world. The South African context in which this research project took place had an important impact on the selection of visualization as the object of the learning activity and its implementation within the domain of Film and New Media. The second of the two implementations expands on the visualization activity in the domain of Film and media and it is therefore important for this context to be accounted for.

> *It's a conjurer's word really. How else would you describe something that turns dreams into reality or makes the imaginary visible? Magical as it sounds, visualization was just another description of the creative process until the human potential movement discovered that it could be put to work (Katz, 1991, p. 4).*

Visualization is the creative process whereby a person creates a visual representation (image, diagram, animation, model, virtual world, etc.) to give form, preserve and communicate an idea. Since the dawn of humanity, humans have been using visual representations such as cave paintings to give shape to their thoughts, preserve their experiences and communicate them with others. Over the centuries these visual representations have developed into complex representational systems with specific cultural meanings, practices, codes and instruments. Some examples of these representational systems are the Egyptian hieroglyphs, Euclidean Greek geometry, the linear perspective drawings of the Renaissance and more recently photography and film. Today there is an unprecedented use of visualization in science, engineering, business, education, entertainment, medicine, etc.

Of particular significance to the development of these representational systems is the advent of the computer and its developing functionality for graphical representation and manipulation. Computational technologies and the digitization of the image have has facilitated the capturing, generation, transformation and dissemination of visual information; and the proliferation of our contemporary visual culture. Indeed, the linear perspective in drawing as representational system and cultural practice has become the dominant form of visual representation in our contemporary culture through television, photography, film, video, video games, virtual worlds and virtual realty. The practice of perspective drawing by artists and draughtsman, between the sixteenth and nineteenth century, lead them to development of various "perspectival machines" to support their labors. These

instruments included versions of camera obscura and camera lucida and although these optical apparatuses automated some of the work considerable effort was still required to produce images; it was only with the development of photography that this time-consuming process was eliminated (Manovich, 1994). Photographs, however, as with the moving image of film requires that there be a physical reality reflecting light to be caught on film. Therefore the practice of perspective drawing remains crucial for the development of visual representations of that which only exists in fantasy and the imagination. However, with the development of computers much of the hard work of producing perspective images has been automated. Manovich (2001) regards this as consistent with the overall trajectory of the computerization of culture.

> *To take the automation of imaging as an example, in the early 1960's the newly emerging field of computer graphics incorporated a linear one-point perspective in 3D software, and later directly in hardware. As a result, linear perspective became the default mode of vision in computer culture, be it computer animation, computer games, visualization or VRML worlds. Now we are witnessing the next stage of this process: the translation of cinematic grammar of points of view into software and hardware (Manovich, 2001, p. 85).*

The commercial 3D rendering software of today utilize many of the same techniques that were used by renaissance painters (consistent depth cues, etc.) for generating realistic images; however, the radical innovation is the introduction of the synthetic moving image (Manovich, 2001). Furthermore, the hardware (graphics cards) utilized for video games, virtual worlds and virtual reality have the techniques of linear perspective drawing, lighting, shading, texturing, virtual cameras, etc. engineered into their very circuitry. The result is an interactive perspective picture, which updates dynamically as the virtual camera moves, or the represented environment information transforms. Many of the techniques and cultural practices of visualization has to a great extent been mechanized and automated within contemporary computer hardware and software.

Clearly, virtual reality and virtual worlds, with much of the cultural heritage of visualization engineered into the very artifacts which constitute them afford opportunities for learning the practice of collaborative visualization. The Collaborative African Virtual Environments System (CAVES) project at the Collaborative Visual Computing Laboratory (CVC Laboratory, 2004), which funded the research for this text, aimed at developing methods and systems for collaborative visualization. Indeed, the South African context in which the research for this text took place played an important role, in the selection of the learning activity, for the implementation of the visualization prototype

and the technological platform selected for development of the virtual world. The context which gives rise to any research project has a deep ceded interaction with the resulting research and text. Describing the South African context in detail, however, lies beyond the scope of this text. This text's explication of the South African context will therefore focus on the contextual factors that had an important impact on the selection of visualization as the object of the learning activity and its implementation within the domain of Film and New Media. Readers seeking a more general explication of the South African context can look at Beinart, 2001; Southafrica.info, 2009; University of Colorado, 2009 and Wikipedia, 2009.

4.1. South African context

The CAVES research project had been set up as a joint venture between the South African Government and Industry. It included stakeholders from the University of Cape Town, National Research Foundation, Council for Scientific and Industrial Research (CSIR), Contemporary African Music & Arts Archive, Visual Information Systems and Video Labs. South Africa is a developing, multi-cultural society. As a developing country South Africa faces many challenges, most pressing of these are poverty and unemployment. The government has been mandated to halve poverty and unemployment by 2014. To reach this objective a sustained growth of the economy is paramount. The Accelerated and Shared Growth Initiative for South Africa (AsgiSA) mandate was formulated to meet this objective. Education and skills development in particular are identified as key to meeting the required growth rate.

> *For both the public infrastructure and the private investment programmes, the single greatest impediment is shortage of skills – including professional skills such as engineers and scientists; managers such as financial, personnel and project managers; and skilled technical employees such as artisans and IT technicians (South African Government, 2006).*

The National Film and Video Foundation (NFVF) is a statutory body mandated by an Act of Parliament (the National Film and Video Foundation Act, Number 73 of 1997), to spearhead the equitable growth and development of the South African film and video industry. It is clear that the South African government has recognized the potential of economic growth and development within the film industry.

> *Government, in the body of the dti, is already persuaded about importance of the film industry. Indeed, the dti's vision was - by 2014- to make South Africa the leading producer of film and*

> *television content from Africa and the Middle East, watched by the world… The worldwide entertainment and media industry was expected to grow from US $1,1 trillion in 2001, to US $1,4 trillion in 2006. Total value of South Africa's entertainment industry was R7,7 billion (the local film industry accounted for R1,4 billion, excluding commercials)(National Film and Video Foundation, 2005, p. 11-12).*

Despite the potential for growth and development recognized in the film industry, there are considerable challenges to be overcome. Skills development is one of the key challenges. The third aim of the NFVF states: "To stimulate and advance skills development, film education and training" (National Film and Video Foundation, 2005). However, at the 2005 NFVF Indaba the issue regarding the restrictive definition of film and video content was raised:

> *New entrants into distribution and marketing people have misconceptions about new media. This needs to be challenged… We need to establish forms of value other than commercial value. Content for us, includes cultural practices, new media and content industries…Need to consider and develop television and new media, IT and not just film: Need to promote all genres…Expand the mandate of the NFVF to encompass the entire content industries beyond the technological specificity of film and video. The focus should be on moving images (National Film and Video Foundation, 2005, p. 31-41).*

4.2. Film and New Media

Indeed, the synergy between New Media and film (cinema) offers an exciting opportunity for the exploration, study and development of visualization. This is an opportunity which the research of this text aims to exploit.

> *It is useful to think about the relations between cinema and new media in terms of two main vectors. The first vector goes from cinema to new media... The second vector goes in the opposite direction: from computers to cinema. How does computerization affects our very concept of moving images? (Manovich, 2001, p. 287).*

Increasingly, computers are being used in the production of film. Computer Graphics (CG) play an indispensable part in the production of film today. CG is used in the generation of artificial characters, environments and effects. These computer generated elements are then digitally composited over live footage to create realistic film sequences which would be impossible, too expensive or dangerous to film in real life. Take for example "Jurassic Park" (Spielberg, 1993), a good example of all three these conditions. CG is furthermore used in animations and has resulted in

many “block buster” full length animated films. CG is also being used for the planning and visualization of film. One of the popular techniques of visualization for film and animation is the production of storyboards by artists. Storyboards are a sequence of boards or screens representing the critical shots that will make up a film. With CG, however, these shots can be planed and visualized in detail before a single frame is shot for production. CG visualization has become an indispensable technique for the detailed planning of complex stunts and the realistic compositing of CG elements, characters and effects.

Conversely, film is making an impact on computers and our use of them. Not only are the “physics” of light and cameras engineered into the hardware and software capabilities of computers. The cultural practices and conventions of film are also finding their way into computers, for example the cinematic sequences automated in games. The metaphors of film and the camera are also finding application in the design of computer interfaces and interactions, for example the use of zoom in word processing software. The blurring of the borders between film, CG, animation and other older media form part of the remediation of New Media, i.e. translating, refashioning, and reforming other media, both on the levels of content and form (Manovich, 2001). Computers afford a synergetic relationship between distinct media in new and exciting ways, adding interactivity, enabling the audience to actively participate and influence the message of the medium, etc. Film production is by definition a collaborative visualization activity. Producing a film requires the expertise of many people. One of the popular practices for the collaborative visualization activity of film is storyboarding.

The implementation of the dialectical method, developed in chapter three, for designing and evaluating learning in a virtual world benefited greatly from participating in the CAVES project. Some of the CAVES collaborators were from the Centre for Film and Media Studies at the University of Cape Town. This provided access to experts and research opportunities in the field of Film and Media. During consultation with these colleagues from the Centre for Film and Media Studies the summer school storyboarding course was selected as the prototype learning activity for analysis, design and evaluation in the virtual world. The summer school storyboarding course is an extra curricular course offered by the Centre for Film and Media Studies at the University of Cape Town during the holidays to enable students to accumulate additional skills and credits. The summer school storyboarding course is offered to first year film and media students, introducing them to the storyboarding concepts, practices and conventions. The course provides both theory and practice of storyboarding; however, the emphasis is placed on the actual production of storyboards. This activity

of storyboarding was utilized as learning activity for the design and evaluation of the visualization prototype.

4.3. Storyboarding

Storyboarding is a popular visualization practice used in film production. Visualization within this context does not refer to the introspective reports of summoning images before the "minds eye"; it refers to the collaborative production of a visual artifact with the aim to communicate and think through the design decisions necessary for planning the shots of a film. It is the search for the most appropriate form to deliver a message (content).

> *…visualization isn't a strictly cerebral process, but rather the merging of the physical act of making or doing with several different mental processes that together we call imagination. It isn't until our vision emerge in a raw state while we are at work drawing, writing or editing a film sequence that our creative energy is fully engaged in the process of visualization (Katz, 1991, p. 4).*

Storyboarding has become a well recognized visualization technique in the process of film production. It has important benefits, in particular with regard to the pre-production planning, communicating shots and facilitating visual design decisions. Storyboarding is a cultural practice which has developed in visual media to facilitate the thinking through of a visual sequence and therefore best learned through practice. It has a community of practitioners and within context of film has become a visual language in its own right, with its own history, methods and conventions. Storyboards are typically appended with descriptions of the transition and movement between the shots, dialog, characters, sounds, etc. *Storyboarding provides an excellent learning activity for the first of the two implementations of the dialectical method for evaluating learning in a virtual world (See 3.3); and it will start with the delineation of the storyboarding activity.*

4.3.1. Delineation of the storyboarding learning activity

Congruent with principles of user-centred design and the interpretive evaluation of the dialectical method developed in this text, the author of this text and the designer of the visualization prototype participated as a student in the summer school storyboarding course. The author conducted participant observations of the lectures and workshop, taking notes and collecting lesson materials (See 4.3.3.5). The course combined both theory and practices of storyboarding. The theory session of the course consisted of presentations, lecturing and discussion. The practical session consisted of a workshop on drawing storyboards, facilitated by the "An introduction to drawing storyboards"

(Walton, 2004) web based resources. The theory component consisted of 2 x 2 hour sessions, while the practical component consisted of 3 x 4 hour sessions. The course's assignment required the students to complete a ten board storyboard, in groups of two, in their own time.

The storyboarding course started with the theoretical explication of storyboarding as a film visualization technique, the benefits of using storyboarding and the presentation of examples from actual films. During the presentation of examples, both storyboards and final shots (movie clips) from the films "The Birds" (Hitchcock, 1963), "Empire of the Sun" (Spielberg, 1987), and "The Graduate" (Nichols, 1967) were presented (using an overhead projector) and discussed. During the presentation the function of storyboarding in the production process was highlighted; and the storyboarding conventions and techniques used in the examples were emphasized with reference to the practical session that would follow. The requirements of the course's assignment were also introduced.

The practical workshop session was facilitated by the "An introduction to drawing storyboards" (Walton, 2004) web based resources. These resources were designed to scaffold the students' development of the practical skill of storyboarding by providing them with examples, conventions, techniques and small exercises. These included: Planning shot flow, Drawing the mise en scène, Using a floor plan, Shot scale, Close ups, Longer shots, Shot angles, Pan, Zoom, Tilt, Transitions, Shot-reverse shot, Crossing the line, Drawing human figures, Basic forms (sphere, cube, ovoid, cylinder and cone), Buildings in perspective, Seeing lighting and shadows, Cast shadows and Lighting. The workshop exercises provided students with the opportunity to practice their drawing skills, and utilizing storyboarding conventions and techniques. Drawing a good storyboard is greatly facilitated by having drawing skills and artistic abilities. It was, however, emphasized that the goal of the storyboarding assignment was to produce a storyboard that communicated the shot flow of the envisioned cinematic sequence. This is also what would be considered in the evaluation of the storyboard and not the students' artistic ability.

The storyboarding course culminated in the assignment, which was the evaluation component of the course. The assignment required pairs of students to produce a 10 board storyboard. The students were provided with a storyboard template to print out and use for the assignment (See appendix 8.1). The students were required to append the storyboard template with Action of characters, Lighting, Camera Directions, Dialogue, Sound effects and Shot transitions. The template made provision for this information. The storyboarding assignment presented the visualization prototype with a contained learning activity integrating all the theoretical and practical elements

covered in the course. The storyboarding assignment was therefore selected as the delineated learning activity for the implementation within the visualization prototype. As the storyboarding assignment counted for the marks of the students, the author of this text could not participate in the storyboarding assignment learning activity. This meant that there was no learning activity 1 to base the user-centred design of the virtual world on. However, according to Hartson and Hix's (1989) "Star life cycle" the user-centred design can start at any stage. The research conducted for this text consequently started by prototyping the storyboarding virtual world. The analysis of the learning activity 1 (See 4.3.4), necessary for the comparative evaluation, was conducted later as part of the virtual world's implementation (See 4.3.3).

4.3.2. User-centred design of the visualization prototype

The user-centred design of the visualization prototype started with the Hartson & Hix's (1989) "star life cycle" (See Figure 12) category of prototyping (See 3.3.3.4). The star life cycle model (Figure 13) does not specify the sequence of design stages. The designer can enter the design cycle form any stage and move from any category to any other, provided that you move through evaluation (Preece *et al.*, 2002). The visualization prototype was demonstrated and discussed with the lecturer of the storyboarding course during its user-centred design to evaluate it formatively. The explication of the design of the visualization prototype as an interactive system will therefore also begins with prototyping.

4.3.2.1. Prototyping

The user-centred design of the visualization prototype starts with the prototyping of the virtual world aimed at facilitating the learning process of storyboarding. Prototyping entails developing an experimental or incomplete design of the system in order to test design concepts; this is an integral part of user-centred design, as it enables designers to try out their ideas with users and gather feedback (Preece et al., 1994). Central to prototyping as strategy to software design is that the envisioned system should be built cost effectively and quickly. This enables designers to prove their concepts, methods and assumptions within a short period of time and without investing large amounts of money.

4.3.2.2. Requirements/ Specification

The requirements and the specification were conflated in the prototype as requirements, i.e. statements about what the intended software should be able to do or how it should perform (Preece et

al., 2002), was the specifications, i.e. formal documents or other representations that detail what the system will do (Preece et al., 1994). The following specification list was derived from contextual issues regarding the research project, the summer school storyboarding course's practical session, the "An introduction to drawing storyboards" (Walton, 2004) web based resources and the course's assignment as learning activity:

1. Time and cost are two of the most important requirements of any prototype.
2. Accessible technology (CAVES requirement).
3. Using a floor plan.
4. Planning shot flow.
5. Drawing the mise en scène.
6. Cinematography.
7. Drawing human figures.
8. Basic forms - sphere, cube, ovoid, cylinder and cone.
9. Buildings in perspective.
10. Cast shadows and lighting.
11. Facilitate collaboration.
12. Produce storyboard.

4.3.2.3. Conceptual Design/ Formal Design

The requirements specification is transformed into a conceptual model through the process of conceptual design (Preece et al., 2002). The core concept for the visualization prototype was to provide storyboarding students with a shared, dynamic perspective drawing (meeting requirements 4-10), which would facilitate the collaborative production of a storyboard (meeting requirements 11-12). The concept aimed to exploit hardware and software used for video games, virtual worlds and virtual reality; which have the techniques of linear perspective drawing, lighting, shading, texturing, virtual cameras, etc. engineered into their code and circuitry. Conceptual design is closer to requirements and what the system should do, while formal design is the process of representing that design in a physical medium. There is a tension between conceptual and formal design, as implementing the concept in a physical medium (typically hardware with operating system and

software) often introduces contradictions and constraints at the level of the system. This means that there is a reciprocal interaction between conceptual and formal components of design, resulting in the practical implementation. The formal design of the visualization prototype started with considering the first requirement, i.e. time and cost.

The two most costly components of developing a virtual world as an interactive system are the graphics engine and the content. Developing a graphics engine which is optimized to utilize computer hardware (graphic card) acceleration and support the required features (requirements 4-11) of the visualization prototype through BSP geometry, Static meshes, Lighting, Shadows, Texturing, Input controls, Networking, Content creation tools etc. is a very costly and time consuming endeavor. It would take a team of programmers many months to develop such a system, even before a single piece of content was produced. However, this functionality is provided by most of the game engines used by commercial video games. The increasingly popular medium of video games fall somewhere between video and VR (Lemke, 2007). Video games typically utilize “Desktop VR”, i.e. 3D computer hardware is used to render projected perspectives of 3D environments in real-time on normal computer screens. Desktop VR is also used in MMOG; the most popular form of VR in use today and therefore met the CAVES requirement of accessible VR (meeting requirement 2). It is not stereoscopic 3D, however, the manipulation of the perspective is in real-time and the experience is immersive (Beirowski & Vermeulen, 2004). Video games also come with large libraries of content (models, animations, textures, etc.) required for the game. Some video games enable users to go beyond playing and to modify games, providing tools for changing game play, adding content and even creating their own complete games.

The commercial game Unreal Tournament 2004 (Epic Games, 2004) was selected as the formal design for the development of the visualization prototype. The Unreal Tournament 2004’s “Unreal 2 Engine” engine is state of the art, supporting much of the complex functionality required for the envisioned prototype. Unreal Tournament 2004 further provides a large amount of game assets, tools, documentation and large community supporting the modification of the game. The community of developers had furthermore developed drivers for the games engine that enables stereo projection and HMD support. In addition the Unreal 2 Engine supports alternative platforms such as the Sony Playstation 2 and Xbox, in addition to the PC (windows and Linux). This was considered important if alternative platforms and HMD support were to be considered after the prototype. The Unreal 2 Engine is available for developers for free for non-commercial and educational use. This was one of the most important reasons for selecting Unreal Tournament 2004 for prototyping, as the

Unreal 2 Engine could be used and evaluated for the post-prototype system. In addition the Unreal 2 Engine provides functionality for “demo” recording the events which occur in the virtual world. This would enable the researcher to replay these “demo” recordings for the later analysis and evaluation of the interactions which occurred in the virtual world. The disadvantage of using the Unreal 2 Engine was that it dictated the formal design of the system and the conceptual design was to a certain extent constrained by it.

The prototype system was essentially a modification (MOD) of the Unreal Tournament 2004 game. As prototyping aims to test concept and system cheaply and quickly, the prototype utilized already existing game assets. Part of the Unreal Tournament 2004 game is cinematic sequences used for the introduction of the game, tutorials, etc. Unreal Tournament 2004 also provides tools for creating and editing cinematic sequences. The fourth scene from the introductory cinematic sequence of the Unreal Tournament 2004 game was selected to be used for the prototype. Unreal Tournament 2004 is a first person shooter game and much of the content and animations are therefore developed around fierce action. The scene selected for use in the prototype represents a fighting sequence between the antagonist Xan and three protagonists (See Appendix 8.3.6 for script of the action and 8.4.8 for characters). The scene provides a detailed world (See Appendix 8.2.1 and 8.2.2 for screenshots) with derelict buildings, fires, smoke, four models with their associated animations, weapons and weapons fire, explosions, etc. This was required for the mise en scène, i.e. everything that appears before the camera and its arrangement (sets, props, actors, costumes, and lighting) and blocking (the positioning and movement of actors on the set) which are both needed to meet requirement 4. The sequence presents students with a detailed action sequence, which is great for shot-reverse shot cinematography, with special effects elements that would have been inaccessible for the students in the University course context due to the dangers and cost.

The conceptual design was to use the cinematic environments, models, animations and effects to develop a virtual world in which the storyboarding course students could collaboratively produce a storyboard, taking into consideration requirements 4-11. For this the cinematic sequence had to be modified to become a playable level. Each of the students would be able to navigate their computers game-client’s virtual camera through the shared virtual world and have its linear perspective drawn dynamically on their screen. The virtual cameras needed to be programmed to be able to zoom, pan and tilt to meet the requirements of the cinematography (requirement 6). The Unreal 2 Engine provided the functionality of requirement 12, whereby a screenshot of the virtual camera’s view could be produced for the storyboard by pressing the “F9” key on the keyboard. The

students were represented as avatars (representations of the students in the virtual world), so that they could have a reference of one another in the shared environment. The Unreal 2 Engine further provided additional functionality, which enabled students to change their point of view to that of the other participant's virtual camera. With the click of the mouse, they could see what the other students saw through their virtual cameras. This functionality was considered as an opportunity to leverage with the aim of facilitating collaboration (requirement 11). The virtual world was designed to afford students opportunities of interaction by giving participants (players) different abilities and roles (See Appendix 8.4.9). In an attempt to further facilitate collaboration, all of these abilities were required to produce the storyboard. Finally, the virtual world's animations were programmed to be played and paused repeatedly and so provide dynamic humanoid poses for capturing and inclusion in the storyboard (requirement 7).

Although all the content had been available it took approximately two weeks of programming, by the author of this text, to modify the game for the visualization prototype. However, this is considerably shorter than the time it would have taken to develop a similar interactive system from scratch. The modification of the cinematic sequence included: adding spawn points for players avatars, programming input controls for the movement and interaction with virtual world, mapping these movements and interactions to the virtual camera and avatar, binding keyboard keys according to role, adding camera model and textures, attaching camera to avatar's bone, appending player model animation with the "camera hold" animation, triggering camera hold animation, programming the playing and pausing of skeletal animations of humanoid models, switching POV and the game server to replicate all events occurring in the virtual world to the clients. Although the Unreal 2 engine supports spatialized audio, it was decided not to use this functionality as the focus of the research was on visualization. Furthermore, although the storyboard can reference sound in its description, audio is not usually included in a paper storyboard. The visualization prototype was implemented by recruiting (See Appendix 8.3. Recruitment poster) a group of three students from the summer school storyboarding course.

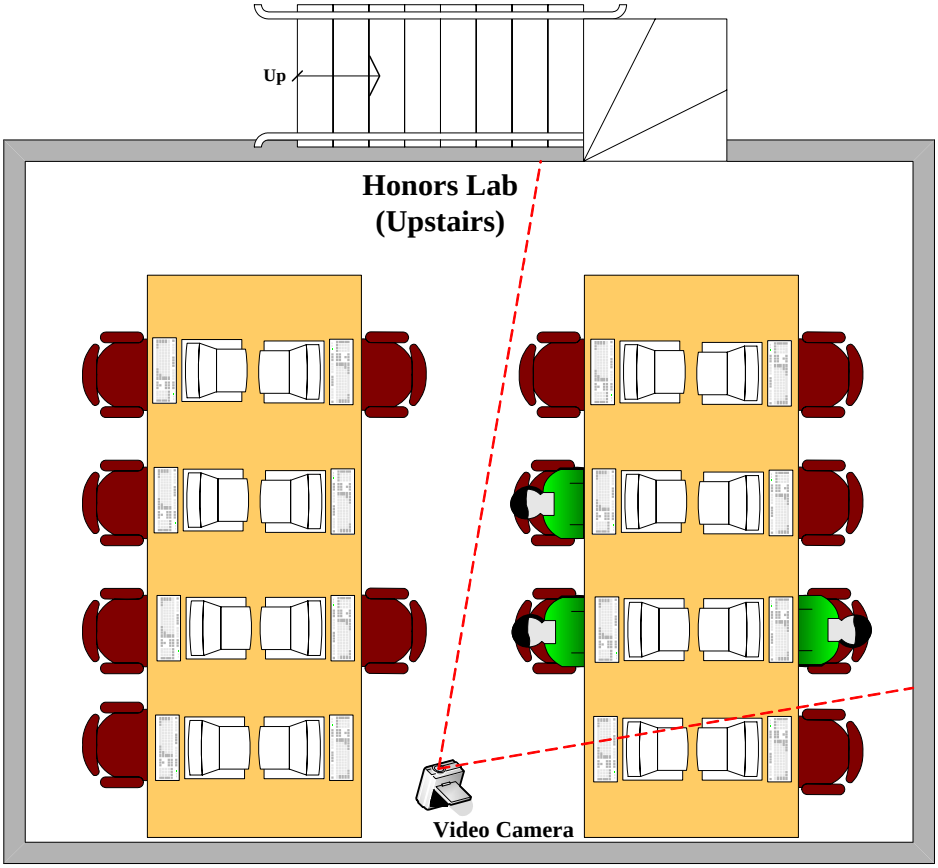
4.3.3. Implementation of the visualization prototype

The visualization prototype was implemented in the "Stunt Action Clip" storyboarding task (See Appendix 8.4). The virtual world's interactive system was hosted on three networked, client computers and a fourth server computer. The implementation was done in the upstairs section of the Honors lab (See Figure 14) at the Department of Computer Science, University of Cape Town.

4.3.3.1. Research setting

The upstairs of the honours lab was reserved for the morning to ensure that the participants would not be disturbed by other students while completing the task. The students were arranged facing one another, while the video camera was positioned to capture all three participants' interactions and dialogue (See red lines in Figure 14 below, for video camera's field of view). The computer screens of two of the participants were also captured in on the video camera to facilitate synchronization between the video recordings in the Honours lab with the "demo" recording within the virtual world.

Figure 14. **The Honours lab (upstairs) implementation space**



4.3.3.2. Participants

The group of three students participating in the visualization prototype was recruited from the summer school storyboarding course which was analyzed to produce the virtual world. The participants were three white males between the ages of 17 and 19. All participants were full-time

first year students at the University of Cape Town. Two of the participants were from the Centre for Film and Media, while one of the participants was from the Department of Computer Science, pursuing their interest in film studies as an extra credit.

4.3.3.3. Participants' tasks

The participating students were introduced to the task by showing them an action sequence from the computer graphics animation film "Final Fantasy" (Sakaguchi & Sakakibara, 2001) while emphasizing terminology and techniques of action sequence cinematography. This was done to activate the students' attention and refresh the terminology they would soon use in the task. Students were provided with the shot list (See Appendix 8.4.4), 10 storyboard templates (See Appendix 8.1), floor plans (See Appendix 8.4.7), the back story (See Appendix 8.4.5), characters (See Appendix 8.4.8) and the students' respective roles (See Appendix 8.4.9). Students were initially required to fill in the shot list, append floor plans with these shots' camera positions and storyboard each of the shots with additional descriptions according to the template. This would provide the opportunity for analyzing the paper storyboarding (learning activity 1), in which the author of this text could not participate on account of the assignment being for marks and which would be later required for the comparative evaluation of the virtual world.

The analysis of learning activity 1 and 2 required for the comparative evaluation was therefore combined within the "Stunt Action Clip" storyboarding task. Only after the students had completed filling in the shot list, appended the floor plans with camera position and produced a paper storyboard using the template (learning activity 1); they proceeding to the virtual world to implement the shot list and paper storyboard in the virtual world (learning activity 2). This would constitute the two learning activities needed for the comparative evaluation. Having students implement the shot list, floor plans and paper storyboarding before proceeding to the virtual world was also used as a strategy to scaffold and organize learning activity 2. The students had not had much experience of learning in a virtual world. The screen shots taken in the virtual world were to be pasted in a Microsoft PowerPoint version of the storyboarding template (See Appendix 8.1) and appended using the AutoShapes functionality provided.

Combining the two learning activities in the implementation could, however, also result in the paper storyboarding (learning activity 1) impacting on the virtual world storyboarding (learning activity 2). To use this interaction between the two learning activities to the advantage of the research for this text, students were encouraged to revise their initial shot list, camera positions on floor plans

and storyboarding descriptions (See Appendix 8.4.3). Such amendments could provide valuable clues to learning interactions, where the virtual world had brought students to a new insight and understanding, i.e. empirical evidence of learning and conceptual change (Roussou *et al.*, 2008). It was hoped that revisions of camera positions on the floor plan would provide evidence of how the virtual world might afford students a better understanding of the relationship between camera placement and the resulting framed space captured by the camera. Of concern, however, was that the interaction between the two learning activities could alter the object of the activity. *It is critical for the validity of the comparative evaluation of the two learning activities that the object remains the same.* However, this could only be determined after the analysis of the two learning activities had been carried out.

4.3.3.4. Research methodology

There are no established methods for the study of learning in virtual worlds from the theoretical perspectives of activity theory and constructivism (Roussou *et al.*, 2008). With the increasing interest and demand for custom virtual worlds that offer educational opportunities and experiences which fit within the curriculum; it is clear that such methods are sorely needed and it is hoped that the method explicated in this text will make a small contribution in this direction. The research methodology that emerged from the research studies explicated in this text have much in common with the research methods employed in the studies of Barab et al. (2002) and Roussou's (2004a, 2004b, 2008). Barab et al. (2002) accounts that their research approach can be best described as naturalistic inquiry. Their research spans a 2-year period where data was collected through the multiple methods of direct observation and field notes, the use of multiple video cameras directed at individual learning groups in a particular classroom, interviews with students and instructors, etc. Although the research explicated in this text followed this general method, it cannot be considered as a naturalistic enquiry since it was constrained by the shorter time span and consequently produced a smaller corpus of data. As such it is closer to the qualitative methods employed in Roussou's (2008) research. The research approaches of Barab et al. (2002) and Roussou's (2004a, 2004b, 2008) both utilized activity theory and activity systems to iteratively select and analyze the data collected.

The research for this text examined the relationships between participant and object as mediated by the primary components that constitute an activity system (Barab *et al.*, 2002). The general activity system serve as a compass to navigate and explore the data analyzed and to identify instances that would serve as exemplars of the emerging systemic tensions. This generalized

depiction of the activity system so provided an analytical tool for clarifying the systemic tensions that characterized the activity system. This text concurs with Roussou (2008) not to use the prejudiced "node" approach of Barab et al. (2002), where data was grouped into units of analysis called ''nodes'' within their research databases. Rather all video recorded sessions were reviewed for interesting interactions. Activity theory as analytical framework facilitated this revision as it provides a conceptual vocabulary to facilitate the interpretation of these interactions (Roussou et al., 2008). Using the activity theory concept of contradictions highlighted instances contributing to the identification and description of the systemic tensions emerging from the analysis. This was the primary research method used in this text and worked in symbiosis with the "Dialectical method for designing and evaluating learning in a virtual world" (See 3.3). The data for the research of this text was collected through the methods of participant observation and semi-structured interviews.

4.3.3.5. Participant observation

The researcher conducted a participant observation of the summer school storyboarding class' lectures and workshop, for the delineation of the storyboarding learning activity (See 4.3.1), taking notes and collecting lesson materials. Participant observation require the researcher themselves to become a participant in the learning activity to ensure that they have the proper understanding of the learning activity and know how to interpret its intersubjective meanings. The role of the researcher within the visualization prototype was also to make reliable observations and interpretations of the diverse actions exhibited by participants. However, in addition to this the researcher also had to support the learning activity in the virtual world. Participant observation is the most efficient method for supporting the learning activity, while gaining first hand insight of the participant's interactions in the virtual world. The support provided was, however, aimed at technology and information related requirements arising from the learning activity enacted in the virtual world, rather than directing the learning activity directly. However, as participant observations require a high level of participation by the researcher it can detract them from observing and documenting the other participant's interactions. To overcome this it was decided to record the interactions taking place in the honours lab using a video camera (See figure 14), while the researcher "demo" recorded the participant's avatars and their interactions in the virtual world from the researcher's virtual camera. Demo recording, as mentioned before, is the functionality of the games engine whereby the virtual interactions taking place in the virtual world can be captured and replayed from one of the game avatar's perspectives. Having recordings of interactions inside the virtual world to synchronize with the interactions and dialogue taking place in the honours lab would

provide the opportunity to iteratively analyze the learning activity taking place within the two attentional spaces. However, due to the technical demands of the virtual world system, it came to be that the researcher did not get much time to "demo" record interactions in the virtual world. Thus the majority of the recorded interactions came from the video recording in the honours lab; however, the video camera did capture the screens of two of the participants and thus a view into the virtual world interactions taking place.

4.3.3.6. Semi-structured interviews

On completion of the participant's task the researcher who conducted the participant observation carried out a semi-structured interview with the group of participants. The video camera and honours lab setting was also used to video record this interview for later iterative analysis. This semi-structured interview aimed to clarify and get deeper insights into the observations made during the execution of the participant's task. As the task was a collaborative endeavor it was considered more prudent to interview the group as a whole, as questions directed at the group could be discussed and lead to group consensus rather than the individual participant's interpretations of events. The interviews were structured around 22 predefined questions (See Appendix 8.4.10). The questions aimed at eliciting the participant's goals and outcomes sought, as well as the various aspects of the learning activity system, which facilitated or hindered the mediation of the activity in the virtual world. Although these questions provided a good base for the interview, the interviewer found that focusing on the interesting interactions and contradictions that occurred, and navigating these through the theoretical framework of activity theory and the activity system, was more productive.

Another ad-hoc semi-structured interview was conduced with two female students, who showed disinterest when the summer school storyboarding class was approached with the request to be participants for the visualization prototype. The interview was recorded using an mp3 audio recorder and was structured around the questions: "Why are you not interested in participating in the virtual world?" and "What would make a virtual world interesting for you?" This interview made an important contribution to the conceptual design (See 5.3.2) of the Virtual Film Production World (See 5).

4.3.3.7. Data selection and analysis

The primary form of data collected was the video recordings taken of the participant observations and semi-structured interviews. The video analysis of these recordings was done

through the theoretical framework of activity theory and its model of the activity system. The video analysis started by extracting the video from the video camera using video editing software. This software facilitated the video analysis process, as the video camera was stationary and not operated during the recording. The video recording was consequently one long recording. The video editing software enabled the researcher to mark shorter meaningful sections that could then be extracted into individual files, which could then be played individually on computer or edited together. The editing software's functionality of marking shorter video sections also enabled the researcher to annotate the sections with meaningful comments. Marking specific sections of the video, adding comments to identify them and providing the individual segmented files with meaningful names were therefore important parts of the video analysis process. The concepts of activity theory and the activity system model proved themselves as very valuable in providing the researcher with a vocabulary and concepts for categorizing and commenting the interactions selected from the video record. The short segments of video was then edited together chronologically according to their categorization, providing focused accounts of different aspects of the learning activity. The most suitable segments which emerged from the data, supporting the analysis developed in this text, were then selected and transcribed (See excerpts 4.3.3.8 and 4.3.3.9). These excerpts make up approximately 3.5 minutes (3%) of the total 2 hours of video record; which consisted of 40 minutes for learning activity 1, an hour for learning activity 2 and 20 minutes for interviews.

4.3.3.8. Paper storyboarding activity excerpt

The Unreal Tournament 2004 avatar names are used for anonymity.

1. *Brock: Do we want an establishing shot*
2. *Torch: O, Ja, that's good*
3. *Brock: (While filling in shot list) Establishing shot (pause) that has to be from the side shot (break)*
4. *Brock: Ok, you've got the scene here (move floor plan 1 closer, indicating camera framing with hands, looking down on floor plan) Ok you are looking, from it, from over here*
5. *Wraith: Ja*
6. *Brock: and then all of a sudden you are looking at it from here (turn floor plan around to illustrate perspective from the other side)*

7. Brock: *You jump to (pause) gd (pause) well (gets floor plan 2) you are looking from here right (using hands to illustrate looking down on floor plan)*
8. Brock: *So you are looking like that (using hands to illustrate looking down on floor plan)*
9. Brock: *and you are watching (pause) ew (pause) in this case (turns floor plan around)*
10. Brock: *you are looking like that (show framing with hands)*
11. Wraith: *ja*
12. Brock: *and then all of (drop hands) now we are messing with the axis of action*
13. Brock: *So maybe we have the camera here (turns floor plan around and marks camera position on it with pencil)*
14. Brock: *The two wrecked ships are sort of in the middle of our establishing shot (showing position of ships with both hands)*
15. Wraith: *Ja*
16. Brock: *And then all of a sudden (pause) we have*
17. Torch: *you've switched to the other side of the axis*
18. Brock: *Ja, or we have it (drop ship) slowly coming in, (pause) in the establishing shot (using eraser to represent drop ship and movement)*
19. Brock: *So you have the drop ship (puts eraser down) (pause) depends what, which direction is the drop ship coming from*
20. Brock: *(take floor plan 1 out again)*
21. Brock: *Drop ship*
22. Torch: *See it is coming in (pointing at drop ship and moves hand in direction drop ship move is indicated on floor plan)*
23. Brock: *It is coming in this way (draw on floor plan making drop ship movement more explicit)*
24. Brock: *That's the drop ships direction*

4.3.3.9. Digital photoboarding activity excerpt

The Unreal Tournament 2004 avatar names are used for anonymity.

1. Brock: *Ok, lets, guys, why don't you come up to where I am and we try and get an establishing shot*

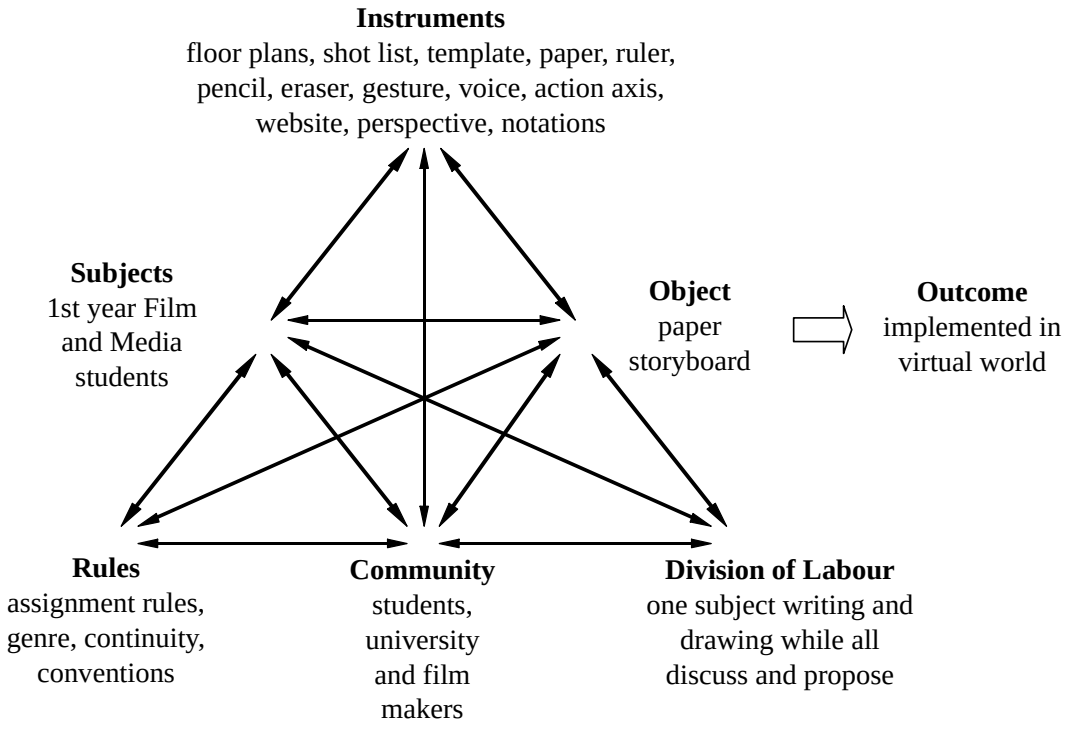
2. *Brock: Except I am on the wrong side, I need to be on the other side (break)*
3. *Brock: I am trying to work out an establishing shot (break)*
4. *Wraith: This (referring to his point of view) would be a quite nice establishing shot (break)*
5. *Wraith: Ok, check my one (pause) do you think it is ok? (break)*
6. *Brock: What about my establishing shot? (pause) but you can't really*
7. *Wraith: (looking at Brock's view) It is too far away (break)*
8. *Wraith: From where I am it looks better (pause) what about mine (pause) it?*
9. *Brock: (looking at Wraith's POV) It's nice (pause) it's just, it lacks the freeway*
10. *Wraith: Oh do you want to get in the freeway?*
11. *Brock: I think I need to come down lower*
12. *Torch: Here, try this (my view)? (pause) a bit closer (pause) or is this tool close?*
13. *Wraith: (Looking at Torch's view) No that is a bit to close and then you can't see the (break)*
14. *Wraith: How about that (pause) check mine*
15. *Brock: (looks at Wraith's view) That's yours*
16. *Wraith: Ja (pause) then you still got the highway*
17. *Brock: (Leaning back in chair considering Wraith's view onscreen) FFFFFFFFF (pause) Just lift it a little bit like (pause) try and get a bit*
18. *Wraith: A bit where (pause) forward?*
19. *Brock: Lower*
20. *Wraith: Lower?*
21. *Brock: and look a bit (pause) no don't come closer, just get lower (break)*
22. *Brock: Now what about my one (view for establishing shot)?*
23. *Wraith: (looking at Brock's view) That is very similar to mine*
24. *Brock: (looking at Wraith's view) That is very similar to yours (pause) actually yours is better*
25. *Brock: (looking at Wraith's view) Try to move it up a little bit (pause) try and get the top of that building*
26. *Wraith: Ok*
27. *Brock: (looking at Wraith's view) No, no, no, no, no, no, go back to where you were (pause) no, no, no, go back, go back*
28. *Wraith: There like that?*

29. Brock: *(looking at Wraith's view) Ja (pause) what do you (Torch) think?*
30. Wraith: *Ja (pause) we just need (pause) we just need to see whether (pause)*
31. Brock: *Torch! What do you think of Wraith's view?*
32. Torch: *Let's see (changes view to Wraith's view) Ja that's cool (break)*
33. Brock: *Actually I think I've got it*
34. Wraith: *Ja, ja, that's quite, that's very good*

4.3.4. Storyboarding learning activity 1: Object-historical analysis

The initial learning activity required students to fill in the shot list, append floor plans with camera positions and to produce a paper storyboard using copies of the template (See Appendix 8.1). The object of this learning activity is therefore the paper storyboard. At the end of learning activity 1, its object (the paper storyboard) was to be implemented in the virtual world (learning activity 2) and this was therefore the outcome of learning activity 1. The object is produced and transformed by the subjects, i.e. the group of three 1st year Film and Media students. They utilized various instruments producing and transforming the object of the learning activity. The instruments include the floor plans, shot list, template, paper, ruler, pencil, eraser, gesture, voice, action axis, website, perspective and notations (See the video analysis excerpt 4.3.3.8 above, from which detailed examples will be drawn and discussed in the comparative evaluation 4.3.6). Constraining the students' production and transformation of the object is the assignment rules (time, number of shots, etc.) and film genre, continuity and conventions. The labor of students during the paper storyboarding activity were divided, with one student doing the writing and drawing, while all discussed and came up with proposals. The activity system of the initial learning activity system is identified by its object. The paper storyboard activity system is consequently graphically represented using Engeström's (1987) triangle in Figure 15 below.

Figure 15. **Paper storyboard activity system**



The production and transformation of the paper storyboard as the object of learning activity 1 is of crucial importance. This is what identifies the learning activity and determines its outcome, i.e. the success of its object's implementation in the virtual world (learning activity 2). The shot list and floor plans are particularly significant instruments within the process of producing and transforming the paper storyboard. Students start the activity by filling in the shot list and by dividing the 10 shots over the action sequence (See Appendix 8.3.6 for the script). The shot list is revised as shots are reconsidered in light of the floor plans, camera positions and the development of the paper storyboard using the template. This is clearly, like systems design (See 3.3.3), another example of the dialectical design process reciprocating between synthetic and analytic modes. This process is facilitated by other conceptual (action axis, POV), physical (paper, pencil, eraser, ruler, etc.) and symbolic (gestures, voice, etc.) instruments.

> *When planning a sequence of shots you should be aware of maintaining continuity through the convention of not "crossing the line", or of positioning cameras on the same side of the 180 degree line of action (or axis of action). This is harder when storyboarding -- you're not working with real cameras, after all (Walton, 2004).*

The axis of action is a film technique used for maintaining the continuity between shots. It is typically used in dialog scenes with shot-reverse-shot or action sequences happening between a protagonist and antagonist. Crossing the line would result in the protagonist and antagonist reversing sides between shots, resulting in a disorienting effect, breaking down the continuity of the sequence. Students utilized this technique by drawing the line of action on the floor plan early in the production of the storyboard. The point of view (POV) in the cinematographic exposition was also an important concept that was discussed by the students in context of the continuity of the envisioned film sequence. It was decided to emphasize Xan's POV. The students used their bodies and the space around them to think through the shots. Using the floor plan as base they used their hands and also the eraser as symbols for framing, wreaked ships, the drop ship and later Xan. This was done to illustrate the movement of characters and objects and to work out the locations of the camera on the floor plan and appropriate shots.

The central contradiction, which came to light from the initial learning activity, was the tension that exists between the students' imaginations and the paper storyboard. The students reported having difficulty in visualizing the storyboard purely from their imaginations. Although they had found the floor plans and other supporting materials helpful, they wanted more detailed information regarding the environment, actors, objects and action of the scenario. Planning shots in a purely abstract imagined location is difficult. If students have a concrete location to think about it is often easier to think through practicalities that otherwise might get overlooked in storyboarding exercises based in pure imagination. Artists producing storyboards typically use a variety of media to facilitate the visualization process and giving form to their imagination; including location shots, magazine clippings, pictures from the internet, etc. These additional resources were lacking from the paper storyboarding exercise. Although providing students with screen shots of the environment had been considered, this was not implemented for the sake of minimizing the interaction between the two learning activities. The students drawing skills and ability also contributed to the challenge of realizing the students' vision in the storyboard. Students had difficulty drawing and found perspective drawing particularly challenging. This central contradiction should, however, not be regarded in a negative light. It is the driving force behind any visualization process, i.e. the challenge of giving form to ones ideas and imagination.

4.3.5. Photoboarding learning activity 2: Object-historical analysis

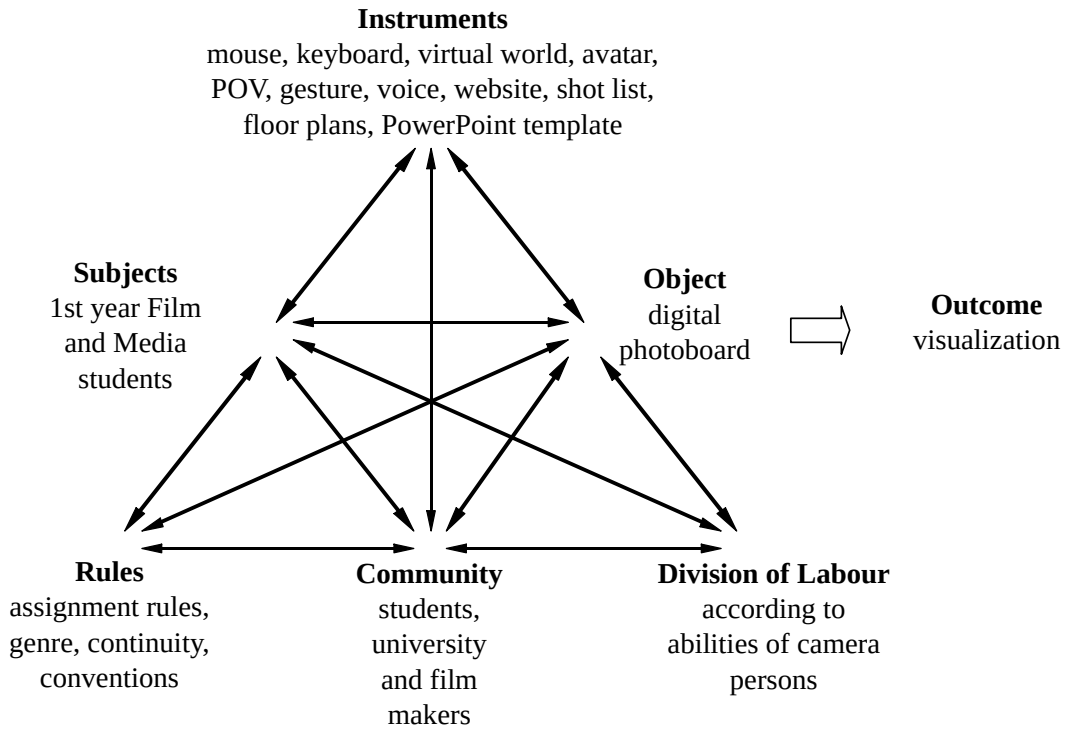
The virtual world enabled students to produce a very detailed picture without needing drawing skills and artistic abilities. They could focus their attention on the relationship between camera, actors, environment and objects. What was important was not how well they could draw, but rather, how well they could frame the environment for maximizing the storyboards message. However, this implementation of the storyboarding learning activity in a virtual world had changed the object of the activity; within the virtual world creating the storyboard was more likened to taking a photo. The in virtual world activity was therefore closer to the production of a photoboard than a storyboard.

> *Storyboarding is not the only way to visualize your ideas before committing them to film. Another approach is the one in this book: photoboards. Their advantage is that they are easy to create and share the optical and graphical properties of motion pictures… The disadvantage of this method is that models are necessary and scenes must be staged, however simply… A small dramatic scene with a limited cast is ideal for photoboards, while an action sequence featuring large groups of people is more easily created with illustrations (Katz, 1991, p. 85).*

Photoboarding is a closely related technique to storyboarding; however, instead of drawing the storyboard by hand you create it by staging the scenes and taking photos of key shots of the envisioned film. Furthermore, digital photoboarding can help overcome the limitations mentioned above of being constrained by the scenes and models you use, since models and scenes are created on computer and afford the opportunity of automation and duplication. The digital photoboard is therefore a better description of the object of the second learning activity. The second learning activity is identified by its digital photoboard object which determines the success of the visualization as outcome. The virtual world is the most important instrument used by the students in the production and transformation of the digital photoboard (See the video analysis excerpt 4.3.3.9. above, from which detailed examples will be drawn and discussed in the comparative evaluation 4.3.6). The virtual world provides the students with a detailed shared environment, which each of the students can navigate and frame from the point of view of the virtual cameras associated with their avatars. Students can also perform various functions within the virtual world associated with their player's role, such as playing or pausing the action animation sequence and taking screenshots. Students can also change their point of view to that of other participants' virtual camera, to see what one another sees. All this functionality is aimed at facilitating the collaborative production and

transformation of the digital photoboard. The activity system of the second learning activity is identified by its photoboard object. The digital photoboard activity system is consequently graphically represented using Engeström's (1987) triangle in Figure 16 below.

Figure 16. **Digital photoboard activity system**



The second learning activity required students to produce a digital photoboard using the shot list, floor plan, paper storyboard and virtual world. The filled in shot list and amended floor plans with camera positions functioned as instruments for the production and transformation of the photoboard by the students. Furthermore, the digital photoboard introduces another level of mediation, as the student's interactions in the virtual world are also mediated by the computer instruments of the mouse and keyboard. However, unlike in the paper storyboarding activity, the conceptual (action axis, POV) and physical (paper, pencil, eraser, ruler, etc.) instruments was not used in the digital photoboarding activity; and while the symbolic instruments of voice and gestures were used, gestures were less pronounced. The interaction between the two learning activities made it impossible to account clearly for the omission of discussions of the axis of action within the virtual world. However, some of the dialog during the photoboard activity suggests that students could simply see when they were on the wrong side of the axis of action from their virtual camera's

perspective (See excerpt 4.3.3.9, line 2). The opportunity that the virtual world could bring students to new insights and conceptual change, in particular the relationship between camera position and framed space had not been realized, as there were no amendments to the floor plans, camera positions and paper storyboard.

The central contradiction coming to light in the second learning activity was the tension between the student's imagination and the virtual world. The students reported constraints which the virtual world made on their imagination. Students for example wanted dust clouds to appear when the drop ship lands and have it move slower. As the students had not the skill, the time nor the resources to edit and change these aspects of the virtual world themselves, this placed constraints on the students' imagination during the digital photoboarding activity. This is interestingly an inversion of the contradiction of the paper storyboarding where students wanted more information and details, i.e. wanting constraints on their imaginations to help their planning. To a certain extent the virtual world replaces the imagination by providing the complete environment, actors and actions. The process of visualization is clearly a fine balance between the constraints and affordances of the material forms of the storyboarding and photoboarding activities; and the creative possibilities of the imagination. The forms provide the concrete information and context required for making decisions and planning; yet, these very forms constrain the imagination. It is another excellent example of the complex dialectical process at the heart of visualization, mediating between form and content, reciprocating between synthetic and analytic modes.

4.3.6. Comparative evaluation of storyboarding learning activities

The paper storyboarding and digital photoboarding's central contradictions reveal two opposite "forces" united in the tension of the visualization process, i.e. the dialectical relationship iterating between imagination (content) and representation (form). The virtual world provides learning activity 2 with a detailed context for planning and producing the digital photoboard. Student's found photoboarding in the virtual world "not as brain sapping" as they had the paper storyboarding. The virtual world had constrained students imagination; however, it greatly facilitated the organization and negotiation of the screens captured for the photoboard. Students had found drawing challenging, in particular producing linear perspective drawings. In the virtual world the student could produce a highly detailed perspective drawing by positioning their virtual camera and pressing the "F9" button. However, it was not within the students' ability to change and edit the virtual world, and this clearly place constraints on the students' ability to realize their imaginations in

the photoboard. The paper storyboarding provided students with a blank piece of paper and complete imaginative freedom. However, complete imaginative freedom also has its drawbacks; it lacks the detailed information needed for planning and facilitating the storyboarding production process. Despite having being given the floor plans and information about characters and script to help the students plan and produce the paper storyboard, the students required more detailed information about the scenario for their planning. Having to imagine these details whilst planning and producing the paper story board required more time and effort. Finding concrete forms for the imagination is a crucial part of the visualization process.

During the implementation of the virtual world the object of the activity had changed. The object of the learning activity 1 was the storyboard while the object of the learning activity 2 was a photoboard. This diminishes the validity of the comparative evaluation since the two learning activity's objects were not the same and consequently two closely related activities were compared rather than the same activity in two different situations. The photoboard is closer to the actual process of film making, i.e. using a camera to frame and capture the scene. During post-interviews the students reported that the virtual world learning activity made it clear how storyboards fits into film production and how useful storyboards were for setting up a shot. Storyboarding is more flexible than photoboards. Drawing enables you to quickly add and remove elements from the scene. This would be a cumbersome and time consuming task to do within the virtual world. A better tool for storyboarding might have been Google's SketchUp (Google, 2007b) which enables students to draw and import models and pictures from the Internet into a Desktop 3D virtual world. Collaboration could also be implemented using Google Earth (Google, 2007a).

Not withstanding a comparative evaluation between storyboard and photoboard activities can be made on the basis of the criterion of the summer school storyboarding assignment. The aim of the assignment was to produce a storyboard that communicated the shot flow of the envisioned cinematic sequence, and students were not to be evaluated on their drawing skill (See 4.3.1). This lead was followed in the comparative evaluation by considering how well the two learning activities had facilitated the collaborative visualization and production of the storyboard and photoboard respectively. This also fits with this thesis' definition of learning as a process that facilitates the construction and acquisition of new practices, knowledge and meaning. Two excerpts, one from the papers storyboarding activity (See excerpt 4.3.3.8) and another from the digital photoboarding activity (See excerpt 4.3.3.9) will be briefly discussed and compared.

The Unreal Tournament 2004 avatar names are used for anonymity. Brock was the leader in both learning activities. He clearly took the lead (See excerpt 4.3.3.8, line 1 and 4.3.3.9, line 1) and contributed the most to both the paper storyboard and the digital photoboard. During the paper storyboarding activity Brock did all the drawing and annotating while other students mainly discussed and came up with proposals. Brock clearly plays a dominant role in the interactions. In the virtual world the interactions between students are more equal, although Brock still plays the dominant role. The functionality of the system provides each participant with unique abilities (See Appendix 8.4.9). All these abilities are needed to complete the task and students are thus compelled to participate. Another feature of the virtual world which greatly facilitated the digital photoboarding activity was the ability to take the perspective of another participant's virtual camera, and to "see what they see". Excerpt 4.3.3.9 provides a clear example how this functionality facilitated students' interaction, enabling them to quickly iterate between their points of view to find the most appropriate shot. Students were furthermore able to direct others student's "view" to negotiate the most appropriate framing (See excerpt 4.3.3.9, line 17-21 and 25-29). In post-interviews this functionality was described by the students as "essential". The virtual world represents and scaffolds much of what had to be imagined and represented by the students themselves within the paper storyboarding activity.

In the paper storyboarding activity students were provided with a two dimensional representation in the form of the floor plans. However, they needed to put a lot of effort into translating floor plans into the three dimensions required to plan the framing and cinematography of the shots. Students utilized various strategies to represent the three dimensions of the environment, elements and interactions to themselves and one another. Students used their hands to represent their camera's point of view, its framing and relationship to the floor plan, as a representation of the environment (See excerpt 4.3.3.8, lines 7-10). Student's hands are also used as symbols to represent the wreaked ships (See excerpt 4.3.3.8, lines 14), while the drop ship and its movement is represented, communicated and discussed using an eraser (See excerpt 4.3.3.8, lines 18). These strategies aim to make the scenario more concrete, to facilitate their collaborative visualization and the production of the paper storyboard. The students are clearly looking for tools conceptual and physical to facilitate the complex task of visualizing the paper storyboard. The axis of action is a conceptual tool that the students utilized in their production and transformation of the paper storyboard. As explained previously (See 4.3.4) the action axis is a heuristic technique used on a floor plan to plan for shots not to "cross the line". Students clearly had to make an effort to keep from

"crossing the line" (See excerpt 4.3.3.8, lines 12 and 17). In the virtual world the heuristic of the axis of action was not necessary because you could simply see if you were "crossing the line" (See excerpt 4.3.3.9, line 2).

It is important to note that the virtual world had not provided a full 3D representation as with a head mounted display. The system displayed a dynamic perspective drawing on each of the student's computer screens, which they could transform by moving their virtual camera with the keyboard and mouse. This real-time display was none the less sufficient in supporting the student's experience of the 3D space and delivering the benefits highlighted above. As previously discussed (See 4.3.5) the possibility exists that the interaction of the paper storyboarding activity had facilitated the digital photoboarding activity; yet, this could not account for the all the affordances the virtual world provided students during the photoboarding activity. However, interacting in the virtual world was far from plain sailing. During its implementation various technical problems arose: student's had difficulty with navigation, some of the character's replication from the server failed and disappeared, there was a lag on the pause function; and the system had to be restarted several times. However, despite these challenges the students persisted with their task, even after being given the opportunity to "call it a day" several times. They came up with several creative solutions to overcome the technical challenges which arose, for example counting to counter the pause's delay. This is a clear indication that the students were motivated and engaged in the virtual world learning activity. This motivational factor is one of the important reasons why educational technologists are considering virtual worlds for education.

A great many lessons had been learned from developing and implementing the visualization prototype. The Unreal 2 Engine had been put through its paces, the domain of film and New Media had proven to be an excellent context for collaborative visualization research; and the dialectical method had been put to the acid test of practical validity and relevance. The visualization prototype concluded that the approach looks promising but careful attention needed to be given to the activity's object and maintaining this object in the design and development of the virtual world. The implementation had further demonstrated how Activity theory provided a robust framework for understanding and communicating the complex learning activities and their virtues and vices. The virtual world was found particularly useful for planning shots and facilitating collaboration. It was decided to develop the next iteration of the virtual world with the specific aim of facilitating collaborative visualization. Film production is one of the clearest examples of collaborative visualization and requires complex planning. The affordance of the virtual world with its virtual

camera was also found to be closer to that of taking photos than storyboarding. This affordance could be expanded to recording a digital moving image instead of a still. In the next chapter the second iteration of the virtual world will therefore aim to develop a virtual world which facilitates the learning activity of film production.

5. Virtual film production

This chapter describes the second implementation of the dialectical method. It starts by explicating the concept of film production, which will become the object of the learning activity designed and evaluated in the Virtual Film Production World (VFPW). Film is an encompassing term. It originally referred to the physical medium, celluloid film, used to capture and project motion pictures. However, it has become associated with various technologies, cultural practices, an art form, theories and an industry. Film is still evolving as a cultural interface. This text concurs that when considering film the focus should be on moving images, as was highlighted at the 2005 NFVF Indaba regarding the restrictive definition of film and video content (See 4.1). Film is a representational system which has evolved with its own cultural meanings, practices, codes, conventions and instruments. Film has a long and colorful history. Its roots are found in the nineteenth century's pre-cinematic devices such as the praxinoscope and zoopraxiscope, which displayed a sequence of images at a sufficient speed to be perceived as a moving image. Deriving from magic lanterns these devices also relied on hand painted images (copied from photographs) rather than photographic images. It was not until the last decade of the nineteenth century that photography, the mechanical eye, became coupled with a mechanical heart, the motor, resulting in film as the moving image we now today (Manovich, 2001).

During film's colorful lifetime the technology and practices used to produce the moving image has been innovated and this has lead to the development of cultural codes and conventions which has specific meanings within film. Early film was a purely visual art, as the technology for recording and projecting sound along with the moving image had not been developed. These innovative silent films developed narrative structures by sequencing scenes, and later text, together to tell stories. The later addition of sound and color greatly contributed to the moving image's ability to tell stories and produce meaningful experiences for its audiences. As camera technologies developed, cameras became lighter and therefore more mobile. This enabled the audience to not only experience the fixed point of view on an animated space but also the movement through space. The innovation of lenses also enabled new effects to be used by the directors of cinematography in films. Cinematographers could use different focal lengths revealing more or less of the scene's depth. The mobile camera and deep-focus are two important cultural conventions used in film today which developed as a result of these technological innovations.

Film is still being innovated today with the development of digital imaging, the generation of computer graphics and software applications that facilitate the transformation and distribution of the moving image. With this diversification of film in both technology and praxis, film production has become a diversified and specialized activity. The film industry as a community of practitioners support the production of film with a large division of labor spread over many countries. The film production community has over these years developed various processes, practices, tools, conventions, knowledge, etc. Learning film production therefore requires learners to become participants of the film production community. As such they are to learn not only the techniques and technologies of producing films but also the terminology and conventions needed to enable them to become full participants within the community of film production. The terminology and concepts developed to describe the process of film production therefore plays an important role in learning film production, as well as how to use these concepts and terms appropriately in communication. Working as a participant in a production team is essential for this learning experience. A successful film is often one in which collaboration of all parties involved, together with creativity, has led to a singular focused film, memorable as well as profitable; collaboration goes to the very heart of the film making process (Dancyger, 1999).

Film is clearly a visual medium that requires careful planning and collaboration between the members of a production team, with diverse roles and objectives. Considering the aim of this text to put the dialectical method through its paces by exploring collaborative visualization and exploiting the synergies between 3D virtual worlds and film: Can the affordances of virtual worlds be utilized to facilitate the learning activity of film production? Hollywood has been producing virtual realities for the last 100 years or so, often creating their artificial cinematic spaces from shots taken from sets on different locations. Surely, the affordances of virtual worlds with their virtual cameras and sets can be exploited to collaboratively produce a digital moving image. This text sets out to expand on the storyboarding prototype by developing a virtual world aimed at mediating the collaborative learning activity of producing a moving image.

5.1. Delineation of learning activity 1

The research for this text was again greatly facilitated by having access to experts from the Centre for Film and Media at the University of Cape Town, through its collaboration with the CAVES project. Through consultation with these collaborators the author gained access to participate in the lectures, workshop and assignment of the “Long Take” (LT) module. The researcher

conducted participant observations of the lectures, workshop and assignment; taking notes and recording the audio of the lectures and workshop on a mp3 player, while recording the LT assignment with a handheld video camera (See 5.4.5).

The LT module forms part of the curriculum of third year Film and Media students enrolled in the Film Production program at the University of Cape Town. During the lectures the lecturer led students through an exploration of the concept of the LT and the LT assignment was also introduced. The lectures explored the techniques used for producing long takes, while the function and elements of the LT was demonstrated by presenting various clips from movies such as (Dogma (K. Smith, 1999), Citizen Cane (Welles, 1941), Touch of Evil (Welles, 1958), Russian Ark (Sokurov, 2002), The Player (Altman, 1992), Jackie Brown (Tarantino, 1997), etc.) on an overhead projector. Students further participated in a workshop on cinematography and operating the digital cameras they would be using for the LT assignment.

In film terminology the “take” refers to one recording, from when the director says: “action” and the camera starts rolling, till when it is stopped by the director saying: “cut”. The appropriate takes are edited together to produce the movie. The Long Take (LT) in film terminology refers to a particular type of take, most generally identified by its extended duration. A LT is where you could have cut together a whole lot of short shots, but you decide not to for a particular reason. The LT has become a convention within film and within this context serve specific functions in film production, i.e. eliciting a particular experience from the audience. The LT gives the audience time to explore the cinematic space and is therefore often utilized to familiarize the audience with the space and characters. The LT also gives greater time to the actors (while performing); as well as the audience (while watching the movie) to engage in the story and the characters, etc. The LT is a much smoother viewing experience than the jarring effect of cut scenes. It is closer to people’s normal experience of space and time and therefore lends itself to a more realistic portrayal. The LT can be used to relocate the shot without using a cut; however, the mobile camera is constantly reframing and recomposing the scene and therefore requires tight choreography. The LT is also great for improvisation; it emphasizes performance and allows things to unfold in front of camera. LT can also function on a more technical level as a display of virtuoso and camera work.

During the lectures the LT’s relationship to mobile framing was also considered. Mobile framing refers to the movement of the camera, i.e. the interplay between camera and mise en scène. It was emphasized as an important component in the production of the LT. The camera moves through the cinematic space revealing the action. Particular emphasis was also placed on the LT function of

the exploration of space. Although a LT typically uses the mobile frame, this is not always the case and some examples were shown to illustrate this. The importance of deep space (literal space where the action is taking place over many levels of depth) was discussed with reference to how the revelation of action in these different "layers" gives a sense of relatedness and simultaneity. Deep focus, where all the levels of the action are in focus, was also discussed with relation to its use in LT production. The French film theorist André Bazin emphasized that a realistic representation should approximate the perceptual and cognitive dynamics of natural vision; and that the introduction of depth of field is therefore a step toward realism because it enables the viewer to freely explore the space of the film image (Manovich, 2001). Deep focus is regarded as a more democratic cinematic technique, since the audience can decide where to look, as opposed to the cut which controls what audience is allowed to see. The LT with its deep focus allows the audience to edit the movie with their eyes and is often used to contextualize the film. A more old fashioned technique for creating a sense of reality is using wide angles and deep spaces (revealed through deep focus) in the LT. This was also contrasted with the contemporary gritty "handheld" cinematographic technique for creating a sense of authenticity.

The LT assignment introduced during the lectures, required groups of students to produce a LT entitled "Alan's breakfast". It was a character study adapted from "Directing: Film Techniques and Aesthetics" (Rabiger 1989). The assignment required students to plan, rehearse and shoot a LT. Alan was the only actor allowed. Alan was to prepare breakfast in her/his own way. Alan's character was to be revealed through the action, while counterpoints were developed between these actions and a voice over to be added later in post production. The voiceover contradicts what is seen happening on screen. For example Alan would be making breakfast in a chaotic, disorganized manner, while the voice over depicts Alan in a job interview where s/he is telling the interviewer how organized s/he is. The LT was to be two minutes in duration and handed in without a rationale at a later date.

During the lectures the following points were highlighted with particular reference to the LT assignment: The LT production requires careful planning and choreography between the camera, actor, props and cinematic space. Despite the emphasis on camera movement the exercise was not marked on technical virtuosity. Students were therefore not required to perform technically complex camera shots (crane shot, etc.). The actor's performance was also not regarded as critical to the success of the produced LT. What was important was that when students were constructing their story, planning their shot and choreographing the actor's movement in the cinematic space, they needed to think carefully about framing the actor to make a LT possible and interesting. The

movement of camera and actor within the cinematic space needed to be blocked and rehearsed for the appropriate framing. Since the LT does not control what the audience is looking at by cutting and other techniques, the students needed to use alternative methods to draw the audience's eyes to what were important, i.e. using lighting, mise en scène and action. The framing and mobility of the camera therefore breaks the long take into its constituent parts rather than cuts. Students were encouraged to not use typical shots associated with cutting and television, for example excessive close-ups and zooms. The different functions of LT discussed during the lectures were also to be considered while completing the assignment. The main objective of the assignment was for students to think through all the aspects which required consideration when making a long take, i.e. choreography, blocking, narrative, mise en scène, movement of the camera, layers, etc.; and the relationship between these elements for best telling the story.

The LT assignment like the storyboarding assignment presented this text with a delineated learning activity, bringing together the theoretical and practical elements covered in the LT production module. The important lessons learned during the prototype had been taken to heart. The author of this text and VFPW made sure to get access to participate in the LT assignment. Students were video recorded with a handheld digital video camera during the production activity of the LT assignment. Approximately two hours of video was taken over the two days of the production activity and the theoretical framework of Activity theory was again applied to its video analysis (See 5.4.7).

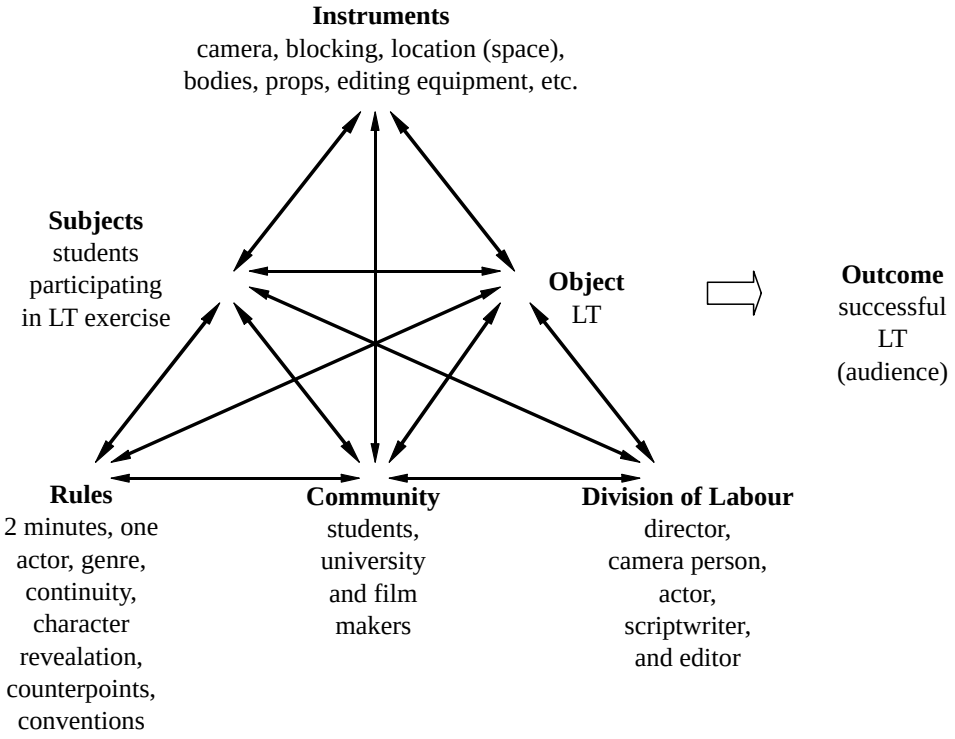
5.2. LT learning activity 1: Object-historical analysis

The object of the LT activity is the LT film (moving image) to be produced by the students; and as its object this identifies the activity. The collective subjects of the LT activity are the third year production students participating in the LT assignment. The outcome of the LT activity is the development of a successful LT. The individual motives of the subjects, for example getting a good grade for the exercise, delivering a message to the audience, etc. are objectified in the collective LT object. Although the LT activity object is under the control of the subjects of the activity, the outcome of the LT is not. The ultimate success of the actual production depends on the teacher and audience's experience of it. The outcome of the LT activity is therefore dependent on value judgments of others. None the less the outcome is indirectly under the control of subjects who transform their object to meet the expectations of their teacher and audience of the LT production. The students use various instruments to transform and produce the LT object. These instruments are

distributed through the division of labor of the LT activity, consisting of the camera person, actor, director, scriptwriter and editor.

The camera person operated the camera to frame and record the actor producing their enactment in the cinematic space. The director directs the action and arranges props within the mise en scène to draw the audience's attention and make the LT more interesting. The scriptwriter produces the story using scriptwriting tools. The editor uses editing equipment and software in post-production to edit the film. The rules of the LT derive primarily from the "Alan makes breakfast" assignment, according to which the LT should be 2 minutes in duration, have one actor whose character is revealed through their action, and on which counterpoints are developed in the post-production voice over. However, the larger context of the university community and its rules are also considered. The students also draw on the conventions and film genres which have been developed by the film community. This collective LT activity system is graphically represented using the Engeström Activity System (EAS) in Figure 17. However, this graphical representation does not seem to account fully for the complexity of the LT activity observed, particularly with regard to its LT object.

Figure 17. **The collective LT activity represented using the EAS representation**

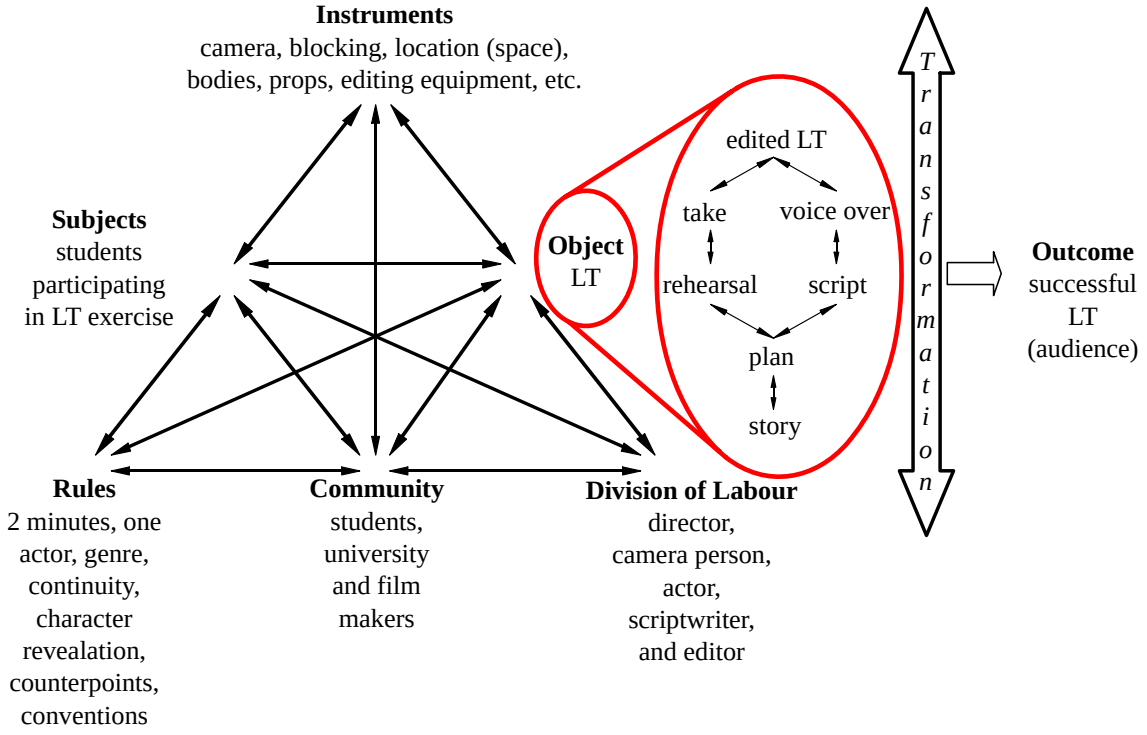


5.2.1. The object's transformation is not represented

If the LT object of the activity is carefully considered, it is also the story or message embodied in the long take and hopefully experienced by the audience. The students' story for the "Alan makes breakfast" task was to make Alan a granny. In the voice over we hear her attending a tea party with friends where she tells her friends how alive her husband is. This contradicts the shot where we see piled up and uneaten breakfasts and at the end a very dead husband is revealed. On yet another level the object of the activity is the plan developed to embody the story within the requirements of the assignment and the resources available. The LT is also the development of the script. The object of the activity is furthermore the rehearsal of the plan and script, the voice over and then finally the edited LT. As product of the activity the LT object is transformed by the subjects from a story to the actual edited LT.

Although the LT activity's collective object (LT) is presented in the EAS triangle (See Figure 17); it is represented as a static singular object. In practice, however, the LT as an object is far from being in stasis. The LT object goes through various transformations (story, plan, script, rehearsal, take, voice over and edited LT). Despite there being a slow linear progression from story to the final edited LT, the interactions between these stages are highly reciprocal, with each of the stages feeding back on one another requiring rework of earlier stages. *The first challenge encountered using the EAS triangle is therefore to represent the transformation of the LT activity object.* In Figure 18 below the various stages of the LT object is expanded and appended to the original representation (highlighted by the red ellipses) in an attempt to represent the LT object expanded into its constitutive transformative stages.

Figure 18. The LT activity representing the stages of the object's transformation



Although the activity now represents the various transformative stages of the object and the interaction between these stages, *it does not represent the transformative interaction of the object (LT) within the activity system; in particular where the transformed object changes its position and role within the graphical representation to bring about transformation.* The object of the LT activity begins as a story discussed by the students, represented and communicated using words, gestures, pen, paper and illustrations. The story is the core concept to be embodied in the production of the LT. It was developed informally by the students discussing ideas, prior to the observed LT learning activity 1. The story carries the message that the LT product intends to deliver to the audience and so reach the outcome of the activity. The students then search for and select a location and resources, from that which are available to them, to realize the story. The story becomes an instrument along with the location, resources and the properties of these instruments to develop a plan embodying the story in an executable form. It is important to note here that the transformation of the object is not only from story to plan. The plan also becomes an instrument for subjects to reconsider the story. The transformation of the object is highly reciprocal, moving in both directions from story to plan and plan to story. The plan then becomes the instrument for the rehearsal. The rehearsal is the next stage

of the LT object's transformation when the plan is executed during the rehearsal. Problems and oversights are identified and this then feeds back into the plan or story which is again transformed. This pattern repeats itself through all the stages of the transformative process (indicated by the double headed arrows between stages in Figure 18), for brevities sake the description of the reciprocal transformations of the further stages will be omitted.

> *However, just as a horizon is forever unreachable, an object is in principle uncatchable. Thus, this article concerns the analytical pursuit of an ever-evolving object that is simultaneously material and ideal, by "catching" facets of the object as it is conceived of and engaged by the participants in an activity system through empirical research (Foot, 2002, p. 132).*

The transformative stages of the LT object can therefore be considered as different "facets of the object" (Foot, 2002). Engeström demonstrates that activities include many antecedent activity systems which achieve the key features of the focal diagram in its current status (Wells, 2002), for example Figure 10, "Four levels of contradictions in a network of human activity systems". This strategy of "breaking-up" the activity system into multiple smaller constitutive activity systems is followed for each of the stages. For brevity only the story and plan stages will be considered and represented in Figure 19 and Figure 20 respectively.

Figure 19. **The story stage of the LT activity represented as constitutive activity**

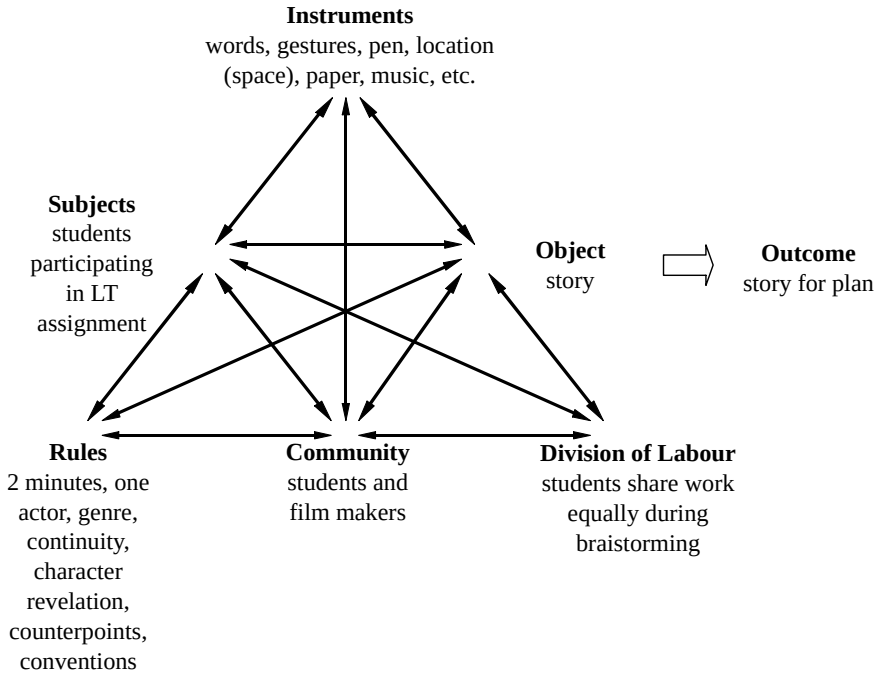
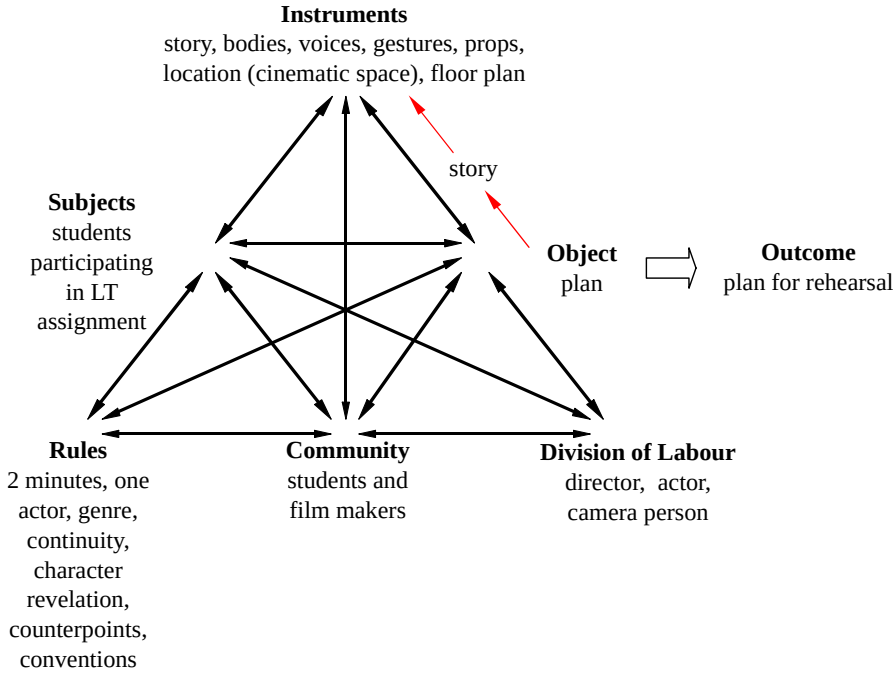


Figure 20. **The planning stage of the LT activity represented as constitutive activity**



Although using Engeström's multiple activity systems to represent the stages of the object's transformation does provide greater detail of each of these transformative stages, *it does not represent the transformations between these systems*.

5.2.2. The static representation does not illustrate temporality

Representing temporal relations using the triangle model is particularly problematic, i.e. to meaningfully reflect time span or duration of activities (Mwanza, 2002). It is essential to keep in mind that the static representation implies a dynamic process in time. The red arrows added to Figure 20; aim to represent how the story object from the previous story stage moves (transforms) to become an instrument in the planning stage activity system. However, even this amendment to this activity system still represents a static snapshot of the process. *Dynamic relationships between stage activity systems over time are difficult to represent using static graphical representations.*

5.2.3 Reducing the scope of analysis by focusing on the planning stage

For the purpose of this text and the user-centred design of the Virtual Film Production World (VFPW) the scope of analysis was therefore narrowed to the second stage activity system, i.e. the plan represented in Figure 20. This contracted the focus of analysis and presents a more concisely defined activity system. The reduced scope also reduces the activity's complexity, making it easier to represent and facilitates the implementation of the resulting virtual world. This illustrates how object-historical analysis can reciprocate back to the delineation category of the dialectical methodology, represented in the double headed arrow in Figure 12. The LT assignment furthermore emphasized this stage of the LT production. The planning of the choreography between the camera person, actor, props and cinematic space lies at the heart of the LT activity and provides a more contained activity system for analysis and development. Through this choreography, if skillfully practiced, the long take object could embody the story and reveal it to its audience. The planning of the LT would therefore become the final delineated learning activity object to be developed for the VFPW.

The planning stage activity system (See Figure 20) centers on the development of the plan as collective object. The students participating in the LT assignment develop the plan for embodying the story in the selected location using their bodies, props, the physical space and a floor plan. The students draw on the codes and conventions of the film community and are constrained by the rules of the LT assignment. The production of the plan is divided into three roles: director, camera person and actor. However, these roles are not strictly enforced, as the actor sometimes takes the role of

directing the camera person. Notwithstanding the roles played by students can be categorized according to these three categories and the students generally stuck to their respective roles. The three roles played by the students are central to the production of the plan. The students literally think through the plan using their bodies as objects for manipulation. The actor is enacting the character of the story and improvises its actions. The camera person frames the actor and action, and works out the movement of the camera in the location's space. The director observes this interaction and provides feedback and instructions to the actor and camera person regarding enactment, cinematography, blocking, props, etc. The interaction between these three roles is best described as choreography. Like a dance the participants perform individually, yet their reciprocal interaction and feedback develops the activity as one movement. (See excerpt 5.4.10, for the VFPW Group1's development of the plan).

5.3. User-centred design of the virtual world as an interactive system

The user-centred design of the virtual film production world (VFPW) is again explicated here in terms of Hartson & Hix's (1989) "star life cycle". However, the category of "Task Analysis/ Functional analysis" had been considered in the previous object-historical analysis of the planning stage of the LT activity (See 5.2), while the "Prototyping" category had been conducted in the storyboarding visualization prototype of the previous chapter (See chapter 4). The VFPW as an interactive system was also formatively evaluated during the user-centred design process, by having the collaborators from CAVES use the system and provide feedback. The explication of the design of the interactive system therefore moves from the prototype (See 4), through the learning activity 1's analysis (See 5.2), to the VFPW's requirements and specification.

5.3.1. Requirements/ Specification

The requirements and the specification are again conflated as in the prototype. The following list of specifications was developed by expanding on the relevant requirements of the prototype by considering the "Alan's breakfast" LT assignment requirements and the object-historical activity analysis of the planning stage.

1. Time and cost.
2. Accessible technology.
3. Accessible content (to female students).

4. Mise en scène.
5. Cinematography.
6. Mobile camera.
7. Large depth-of-field.
8. Well developed world to contextualize the film.
9. Spaces with levels for deep focus.
10. Cast shadows and lighting.
11. Actor actions.
12. Division of labor.
13. Participant's bodies.
14. Facilitate collaboration.
15. Produce film.

5.3.2. Conceptual Design/ Formal Design

The requirements specification was transformed into a conceptual model through the process of conceptual design. The core concept for the VFPW was to provide students with a well developed shared virtual world that could contextualize and facilitated the planning and production of the LT, meet the requirements of the assignment and so afford students with the same learning activity as delineated and analyzed in the object-historical activity analysis of the planning stage (See 5.2). The conceptual design was again formalized through the use of the Unreal 2 Engine. The Unreal 2 Engine had proved itself as a state of the art interactive system that supported the functionality required and facilitated speedy and cost effective development of virtual worlds of high quality and interactivity. Although the user-centred design had moved from prototyping to the final system, cost and time is always a constraint on any interactive system. The first requirement therefore remains time and cost. However, an important lesson had been learned regarding content, during the recruitment of participants for the storyboarding prototype.

An important finding coming to light from the storyboarding prototype recruitment process was that there seemed to be a sexual bias in the volunteers. All of the volunteers were male. This was of concern, since the aim of the virtual world is learning. Motivation and attention are critical

cognitive components to this process. If virtual worlds were only appealing to males, this would be detrimental to the educational usefulness of virtual worlds. Semi-structured interviews were conducted with female students from the summer school storyboarding course (See 4.3.3.5) to attempt to identify the reason for the apparent lack of interest. An important question that needed clarification was whether this lack of interest was in response to the virtual world as an interactive system or whether it was the content that lacked appeal. The former was clearly a more serious problem, since content could always be changed. During the interviews with the female students it became apparent that if the content was more realistic they would have been more interested. In the words of one of the female students: "More realistic, with scenery and background and what not … like actual people that we know in the movies … if it was more realistic, like, I know that that would be hard to do that, but I don't know, it would help a lot … Like with just a normal scene, like in a park … My chances would be a lot higher for doing it (participating in the storyboarding prototype)". Clearly, the bloodthirsty science fiction action of Unreal Tournament 2004 had not been appealing to the female students.

Although content is expensive to produce it is possible to find content through other means; for example downloading models and textures from the Internet, buying content libraries, using game assets, etc. The research for this text greatly benefited from a content library which was developed by CAVES to support various research projects involving virtual worlds. One of the CAVES colleague's research projects focused on providing nutritional information support in a virtual world, to improve the quality of life for HIV+ individuals (Brown, 2006). This content library included many textured models (simple houses, a more complex house with a kitchen and other rooms, various nutritional and kitchen assets; and people). The kitchen and its assets afforded utilization within the "Alan's breakfast" scenario and provided students with objects for developing the mise en scène (requirement 4). Having access to this content library resolved the tension between the need for custom content (requirement 3) and the cost requirement (requirement 1). Furthermore, the models of people could be used as avatars to provide participants, including the actor, virtual bodies to represent themselves in the virtual world (requirement 13). The library also contained a 360˚ panoramic picture of Cape Town that could be used to contextualize the film and meet requirement 8. These assets were combined to produce a custom playable level using the Unreal 2 Engine (See Appendix 8.5.1 – 8.5.2 for screenshots). The house with interior (See Appendix 8.5.3 – 8.5.7 for screenshots), however, had to be modified to afford deep focus.

Deep focus is a cinematographic technique that developed as camera lenses became more sophisticated. These new lenses could have varying depths-of-field. This enabled the cinematographers to have objects in the cinematic space, at various depths of field (close and far away from camera) in focus simultaneously. This enables action within the cinematic space to occur clearly at many levels. This can have the effect of giving a sense of relatedness and simultaneity to the action taking place on various levels. The LT assignment required students to utilize deep focus. This then required a space that had various levels of depth. Students were required to arrange the mise en scène and choreography of the action in these levels, to draw the audience's attention and make the experience interesting to the audience while telling the story. Deep focus requires a cinematic space with various levels and a camera with a lens with a large depth-of-field. The students that were observed in learning activity 1 had selected an apartment with an open plan kitchen, lounge and balcony. This provided them with a space with three levels of depth to utilize for the LT. The students also used a Digital Video camera to record the LT. Since they had not used the zoom and the camera had remained on auto focus, the depth-of-field had remained large for the entire LT.

When developing the virtual world it was therefore important to create a space with various levels of depth and ensure that the virtual camera had a large depth-of-field. The Unreal 2 Engine, like most graphic engines for games, provides an infinitely large depth-of-field, i.e. everything is in focus. Ironically, simulating a shallower depth-of-field is more challenging and computationally expensive. This has only been realized very recently as a result of cutting edge hardware acceleration. The latest Unreal 3 Engine, released at the end of 2007, supports the simulation of motion blur and depth-of-field (Epic Games, 2007). The Unreal 2 Engine's infinite depth of field was sufficient for the deep focus required for the LT (meeting requirement 7), particularly within the leveled space of the house. Outside the house the depth-of-field was reduced by using the Unreal 2 Engine's functionality to generate fog. The model of the house was modified by cutting a large hole in the wall between the lounge and the kitchen. A counter was also added to the hole, to create an open plan between the lounge and kitchen. Looking from the outside through the house's entrance this then also produced a space with three levels (meeting requirement 9) for the deep focus.

Clearly, as with the visualization prototype's user-centred design (See 4.3.2.3) the challenge was juggling the conceptual design with the formal design affordances offered by the Unreal 2 Engine and the content available in the library. The virtual camera of a games engine is clearly very different from the Digital Video camera used in learning activity 1. Virtual cameras apart from having an infinite depth-of-field, can be placed anywhere and move in dimensions and speeds that

would be difficult to produce with a conventional camera. Virtual cameras are also very different to operate, requiring mouse moves and key presses, rather than physical manipulation. However, in the LT assignment, despite the emphasis on camera movement, the exercise was not marked on technical virtuosity. Students manipulated the camera by hand and they were not required to perform technically complex camera shots (crane shot, dollies, track shots etc.). The movement of the virtual camera was therefore modeled on that of the handheld Digital Video camera. The default movement (mobility) of the virtual camera in Unreal Tournament is close to that of a person with a handheld camera. The virtual camera moves at the eye-level of the player's avatar and can rotate up and down, pan left and right, track (strafe) left and right; and move forward and back (See Appendix 8.6.1). This default camera movement was therefore used for the VFPW (meeting requirement 6). This would also enable the students to produce their cinematography (meeting requirement 5). Although the students in the observed film production activity (learning activity 1) had not used the zoom functionality of the Digital Video camera, this did not mean that they might not use it in the virtual world. Consequently this feature was enabled with the virtual camera by changing the "field of view" property programmatically.

It is also important to consider that the object-historical analysis had further delineated the learning activity 1 through focusing on the planning stage of the LT assignment. The object of the activity is the production of the plan for the LT. The technical correspondence between the virtual and contemporary cameras was therefore less significant, since what would be evaluated would be the planning activity and not the LT object produced. The production of the LT movie clip is however important within the larger context of the LT activity, since it is the outcome that drives the planning activity. The Unreal 2 Engine supports the capture of screens and the recording of demos. This "demo" recording functionality records every interaction in the world and enables it to be replayed. However, before the recorded demo to be played, the game needs to be exited and this results in all the changes to the world being lost. If students wanted to record and view more than one LT, they would have to reproduce the mise en scène, and this would require allot of time and would also be frustrating. The students observed in learning activity 1 had taken more than one LT and it was very likely that students would not get it right the first time. Furthermore, the "demo" recording functionality was required for recording the interactions in the virtual world as research data. It was therefore decided to instead use the real-time video capturing software called Fraps (Beepa, 2007). Fraps was originally designed to enable gamers to record their game play. Fraps produces movie (avi) files by taking screen buffer images directly from graphics acceleration hardware using DirectX

or OpenGL graphics technology. This would enable students to quickly and easily record and produce a movie clip (avi) from the perspective of the camera person in the virtual world and of the action taking place in it (meeting requirement 15). Although the Unreal 2 engine also supports spatialized audio, it was decided not to use its audio functionality as the aim of the VFPW was to facilitate the planning stage of the LT activity. Having students produce a voice over and edit the LT in post-production would clearly make the activity more complex and time consuming without adding much to the planning of the LT, which was the focus of the VFPW.

This planning stage activity system (See Figure 20) highlights the plan as the object of the learning activity. Within context of the planning activity, facilitating the groups' collaboration and the choreography of the various roles required to produce the LT was of crucial importance. The students utilized the cinematic space, with its levels of depth, to arrange the mise en scène, block the actor's actions and the camera person's movement to frame and produce the LT. All these elements had to be planned and tightly choreographed by the students, to draw the audience's attention to the important narrative elements and make it interesting while telling their story. Lighting is often used to emphasize elements within the mise en scène and draw the audience's attention. Shadows and lighting is part of the functionality which the Unreal 2 engine provides (meeting requirement 10). This division of labor required by the observed planning activity was developed into the tree roles of the VFPW, i.e. Director, Actor and Camera Person (meeting requirement 12). Each of the roles was developed as a player (See Appendix 8.6) within the virtual world and each of the players was represented in the virtual world by an avatar (See Appendix 8.7, meeting requirement 13).

The director role is responsible for positioning props, triggering special effects and developing the mise en scène. One of the important components of the LT is to arrange props within the mise en scène. Props are key objects that often determine the actor's actions, position and movement. They are also key points used in the framing of the cinematography and make the cinematic space of the film more interesting for the audience to watch. The director role in the VFPW was therefore given the ability to spawn (create) 22 different types of objects (See Appendix 8.8) within the virtual world by pressing a number or function key on the keyboard. The director also had to be able to place the object within the virtual world. To do this a vector was calculated for the direction the director was looking and the prop positioned at a set distance in this direction. The props position was updated in real time resulting in the prop magically moving a constant distance in front of the director's avatar in the direction of the avatar's virtual line of sight. The director's animated avatar utilized the default navigation of the Unreal 2 Engine to move within the virtual

space (See Appendix 8.6.3); however the walking and crouch animations had to be developed to animate this movement. When the director wanted to position a prop in the virtual world, they spawned the prop, moved to the appropriate location, oriented their line of sight to position the prop in the right direction and height, and then pressed the “p” keyboard key. This disabled the real-time positioning function of the prop that was in the director’s line of sight, which meant that the prop was now stationary. To pick up a prop, the prop’s real-time positioning function could be reactivated by the director pressing the “p” once more while looking at it. The rotate, delete and explode functions were also added to the director role, enabling the director to rotate, delete and explode a prop by looking at it and pressing the “r”, “Delete” and “x” key respectively. Having these seemingly magical powers inspired another unique ability thought to might come in handy in the VFPW, namely invisibility. By pressing the “i” keyboard key the director could toggle their avatar’s invisibility on and off. It was believed that this ability could prove useful if the director had to be within the camera’s frame to interact with a prop whilst shooting.

The actor role is another crucial aspect in the LT production. The LT assignment required the LT to reveal the character of the actor through their actions. The actor reveals their character throughout the duration of the long take at the various levels of the cinematic space by interacting with objects in the mise en scène. The actor role functionality therefore required an animated avatar that could be move through the cinematic space (virtual world), perform actions to reveal their character and interact with the props placed in the virtual world. The actor player was represented in the VFPW through an animated avatar. The avatar could be moved around the virtual world by using the default navigation of the Unreal 2 Engine (See Appendix 8.6.2). However, the walk and crouch animations had to be developed to animate this movement. In addition the grab and release, sit and stand, drink up and down, pour, cooking; and gun take and release skeletal animations had to be developed and programmed to be triggered when the associated keyboard keys were pressed. The grab, drink, and gun hold functions were furthermore required to interact with the virtual world props, enabling the actor to pick up props in the hand of the avatar. To do this the line of sight of the actor was used to identify the prop they were looking at. This prop was then attached to a bone of the actor avatar model’s skeleton. To release the prop the actor player used the same keyboard key that was used to pick up the prop. However, this time the prop was detached from the bone. This provided the actor player with the required functionality to reveal their character through its actions (requirement 11). The VFPW utilized custom content from the CAVES library (textured models). The animations of game assets could therefore not be used. Skeletons and animations had to be

manually developed. Skeletal animation, as all animation, is a very time consuming process. The animations were consequently a few basic actions (no complex facial animations etc.). Motion captured animations would have been ideal; however, this resource was not available. Notwithstanding, it was hoped that the simple animations could be used creatively by the students in different combinations to reveal their avatar's character through these actions. Furthermore, the lectures in which the LT assignment was introduced had emphasized that the actor's enactment was also not regarded as critical to the success of the produced LT. The object of the VFPW modeled on the assignment was to plan and choreograph the LT and thus the actor's acting abilities was not that crucial. For the actor role to be able to reveal the character through the avatar's actions the actor player had to be able to see the enactment the actor avatar was performing. The actor player was therefore the only player given the ability to see their avatar from the third person's perspective, i.e. the virtual camera view framed the actor avatar from behind. This way the actor player could play their avatar like a puppeteer. However, they could also switch to first person view, seeing the world through the avatar's eyes, to pick up props etc.

The camera person role is responsible for operating the camera, moving it through the cinematic space and framing the actor and mise en scène to recording the LT. Their role clearly is central to the production of the LT. As mentioned above the mobile camera within the VFPW was modeled on that of the handheld Digital Video camera, i.e. the virtual camera moves at the eye-level of the player's avatar and can rotate up and down, pan left and right, track (strafe) left and right; and move forward and backward (See Appendix 8.6.1). This is also the default movement of the virtual camera in the Unreal Tournament game and many video games. It was hoped that if some of the participants had played such games their skill of using these navigation techniques would transfer to the VFPW. The camera person could also record their screen as a video (avi) file using Fraps by starting and stopping the recording by pressing the Enter keyboard key. The VFPW like the storyboarding prototype utilized "Desktop VR" and not full stereoscopic vision with a Head Mounted Displays, etc. Although the observed LT production (learning activity 1) had taken place in true 3D with the students having stereoscopic vision, the LT itself was a 2D moving image recorded from this 3D world. It is believed that the "Desktop VR" implementation of the virtual world would be sufficient for students to collaborate and plan the production of the LT. This would also reduce the cost (requirement 1) and make the VFPW more accessible (requirement 2). The Unreal 2 Engine's functionality which enabled students to change their point of view to that of the other participant's

virtual camera was again utilized since it had been described as “essential” for collaboration (requirement 14) by the students of the storyboarding prototype.

The production of the VFPW included: creating a camera model and texture, skeleton and animations for the avatars, adding animations and skeletons to avatar models, exporting all models and importing them into UnrealEd (Unreal 2 engine’s editor), building the level in UnrealEd using the imported models, programming class files for prop models and director’s interaction with them, programming the particle effects for the explosion, programming the different player controllers for the different roles (with appropriate functions triggering animations and interactions), adding spawn points for players avatars, configuring the input controls for movement and interaction with virtual world mapped to virtual camera and avatars, binding keyboard keys according to role, programming switching of the POV and the game server to replicate all events occurring in the virtual world to the clients. This took approximately one month, which is still a considerably shorter time than it would have taken developing such a system from scratch. The VFPW was then implemented by recruiting two groups of three students each (Group 1 and Group 2) from the third year film production program that had participated in the LT assignment.

5.4. Implementation of the Virtual Film Production World

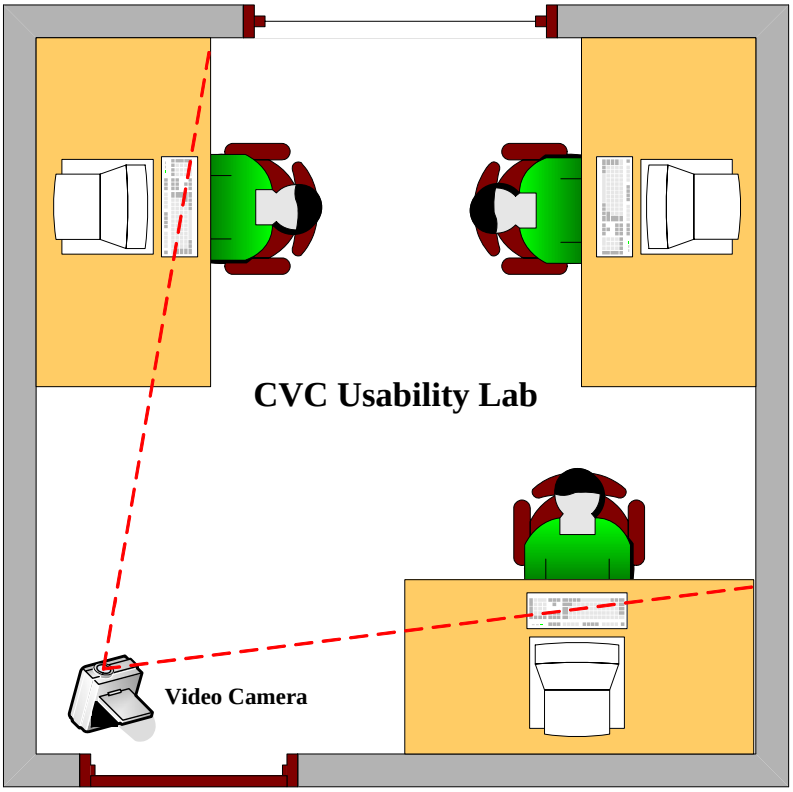
The VFPW was implemented using three networked computers in the Collaborative Visual Computing’s usability laboratory (See Figure 21 below), at the Department of Computer Science, University of Cape Town. While all the computers ran the client of the Unreal 2 Engine required to access the virtual world, one of the computers was also utilized as the hosting server.

5.4.1. Research setting

The CVC usability lab is a small room at the Department of Computer Science, dedicated for experiments and usability evaluations. It contains three desks with networked desktop computers and usability equipment. The desks were arranged facing opposite sides of the room. When standing in the doorway two desks were arranged left and right next to the wall furthest from the door, while the third desk faced the wall on the doors side (See Figure 21). This was done to inhibit the participants from looking at one another’s screens, as the aim was to facilitate their interactions within the virtual world. Although the Unreal 2 Engine supports remote audio collaboration between players for distance play, this had not been implemented. The close collaboration of students using a small cluster of computers in close proximity was regarded closer to their more natural means of

interaction: “In addition, the discourse is not computer mediated; the face-to-face interaction provides richer, clearer, more intuitive evidence for what is taking place” (Stahl, 2006c, p. 295). This also made it possible to capture this dialog on the video camera for analysis.

Figure 21. **The CVC usability lab implementation space**



The video camera was positioned in the doorway so that it captured all three participants; their behavior and dialogue (red lines for video camera’s field of view in Figure 21). However, only the one computer screen of the desk right, next to the wall furthest from the door, was captured by the video camera. This participant played the role of the camera person and capturing their computer screen was important for the later synchronization of the interactions captured inside the virtual world using the “demo” functionality, with the interactions captured outside in the CVC lab using the video camera (See 5.4.5).

5.4.2. Participants

The students participating in both groups recruited for the VFPW implementation attended the third year production program at the Centre for Film and Media Studies at the University of Cape

Town. They were full-time students recruited from the LT assignment class. The volunteers from the class represented a diverse ethnic sample of the student population. Furthermore the equal number of sexes represented would suggest that the sexual bias of the visualization prototype (See 5.3.2) had been overcome. The students in Group 1 consisted of a black female, white female and Indian male between the ages of 20 and 22. The students in Group 2 consisted of a colored female, white male and black male between the ages of 19 and 22. The two groups of three students participated in the VFPW on two separate days and each session with a group lasted approximately two hours.

5.4.3. Participants' tasks

The participating students were each provided with printout copies of the Players (See Appendix 8.6), Avatar choices (See Appendix 8.7) and Props (See Appendix 8.8). The students were instructed to closely follow the same requirements of the "Alan makes breakfast" assignment in which they had participated, however, this time through the medium of the VFPW.

5.4.4. Research methodology

The research methodology that emerged in the visualization prototype (See 4.3.3.4) had proven itself and was compatible with the methods employed in the studies of Barab et al. (2002) and Roussou's (2004a, 2004b, 2008). It was therefore again adopted for the VFPW. Following the lessons learned from the visualization prototype implementation some amendments were made to the participant observation, semi-structured interviews; and the data selection and analysis.

5.4.5. Participant observations

The researcher conducted participant observations of the lectures, workshop and the initial group's production activity of LT assignment. The researcher took notes and recorded the audio of these lessons on an mp3 voice recorder, while participating in the lectures and workshop. The initial group's production activity of LT assignment, prior to the user-centered design of the VFPW, was video recorded in the physical location selected by the students for the production of their LT. The activity took place in various rooms of the location and the activity was therefore recorded by the researcher using a mobile video camera. The researcher participated and recorded the important production activities that took place over the two days of the production. This data facilitated the delineation of the learning activity 1 (See 5.1) and the object-historical analysis of LT learning activity 1 (See 5.2).

After the user-centered design of the VFPW, the participant observations again served the dual goal of facilitating the learning activity 2, while making reliable observations within the virtual world. The participants' interactions were video recorded in the usability lab (See Figure 21) as well as within the virtual world using the "demo" functionality provided by the games engine. However, as a result of the technical demands made on the researcher during the visualization prototype (See 4.3.3.5), it was decided to program the "demo" functionality to automatically record one minute instances from the camera person avatar's virtual camera. This would provide a minute by minute record of the interactions taking place within the virtual world from the perspective of the camera person. Having one minute intervals of "demo" recordings would also make it easier to synchronize the "demo" recordings with the video record from the video camera in the usability lab. This would facilitate the analysis of the two attentional spaces the participants were occupying, as synchronizing the two recordings in time would enable the researcher to consider the participants dialogue from the perspective of their interaction in the virtual world.

5.4.6. Semi-structured interviews

After each of the groups had completed their LT assignment within the VFPW the researcher conducted semi-structured interviews with the group of participants. The CVC lab setting, which the group already occupied, was used to conduct and video record these interviews for later iterative analysis. The semi-structured interviews of the storyboarding prototype implementation (See 4.3.3.6) had proven that this method had facilitated the clarification of observations made during the execution of the groups' learning activity. Interviewing the group furthermore facilitated the discussion and negotiation of group consensus regarding the events which the researcher identified for clarification. The researcher utilized the activity system as framework for structuring the semi-structured interviews, identifying contradictions and guiding questions to clarify these tensions in the learning activity system. This was found to be a more productive strategy than the initial list of questions developed for the semi-structured interviews of the storyboarding prototype implementation (See 4.3.3.6).

5.4.7. Data selection and analysis

The primary form of data collected for analysis was the video recordings taken of the participant observations and semi-structured interviews. This data was found very valuable in providing the researcher with a detailed record of the learning activities that could be iteratively analyzed; furthermore, the concepts of activity theory and the activity system model had proved

themselves as vocabulary and concepts for categorizing and commenting the interactions selected from the video record during the storyboarding prototype implementation (See 4.3.3.7). The video record of the initial group's production activity of LT assignment, as well as video records of the two groups participating in the learning activity in the VFPW was therefore analyzed using this same method.

The total video record of the initial group's production activity of LT assignment, prior to the user-centered design of the VFPW, was approximately two hours long. The total time of the production was approximately 8 hours, 4 hours in the afternoon of day 1 and 4 hours in the morning on day 2. However, as most of this time had gone towards logistical arrangements for the production (arranging the location, props, food, actor, etc.). The researcher had recorded only the important production related activities. The actual video record of the learning activity was of shorter duration. This video record was again marked, commented and extracted into meaningful sections using the video editing software (See 4.3.3.7). The most exemplary segments, which emerged from the activity theoretical analysis of the data and supported the analysis developed in this text, were selected and transcribed (See excerpts 5.4.11). This excerpt makes up approximately 4 minutes (3%) of the total 2 hours of the video record.

The video record of the two groups participating in the VFPW learning activity had also been analyzed and selected as described for the initial group's production activity of LT assignment above. However, the analysis was taken a step further by splitting the most exemplary segments, which emerged from the data and supported the analysis developed in this text, into one minute segments. The one minute "demo" recordings from the virtual world could then be extracted and synchronized with these one minute exemplary segments. These segments were then transcribed (See excerpts 5.4.8, 5.4.9 and 5.4.10). These excerpts make up approximately 6 minutes (3%) of the total 4 hours (2 hours x 2 groups) of the video record.

5.4.8. VFPW Group1 Story development excerpt

Kevin is the actor.

Sandy is the camera person.

Nancy is the director.

1. *Nancy: Teddy bear, cereal, lets make breakfast*
2. *Kevin: Alan makes breakfast*
3. *Nancy: No, we can have like a*

4. *Sandy: What can you do, what can YOU do?*
5. *Nancy: Girl, don't you want to be a little girl with a teddy bear*
6. *Sandy: Lets see*
7. *Nancy: Trying to make like the last one (previous LT assignment)*
8. *Kevin: If I have to a girl again, that's what I'll have to do (pause) I sacrifice for my art (break)*
9. *Kevin: (Looking at the avatar options printout) I like the dude with the afro*
10. *Sandy: He's pretty cool (pointing at the bald avatar)*
11. *Nancy: Which guy?*
12. *Sandy: A bit sinister*
13. *Kevin: He looks like a dead guy (pause) ok, ill be the dead guy*
14. *Nancy: This is like SIMS (referring to the SIMS leisure game)*
15. *Kevin: I want the gun (pause) and the cell phone*
16. *Nancy: Oh no*
17. *Kevin: I'm going to be a hitman*
18. *Nancy: Are you going to be a hitman?*
19. *Kevin: I'll be a hitman*
20. *Nancy: Making breakfast*
21. *Kevin: Yes*
22. *Sandy: Yeah*
23. *Kevin: I'll be (looking at prop list) I'll have a cell phone, a gun, a briefcase with stuff in*
24. *Sandy: a dead body (pause) ha, ha*
25. *Sandy: And a teddy*
26. *Kevin: And a teddy bear*
27. *Sandy: Ahh*
28. *Kevin: I'll be a new age (sensitive) hitman*

5.4.9. VFPW Group2 Story development excerpt

Karin is the director.

Johny is the camera person.

Angus is the actor.

1. *Angus: The corpse is in the bath*

2. *Johny: Ok, can we get a story*
3. *Johny: He comes in (pause) from the outside, we've got that shot already (pause) into the bathroom*
4. *Johny: In the bathroom he sits and he*
5. *Angus: There's a corpse in the bathtub, but he, just doesn't like care, he just goes and*
6. *Karin: Its magical realism*
7. *Angus: Yes, he doesn't, ja*
8. *Karin: Yes, he doesn't care*
9. *Author: Magical?*
10. *Karin: Realism, where there is something absurd, completely extraordinary happening but*
11. *Author: But he doesn't notice it?*
12. *Karin: It's treated like common day*
13. *Angus: Well he notices, but like, it is just normal*

5.4.10. VFPW Group1 learning activity 2 kitchen development excerpt

Kevin is the actor.

Sandy is the camera person.

Nancy is the director.

Kevin’s avatar is positioned in front of the stove in the kitchen.

1. *Kevin: How (pause) how's is this shot Sandy?*
2. *Sandy: (Framing actor with pan in front of the stove) Um, ok, now it looks fine*
3. *Kevin: Look I'm cooking (presses 5 for the cooking animation)*
4. *Sandy: Do it again*
5. *Kevin: Oo hoo (plays cooking animation again)*
6. *Sandy: (Finding the cooking animation amusing) Aaaaa (pause) ha!*
7. *Nancy: Ha Ha!*
8. *Kevin: Yeah baby*
9. *Kevin: Spank my pan*
10. *Sandy: Ha Ha!*
11. *Nancy: Ah ha (pause) Kevin*
12. *Nancy: Ok, what else do we need*

13. *Sandy: Uh (pause) ok (pause) can you put anything else on the counter to make it less boring (looking at counter)*
14. *Kevin: Um*
15. *Nancy: Um (pause) yeah (pause) ja (pause) can*
16. *Sandy: (Looking for the print out of props) Let's pause and see what else*
17. *Nancy: there (pause) there*
18. *Kevin: This is fun*
19. *Nancy: Its (pause) um*
20. *Kevin: (Looking at the printout of props) Beer*
21. *Nancy: Oh my God*
22. *Kevin: I don't think I am a beer type though*
23. *Sandy: Ah (pause) sugar*
24. *Kevin: D (pause) director lady (pause) am I the beer type?*
25. *Sandy: I don't think you are the beer type*
26. *Kevin: No*
27. *Sandy: No I don't*
28. *Nancy: Ok, no beer (pause) sugar*
29. *Sandy: Sugar (pause) ja*
30. *Kevin: Sugar*
31. *Sandy: And a tea cup (pause) and a tea saucer*
32. *Sandy: They have a*
33. *Kevin: Pity we don't have a*
34. *Author: I've got a plate*
35. *Sandy: Ja*
36. *Author: which is small (pause) but you can use it as*
37. *Sandy: use it as a saucer*
38. *Author: cup holder*
39. *Nancy: Ok, then the plate (looking at the prop list) (pause) which is (pause) coming*
40. *Kevin: And we do have a microwave (paging through prop list) (pause) no?*
41. *Sandy: Ja, we do, but (pause) but you are frying your eggs*
42. *Kevin: Ok*
43. *Sandy: Whoa (pause)*
44. *Nancy: Oh yes there is a microwave*

45. Sandy: *Ja, but I don't think we need it (pause) if he is frying the eggs*
46. Sandy: *And then what do you do (pause) after you've fried the eggs (pause) leave (turns camera from actor to the door)*
47. Kevin: *Do you want me to do it*
48. Sandy: *Ok , wait*
49. Sandy: *So he comes from here (turns camera to frame the fridge on the right of the kitchen)*
50. Sandy: *do (pause) do (pause) do (turns camera left panning over the counter at the back of the kitchen, the path the actor will walk)*
51. Kevin: *this guy needs (pause) a bit better acting*
52. Nancy: *Ok, the tea diapered into the microwave*
53. Author: *Oh dear (pause) cause (pause) that means you picked up more than one thing (pause) so, ja (pause) if you press P (pause) it just (pause) will stop one of them (pause) and then if you can pick the other one away*
54. Sandy: *The tea is still floating there*
55. Kevin: *I think I will go pick up my teddy*
56. Nancy: *I don't want this here (moves microwave away and deletes it)*
57. Sandy: *Which way should we, um, pan?*
58. Sandy: *When we go from the fridge to the stove (turns camera from fridge to the stove right, panning over front of kitchen)*
59. Sandy: *To reveal the apartment or to reveal the kitchen?*
60. Kevin: *Um (pause) just explain quickly (pause) just do it*
61. Sandy: *Either like (pause) this (turns camera from fridge to the stove right, panning over front of kitchen)*
62. Kevin: *M (pause) Hmmm (looking at Sandy's point of view)*
63. Sandy: *Or like this (turning camera from fridge left panning over counter at the back of the kitchen)*
64. Nancy: *Fmmmmf (looking at Sandy's point of view) either*
65. Sandy: *And that way we can cut out a lot of the apartment (pause) if we do it the other way (framing the back counter in the kitchen) (pause) there can be something here (pause) happens to be*
66. Sandy: *I think we should go via the kitchen though because then*
67. Kevin: *We can (pause) we are going to be walking through the*

68. Nancy: *Ja, we will walk through there (pause) basically*
69. Kevin: *Ja, that's fine*
70. Sandy: *Ja, but then there should to be something revealing in the kitchen (framing the back counter of the kitchen again) over here where this large empty space of shelf counter*
71. Kevin: *So, should we put something there?*
72. Sandy: *The briefcase!*
73. Sandy: *Depends where*
74. Kevin: *I wonder if, we can like (pause) hide the gun*
75. Sandy: *you mean so that people can notice it if they want to*
76. Kevin: *Ja*
77. Sandy: *Behind the counter here (framing the counter)*
78. Kevin: *You know like (pause) or (pause) or like (pause) behind the briefcase (pause) so that (pause) so that when they (pause) they want to they see, oh there, what's behind the case*
79. Sandy: *Ja, ok, (To Nancy) try and put the gun behind the counter (pause) like*
80. Nancy: *The gun (puts gun on the top of the wall shelf)*
81. Sandy: *Gun (pause) no, down there (pause) like here (pause) where I am looking at now with my camera (using the camera frame to show Nancy where she wants the gun)*
82. Nancy: *Ok (using Sandy's point of view to see where to put the gun)*
83. Nancy: *There?*
84. Sandy: *(moved to the right, closer to the fridge, to see if gun is visible from where the camera will start the move to the stove) Down of the floor*
85. Nancy: *Oh there (positions gun down on the floor)*
86. Sandy: *Ja, so it is just peaking out*
87. Kevin: *There we go*
88. Sandy: *People will notice it instantly because every where else is so sparse*
89. Nancy: *I can put a briefcase here*
90. Sandy: *Ja, put a briefcase there too*
91. Nancy: *Um*
92. Sandy: *Front of it or something*
93. Nancy: *There (puts briefcase on empty counter at the back of the kitchen)?*

94. *Sandy: Ok*
95. *Nancy: Or more here (moves briefcase towards gun)?*
96. *Sandy: Crouching (frames fridge and practices crouching, but presses the jump button) whoops*
97. *Sandy: Shift crouch (presses crouch button)*
98. *Sandy: Here (practices framing and panning from fridge to the stove, turning left and framing the back counter of the kitchen) then filming that way*
99. *Sandy: (Moves camera to frame the actor for the close up in front of the stove) and then we get up to follow him*
100. *Kevin: (Making actor jump up and down) Hmm (pause) hmm*
101. *Sandy: Then he is making his eggs (turns camera left panning from the camera to the door)*
102. *Sandy: Then he goes that way (moves camera towards the door) door*

5.4.11. LT learning activity 1 kitchen development excerpt

Angus is the director.

Danny is the camera person.

Karin is the actor.

Danny stands in kitchen facing lounge through open plan, while Angus is standing in the lounge facing him.

1. *Angus: Can we figure out what we are going to do here (kitchen)?*
2. *Danny: Ja, lets fi (pause) ok*
3. *Angus: So we have to see the toast (points at toast to his left) and we have to see that picture on the fridge (points to fridge on his right)*
4. *Danny: Ja (point at picture to his left) so*
5. *Angus: So see the picture on the fridge as we come in*
6. *Danny: Oh ja (pause) yes, yes, yes (pause) as we come in*
7. *Danny: So (moves to the door on his right and frames the picture on the fridge from there) Ok, I'll get the picture*
8. *Danny: Move to this side (Moves camera to his left to frame the toaster) the toaster (pause) it will be on this side (pause) or where will it be?*
9. *Angus: It will be there*
10. *Author: there*

11. Danny: and (starts moving camera, panning right)

12. Angus: and she'll make the toast (pause) she's going to take the toast out

13. Danny: ok (moves back to frame toast) so like

14. Angus: She's gonna (pause) she's gonna put marmalade on it

15. Danny: Ok

16. Author: Here? (pointing at the plate where toast will be put)

17. Angus: Ja

18. Danny: So, I'll come like this (moved back to kitchen door to frame the toaster) she'll make the toast, put the marmalade on

19. Angus: That's going to be boring (pause) hey (pause) how are we going to do that really quickly? (break)

20. Danny: I don't think (pause) lets (pause) lets not even make, the toast pop up

21. Danny: Lets just like make her take the toast out and put marmalade on

22. Angus: Ja, we are not going to have it popping up

23. Danny: Ja, ok

24. Danny: So

25. Author: but that's gonna (pause) I mean putting that on takes about, what (pause) thirty seconds

26. Angus: Ja, that's the thing

27. Danny: Mmm, that's true

28. Author: It takes a while

29. Danny: Well, lets leave (pause) it (pause) maybe she just shouldn't put the marmalade on at all?

30. Danny: Just like

31. Angus: Karin

32. Angus: Its going to take to long to put marmalade on

33. Danny: It will take a bit

34. Karin: It's going to take to long to put marmalade on?

35. Angus: It's going to be like thirty seconds of

36. Danny: just marmalade

37. Angus: dead marmalade putting on

Karin moves to toast and starts putting marmalade on the toast.

38. Angus: This is you, Karin

39. Author: Ja

40. Karin: No, no, no (pause) don't worry (pause) no

41. Angus: She's not going to

42. Author: Speedy Gonzales

43. Karin: She's doesn't need to

44. Angus: Because we are gonna do it for her (pause) she just cuts it

45. Karin: Yeah

46. Author: Oh cool

47. Angus: Oh, its going to be so hard to cut though the(toast was burnt on purpose)

48. Karin: She doesn't need to, she just does that (dabs toast with knife) and then she can just open it a little (the marmalade) and just dab, because there is on (pause) lots on already

49. Angus: We (pause) we don't see

50. Danny: I haven't seen this much marmalade before in my life (pause) so

51. Karin: Eeeu (pause) jeez this is gross

52. Author: Cause how long does it take to actually walk right through (the long take) (pause) cause maybe there is time to kill (pause) to actually (pause) thirty seconds

53. Angus: But still (pause) we don't want to kill the audience with boredom like

54. Danny: Ja, we don't wanna (break)

Danny is practicing framing and camera moves with the camera while Karin has entered the kitchen to help Angus sort out tea props on the open plan counter between the kitchen and lounge.

55. Angus: How many (pause) how many (pause) a (pause) teacups? Is she just making breakfast for him? Is she (pause) is she not having tea herself?

56. Karin: (While putting the kettle down on the tray) No, she is going out remember

57. Angus: (Picks up the teacup from tray) want me to take it (teacup)?

58. Karin: No, go here (pointing to tray for Angus to put the teacup down)

59. Karin: (Pointing at the other side of the kitchen behind her) There's the other one, that (pause) she has to drink this

60. Angus: Oh (pause) oh

61. Danny: So (pause)

62. Angus: We don't need this little jug (takes jug from tray and puts it on counter)

63. Karin: Hmmm?

64. Angus: We don't need that little jug

65. Karin: No

66. Angus: is just as well

67. Karin: its ok, I'll check it (lifts up the tray to see how heavy it is)

68. Karin: (Puts down the tray) got to check it a bit later

69. Angus: Um (pause) is she left handed or right handed?

70. Angus: How is she going to take the pot?

71. Danny: So I am going to move like this, right

72. Danny: (Moving the camera to the kitchen counter where granny will make toast) She's going to make the toast

73. Angus: M (pause) Hmm!

74. Danny: Aaah (pause) She's going to turn (pause) as she turns, I'll come (pause) ok, Karin

75. Karin: Sorry Danny, hmmm (pause)

76. Danny: So, she's gonna (pause) will be here by the toast, right

77. Danny: Pretend, do you like know the actions (of the actor)

78. Danny: So do it (pause) you need to do it so I can try (camera move and framing)

79. Karin: She comes in here (moves and stands in door of kitchen), right

80. Angus: You catch the picture (pointing at the picture on the fridge the granny's grandson had supposedly drawn)

81. Karin: (Also pointing at picture) catch picture (break)

82. Karin: (Turns to the door, while indicating with her hand to the toaster on her left) popping sound (walks out kitchen)

83. Karin: (Walks into kitchen) Comes in, maybe it pops

84. Karin: (takes out toast and puts it in plate) She takes it out, puts it down

85. Danny: (framing kitchen on the other side of kitchen, says to Angus) It looks good (the mise en scéne)

86. Karin: (Turns to the open plan counter) Goes this way, fiddles here

87. Karin: (Gesturing with hands behind her) Things behind her, she feels a presence

Danny moves behind Karin and frames her with the camera over the shoulder from behind.

88. Karin: (Turning to her left towards Danny) She turns this way (break)

89. Karin: (Gesturing towards Danny with hand) And then

90. Karin: (Turns towards tray for boo moment) He's behind her

91. Karin: (Turns towards Danny to her left) She turns to look this way, right

92. Danny: (Framing Karin) Mmm (pause) Mmmm

93. Karin: (Looking past camera and Danny like rehearsed) And she sees nothing

94. Karin: And she's forget it (shaking head and shrugging shoulders while she turns back to toast on the other side)

95. Karin: (Picks up knife and dabs already marmalade toast) and she caries on and she is here

96. Danny: (Moving to the open plan side while turning camera towards Karin preparing for the pass) And (pause) and then

97. Karin: And she picks this up (Picks up toast on the plate and turns towards kitchen door, then pauses)

98. Karin: Gets passed there (Pointing towards the open plan and Angus) you need to pass it

99. Danny: So (looking at Angus lifting camera and extending it to Angus)

100. Angus: Jo, as she (pause) she disappears, then you pass (Gesturing towards the kitchen door with his hand) just (pause) just before she (points again at the door)

Danny is looking at Karin, while she is pulling a frown at Angus.

101. Angus: You know what I am saying? Cause other wise (pause)

102. Karin: Um

103. Angus: you don't want to waste

104. Karin: Ja

105. Angus: Peggy time

106. Karin: Um (looks at Danny) you don't want dead space

107. Angus: So we minimize the lack of character

108. Danny: So as she walks out the door we pass?

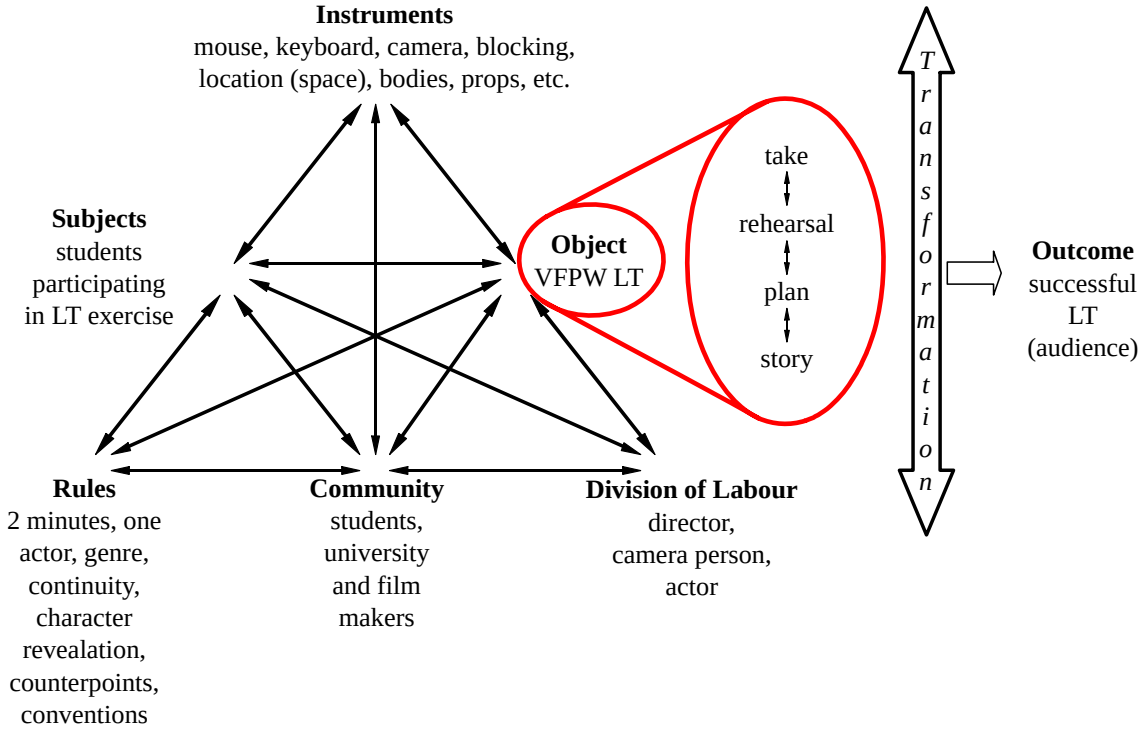
109. Angus: Ja, just, lets practice it

5.5. VFPW LT learning activity 2: Object-historical analysis

The VFPW LT learning activity 2 (LT2) required students to produce a LT movie under the same requirements as they had under learning activity 1 (LT1) and therefore the rules of the activity remained the same. However, due to the complexity of the LT1 activity, the transformation of the

object not being represented during the analysis (See 5.2.1) and the practical requirements of the scope of the implementation; the VFPW was designed specifically to facilitate the delineated planning stage of the LT2 activity. The planning stage, however, does not occur in a vacuum. It is reciprocated by the development of the story, rehearsal of the plan and the shooting of the takes. However, the students were not required to edit the LT and therefore the script and voice over was not produced. Notwithstanding students were encouraged to take the development of counterpoints into consideration whilst planning the LT in the VFPW. As a result the VFPW LT activity system representing the stages of the object, in Figure 22, clearly does not include all of the stages observed in the initial learning activity (LT1, Figure 18). In addition this meant that the second learning activity (LT2, Figure 22) required the students to fulfill fewer roles, i.e. no editor and script writer were required.

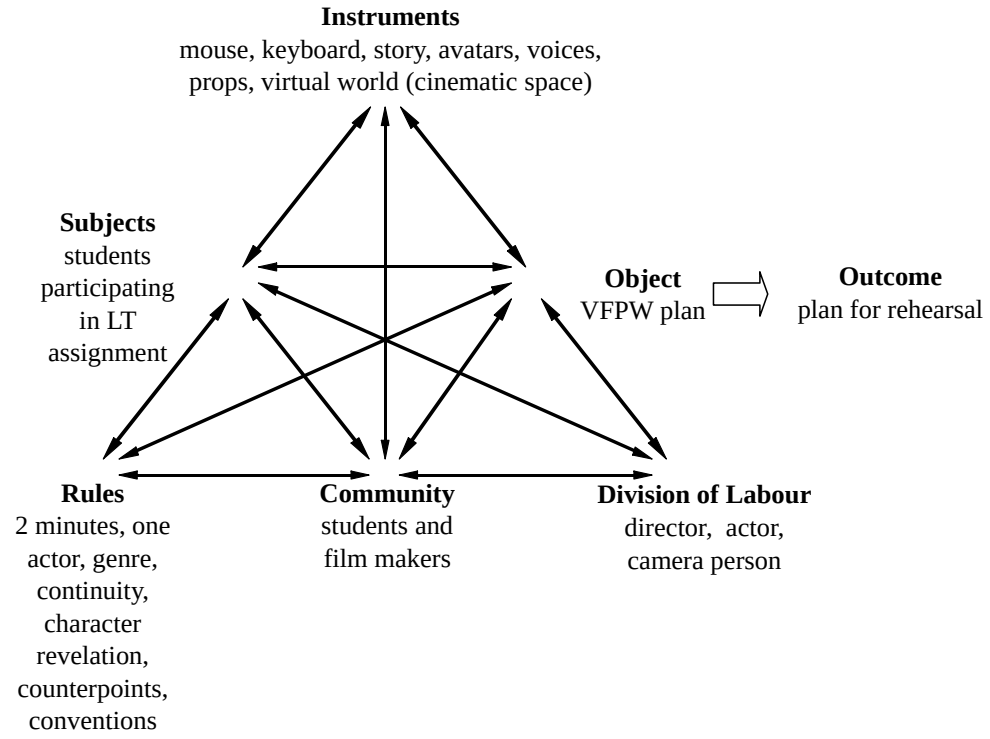
Figure 22. **The VFPW LT activity representing the stages of the object**



The VFPW LT activity system in Figure 22 represents the reciprocal transformative stages of the LT object in the virtual world. However, as with learning activity 1 (LT1) *the VFPW learning activity (LT2), does not represent the transformation and movement of these stages of the object in its position and role within the activity system* (See 5.2.1). The LT2 object in the case of Group 1's story

developed from the printouts of the content of the virtual world (See Appendix 8.5, for screenshots), the actor's possible avatars (See Appendix 8.7.2) and the props available (See Appendix 8.8) to the students. Group 1's story for example originated with their initial consideration of the props available to them. The students considered the teddy bear and briefcase props first; and then the actor's avatar was considered in relation to these props. First it was suggested that the actor should be a girl, however, the male student playing the actor decided to play the "sinister looking dude". Further exploration of the props reveal a gun and the concept was developed for a sensitive hitman, as character to be revealed while "Alan" is making breakfast (See excerpt 5.4.8 for this interaction). The second group developed their story by exploring the virtual world. Group 2 started intuitively producing an opening shot of the actor walking and entering the house. In the meanwhile the director had placed many objects in the world, which the actor starts to describe. As the camera person enters the house and the bathroom they verbalize ideas of what the actor could be doing. The actor then builds on these ideas to develop the concept of magical realism. The props placed by the director and narrated by the actor and camera person mediated the creative development of the story (See excerpt 5.4.9 for this interaction). As with the LT1 (See Figure 18), the planning and rehearsal stages reciprocated the development of the story. However, for the purpose of this text and the user-centred design of the VFPW, the scope of analysis had been narrowed to the second stage activity system, i.e. the plan (See Figure 20). The analysis of learning activity 2 will therefore also be delineated to focus on the planning stage of the VFPW LT2 learning activity. The planning stage of the VFPW LT as constitutive activity is graphically represented in Figure 23.

Figure 23. **The planning stage of the VFPW LT as constitutive activity**



The planning stage of the VFPW LT2 represented in Figure 23 revolves around the development of the VFPW's plan as its collective object. The story, student's avatars and voices, the props and the virtual world as a cinematic space, are all instruments that reciprocate in the students' production of the plan for the LT in learning activity 2. However, the virtual world was the most fundamental instrument binding the other instruments together. Furthermore, the VFPW introduces another level of mediation, as the students' interactions in the virtual world are also mediated by the computer instruments of the mouse and keyboard. The students were instructed to follow the requirements of "Alan's breakfast" assignment and consequently the rules were the same as the LT1 activity, i.e. that the LT should be approximately 2 minutes and contain one actor, which character is revealed through his actions. The students also draw from the film genre and conventions of the film community. The labor of the planning activity is divided between the three roles designed for the VFPW, i.e. director, actor and camera person. Although these roles were strictly enforced by the system and the abilities of the players were constrained by their roles, the director's responsibility of directing action was sometimes taken over by other players. It was found that the actor in Group 2 and camera person in Group 1 sometimes took the responsibility of directing the action.

Notwithstanding, the roles played by students can be categorized according to these three roles. The camera person operated the virtual camera, using the mouse and keyboard keys, moving the camera in the virtual world to best frame and block the actor's avatar. The actor navigated the virtual world, using the mouse and keyboard keys to perform the appropriate actions and interactions with the props. The director positioned the props in the appropriate locations in the virtual world and provided special effects, by using the mouse and keyboard keys. Again the interaction between these roles is best described as choreography between the participants. It develops the VFPW planning activity as one movement through the participant's interactions within the virtual world, its cinematic space and props (See excerpt 5.4.10 for VFPW Group 1's development of part of the plan).

5.6. Comparative evaluation of the planning stage of the learning activities

The planning stage of the VFPW LT2 represented in figure 23 closely resembles that of the planning stage of LT1 represented in Figure 20. The greatest difference between LT1 and LT2's planning stages, according to the activity system triangles developed, appears to be the instruments used in producing the two respective plans. Both learning activities share the story as an instrument for the development of the plan, for the production of the LT. However, the story within Group 1's planning activity in the VFPW derives from the virtual world's content, the actor's selection of the avatar from those available and the props that could be utilized (See excerpt 5.4.8). This is a subtle inversion of the LT1 interaction between story and planning, where the LT1 story object had been developed prior to the LT activity. In LT1 the story leads to the search for an appropriate location and the resources needed for planning. The story in LT2 developed from the given VFPW content. This inversion becomes more explicit when we consider Group 2's story development where the story develops from exploring and interacting within the virtual world (See excerpt 5.4.9). As with the storyboarding prototype it would seem that the virtual world requires the students to be creative within the constraints of the given virtual world. This constrains their imaginations, yet provides the context and information they require to plan the LT. When the world was not a given, as in learning activity 1, the students searched a selected an appropriate location and props to tell their story. As with the storyboarding prototype the actual concrete context in necessary for the formulation of the plan. It provides form to the students' imaginations and facilitates the concrete decisions that the students need to make in planning the realization of the story. However, the logistics of finding and organizing the location and props took up the majority of time during the initial production activity of LT1 (6 of the total 8 hours, see 5.4.7).

During the post-interviews with members from Group2, students reported that the VFPW provided opportunities to think creatively out of the box. In the words of one of the students: “Another thing like, besides like, putting in a already, like planned or evolved idea into practice, this could also be a way of coming up with ideas, like … like if you don't really have an idea yet; and it is like a week before the shoot, you can kind of mess around and this actually stimulates ideas ... that you might not have had without this”. A virtual world is very different to that of our everyday experience. Developing a virtual world which seems similar to that of our everyday experience is a challenging feat. A simple thing like having a cup rest on a table involves complicated collision detection and calculations of specially developed physics engines. This had not been implemented in the VFPW and students could consequently have props float in space and move through walls. This unreality encouraged the students of Group 2 to explore this otherness and incorporate it in their story. Exactly because the virtual world is not like the “real world” it facilitated their creativity. Group 2 develops their story around “magical realism”. Magical realism is a artistic genre applied to film whereby there is something completely extraordinary happening in the world but it is treated as absolutely normal and/or not noticed at all; for example the beginning of the movie “Shaun of the Dead” (Wright, 2004).

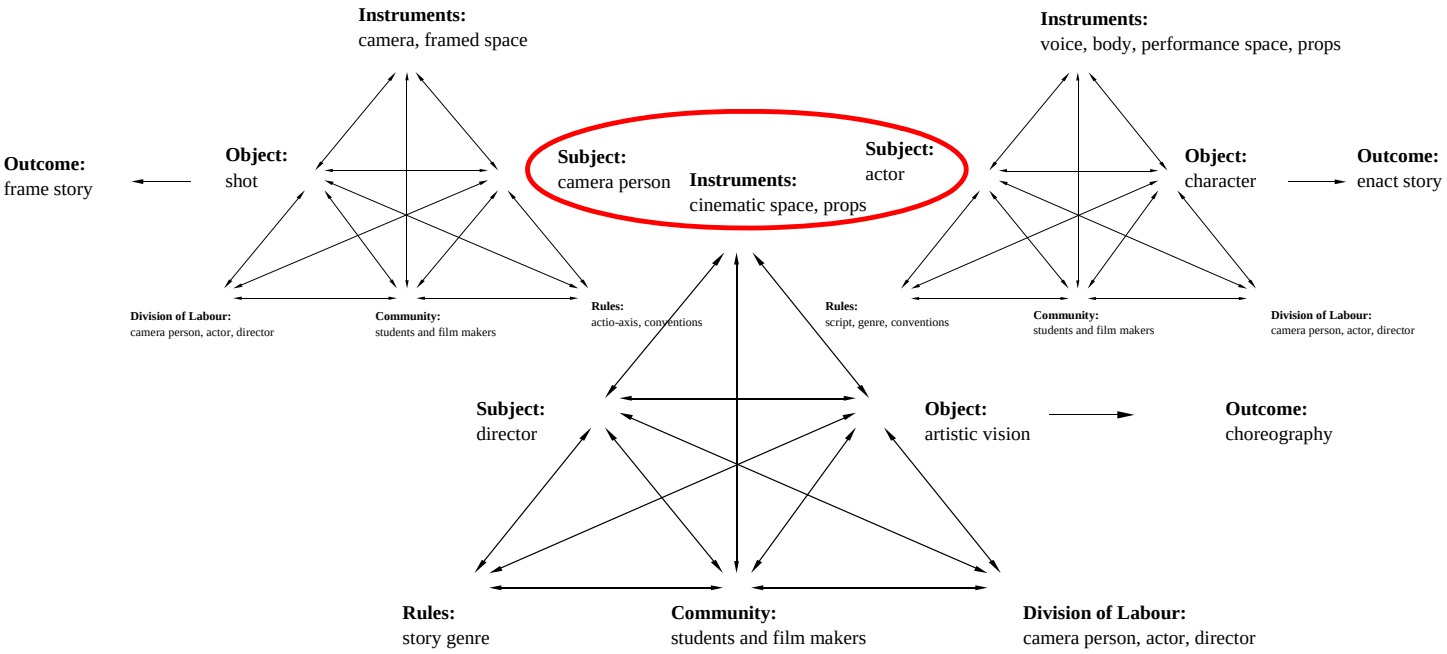
Despite these subtle differences the two learning activities’ structures represented using the Engeström Activity System (EAS) triangle is very similar. The students participating in the LT1 assignment develop the plan for embodying the story in the selected location using their bodies, props, the physical space and a floor plan; whilst the students participating in LT2 use the their avatar’s virtual bodies, props, and the virtual space to plan their LT. However, the VFPW introduces another level of mediation, as props, avatar and virtual camera are themselves also mediated by the computer instruments of the mouse and keyboard. The subjects, rules, division of labor, outcome and community are also the same. Considering the objects of the activity it would seem that they are the same, i.e. the plan for producing a LT moving image. It would seem that the VFPW had overcome the problem encountered in the storyboarding prototype, of comparing two closely related activities rather than the same activity in two different situations. Had this text and the dialectical method developed in chapter 3 succeeded in practically demonstrating a basis for the comparative evaluation of learning activities in virtual worlds? Or do the activity systems appear to be similar because of the analytical frame utilized, its representation or the unit of analysis it implies? Considering the two learning activities (LT1 and LT2) it became clear that the interactions between participants were not represented in Figures 20 and 23. The planning and careful choreography necessary for the two

planning activities are not clearly represented in all their complexity. What was needed was an intermediate level of analysis, where the participant's individual activities were also represented within the collective activity. *The problem with the EAS is that it does not represent the interaction between the participants in collective activities.* It was therefore decided to revert back to, and reconsider the original planning stage of the LT1 learning activity, however, represented as a constitutive activity (See Figure 20).

5.6.1. The interactions between participants are not represented

The dynamic interaction between the director, camera person and actor determine the plan and lies at the heart of the LT activity system. This interaction is not represented in the planning stage activity system (See Figure 20). Again an attempt was made to overcome this challenge by "breaking-up" the collective activity system into multiple smaller constitutive activity systems. Each of these activity systems represented one of the individual activities performed by the students in their respective roles (camera person, actor and director) in the LT planning stage activity system.

Figure 24. **The interaction between LT planning stage activity systems**

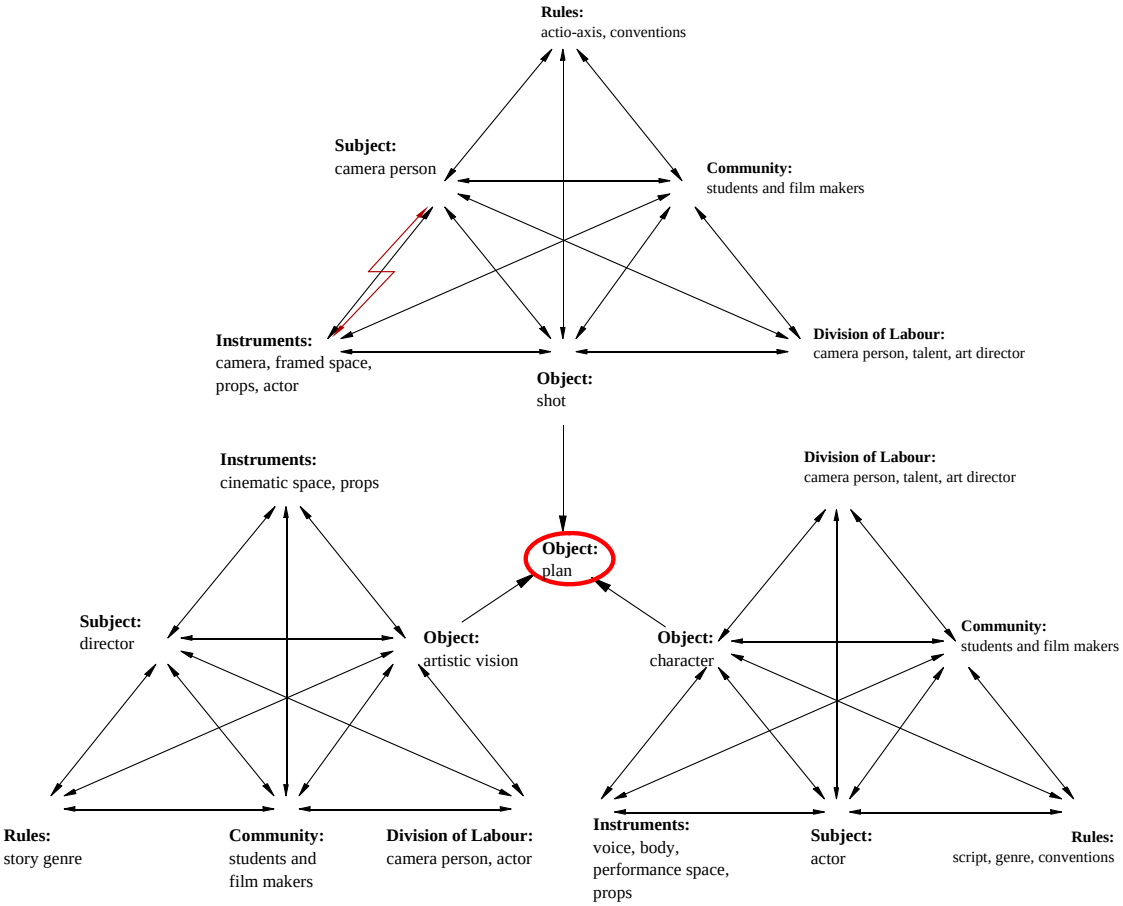


5.6.2. Representing the collective object

However, despite now clearly representing the respective roles, Figure 24 *does not represent the collective object of the planning stage activity system*, i.e. plan. Each of the activity systems

associated with a role has a unique object that the subject of that activity system is transforming. The actor is using his/her body to produce the character, the object of the actor's activity. The shot is the object the camera person is producing using the camera as instrument to frame the performance. The director produces her/his artistic vision using props, cinematic space, the actor and camera person as instruments (red ellipse, Figure 24). However, this significantly reduces the contribution the camera person and actor makes to the planning activity of the LT assignment. All three participants interact dynamically, reacting and building on one another's ideas and suggestions. It is truly a collaborative activity where all participants are contributing equally to the production of the plan. Taking inspiration from Figure 9, "Two interacting activity systems as minimal model for the third generation of activity theory", an alternative configuration was developed, arranging the three activity systems around a collective object (highlighted by the red ellipse in Figure 25).

Figure 25. **The collective object between the LT planning stage activity systems**



Although the shared object is successfully represented in Figure 25, *the individual outcomes for the subject's individual objects as represented in Figure 24 are lost.*

5.6.3. Representing the interaction between activities, mediators and objects

Using multiple activity systems to represent the constitutive activities of a collective activity system (See Figure 24 and Figure 25) *introduces the further problem of indicating the relationships between these activities and also the interaction between these activities' objects and mediators.* In the LT1 planning stage activity system the production space played a very important role in mediating the coordination of the activity. The contradictions between the camera person's framed space vs. the actor's enactment space vs. the director's cinematic space, constrained *and* drove the plan's development (See the excerpt 5.4.11). This contradiction is not represented in Figure 25; and such in-between activity system contradictions are difficult to represent, none the less, they play a significant role in driving the larger activity system.

The interactions between the participant's individual activity systems, participating in the VFPW is also difficult to represent using the EAS triangular representation. For example the camera person in Group 2 had not had much experience in manipulating the virtual camera using the mouse and keyboard. This meant that the student playing the camera person had difficultly with the operation of the virtual camera early on in the activity. This had a significant impact in constraining the collective planning activity. Clearly, the same problem could have occurred in learning activity 1 (Figure 25), if the student operating the Digital Video camera was unfamiliar with it and this had constrained the planning activity of LT1. However, what is important to take from this example is that although this contradiction between the camera person and their instrument can be represented in Figure 25 (See lightening-shaped arrow) using Engeström's lightening-shaped arrows to emphasize these contradictions explicitly (See also, e.g. Engeström 1999, p. 31). The impact of this contradiction on the collective cluster of activity systems representing the planning activity is unclear. This was also the case for the virtual world's functionality which provided participants with the ability to take the perspective of another participant's point of view and literally see what they see. This greatly facilitated the development of the plan as this functionality increased the intersubjectivity between participants. *However, representing this enlarged intersubjectivity between participants using Engeström's activity system triangle is challenging.*

These representational challenges deriving from the implementation of the dialectical method developed in Chapter 3 suggests that the EAS is not sufficient as model, and in addition to the new

methodology, a new unit of analysis and graphical model (tool) is also required. According to Vygotsky (1978) the development of method is simultaneously the prerequisite and product, the tool and the result of the study. The dialectical methodology developed in this text clearly required a new tool and model. The dialectical approach goes some way towards realizing Engeström's (1999) "need for a methodology for studying expansive cycles" (p. 35) and as he anticipates: "Key findings and outcomes of such research are novel activity-specific, intermediate-level theoretical concepts and methods – intellectual tools for reflective mastery of practice" (p. 36). This text developed just such an intermediate-level theoretical construct and tool in response to the 5 challenges identified (See 5.3.1, 5.3.2, 5.6.1, 5.6.2 and 5.6.3). The following chapter will explicate the systematic development of Activity cell transformation, before reconsidering the comparative evaluation (See 6.4) of the two learning activities (See 5.6).

6. Activity cell transformation

This chapter develops Activity Cell Transformation (ACT) a multi-focal analytic "lens" for analyzing learning activities. In addition to the individual and collective units of analysis, an intermediary lens is introduced, which focuses on the interrelationship between the individual and collective activity, i.e. collaborative group activity. The following 5 challenges emerged while using the Engeström Activity System (EAS) triangular representation during the object-historical analysis of the two planning stage activities in the previous chapter:

1. The object's transformation is not represented (See 5.3.1)
2. The static representation does not illustrate temporality (See 5.3.2)
3. The interactions between participants are not represented (See 5.6.1)
4. Representing the collective object (See 5.6.2)
5. Representing the interaction between activities, mediators and objects (See 5.6.3)

Activity cell transformation emerged from practice to respond to these challenges. Activity cell transformation as "lens", arising from practice, enables the dialectical reflection back on Activity Theory to provide new insights into contemporary Activity Theory and some of the 3rd generation theoretical challenges identified. Particularly those related to the reification of the object of activity. These will be highlighted during this exposition of the development of ACT. In developing ACT it was also though prudent to return to the original planning stage of the LT1 learning activity represented as a constitutive activity (See Figure 20). However, before explicating ACT's development, it is important to highlight that various alternatives were considered without success.

6.1. Considering the alternatives

Despite the promise of providing us with a robust analytical framework and a common vocabulary for describing human activity in context, Activity theory does not provide us with a standardized method for putting it to practice (Nardi, 1995a). Rather, Activity theory provides conceptual tools to be applied to the specifics and nature of the activity under study (Yrjö Engeström, 1993). Activity theory is itself a cultural construct, refined and transformed through the community who aims to develop and apply it in their practice. As such Activity theory is continually evolving. In response to this methodological challenge the Activity theory community has over the past decades

collaborated to develop and implement various tools and methods. This text considered some of these approaches.

Engeström (1987) in an attempt to make Activity theory more concrete expanded Vygotsky's model of mediated action, to include the social and cultural aspects of human activity. The resulting EAS diagram is generally accepted as the most appropriate representation of activities as units of analysis. Despite the advantage of visually mapping and labeling the related components of an activity system, the EAS diagrams do not provide guidance on how to go about mapping activities. Engeström (Yrjö Engeström, 1993) provides the following general guidelines for applying Activity theory in practice:

1. Focus on the collective activity system as unit of analysis.
2. Identify both internal and external contradictions 'within' and 'between' the components of the collective activity system.
3. Analyze the historical development of the activity under study.

Nardi (1995a) made the following methodological suggestions with regard to putting Activity theory into practice for HCI design:

1. The research time frame should be long enough for understanding the user's objective for engaging in the activity.
2. Attention should be paid to the broad patterns of the activity.
3. Various data collection methods should be used.
4. Commitment to understand activity from the users' point of view.

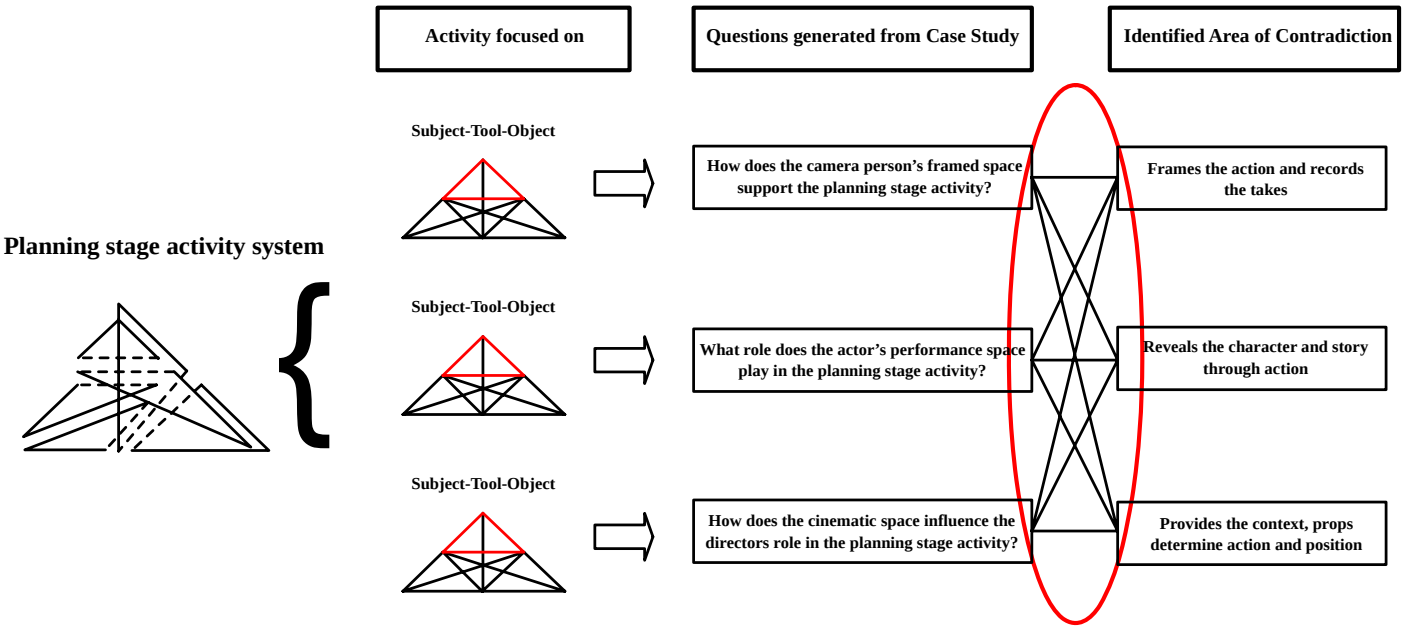
Clearly, both Engeström and Nardi's suggestions and guidelines provide insight into how we can apply Activity theory in practice, however, their suggestions is far from a standard and systematic method for applying Activity theory. It is therefore still up to the individual researcher to interpret these recommendations when applying Activity theory to their practice. The result of this is that Activity theory has been applied in HCI mostly by researchers with a background in developmental psychology, or who have invested the time and effort to come to grips with Activity theory's complex theoretical framework (Daisy Mwanza, 2002). In an attempt to make Activity theory more accessible to system designers Kaptelinin and Nardi (Kaptelinin & Nardi, 1997) held tutorials at conferences to introduce basic Activity theory principles to HCI practitioners. From their

experiences at these conferences they composed the “activity checklist” (Kaptelinin et al., 1999). Although the checklist has proven useful in structuring the fundamental principles of Activity theory and providing sample questions for analysis, an understanding of Activity theory is still needed to appropriately use the checklist. Clear mappings between Activity theory’s theory and the sample questions of the checklist are not given. Korpela (Korpela et al., 2000) undertook a project to teach HCI practitioners in the health information systems how to conceptualize health practitioner’s work using Activity theory. Korpela (2000) reports that participants found the approach and the terminology too abstract and participants experienced difficulties in applying the activity system analysis. The following recommendations were made in response to these challenges by his research:

1. To demonstrate the transferability of theory to practice, the traceable mappings between Activity theory and design process should be illustrated.
2. To support the practice of Activity theory in systems design, “illustrative examples and training materials” are required.

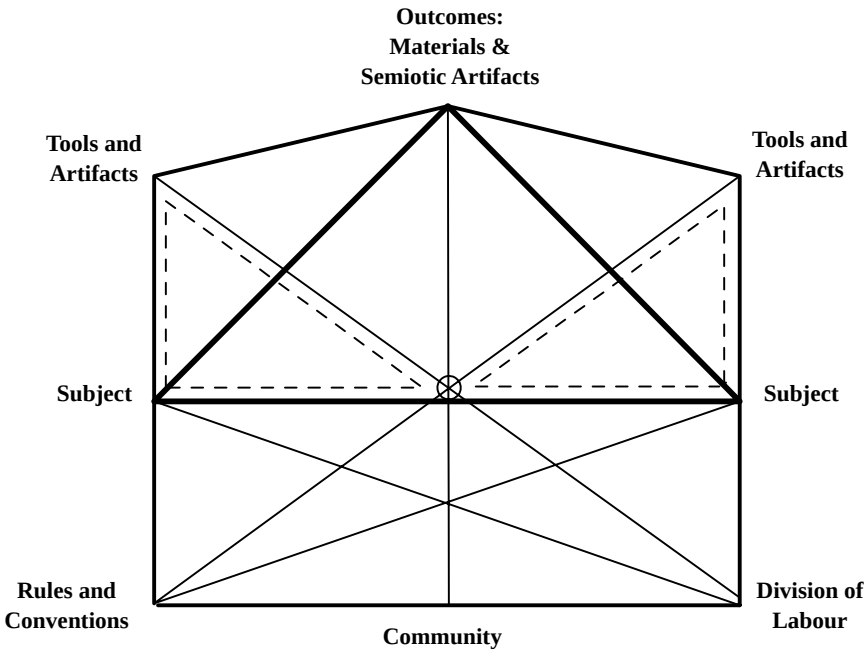
Daisy Mwanza (Mwanza, 2002) developed the Activity-Oriented Design Method (AODM) with the explicit aim of providing practitioners with a structured and replicable method for applying Activity theory in practice. Applying the AOMD techniques to the example of the important role the production space played in mediating the planning stage activity, provides some success in representing the contradictions between the individual’s activities (See Figure 26, red ellipse). The AODM techniques and the resulting visual representation enable us to disengage the components of the planning stage activity system and represent the contradictions between these components; however, it does not represent the collective object. The AOMD therefore does not provide a resolution to the challenges identified.

Figure 26. **The AODM mapping of the planning stage activity system**



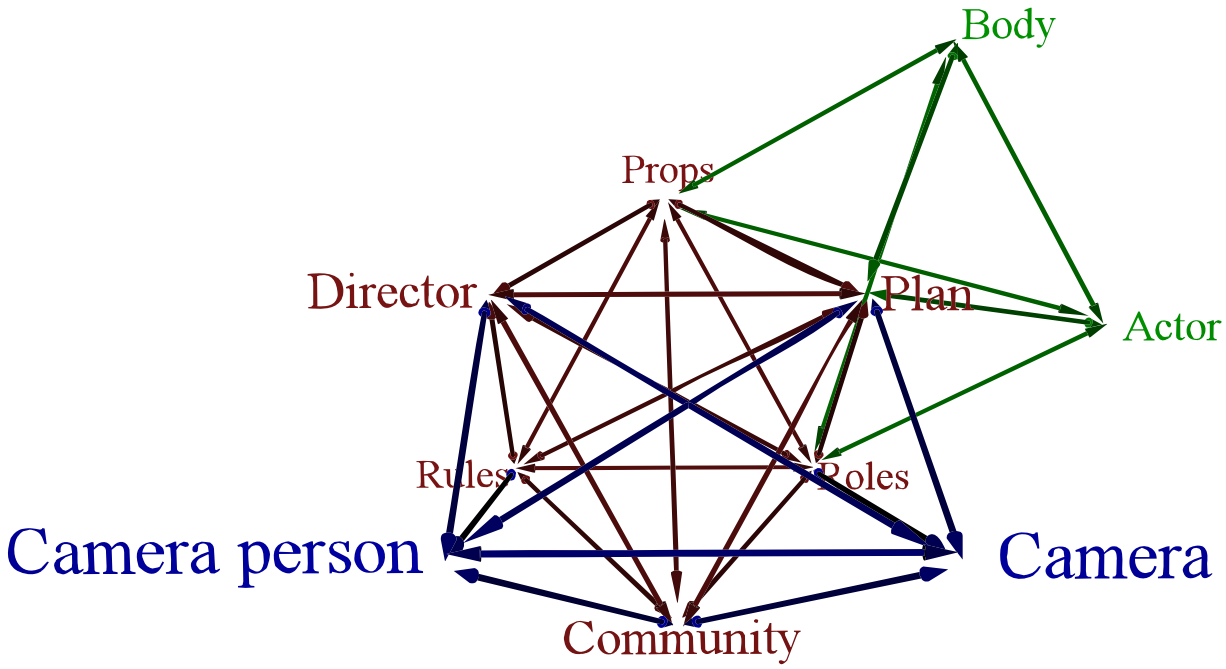
Gordon Wells (2002) identifies similar challenges in his exposition of the co-construction of artifacts and meanings. The temporal sequences of different types of constitutive actions necessitates the use of more than one triangle to represent how artifacts created as the outcome of one action become mediators in subsequent phases and therefore illustrating the shifting relationship between the mediational means employed to achieve the goals of these different phases of activity is even more challenging (Wells, 2002). Clearly, it is not a simple matter representing the multidimensional complexity of activities graphically.

Figure 27. **Discourse as tool in joint activity** *(Wells, 2002)*



In response to these challenges, Wells developed the appealing solution represented in Figure 27. Wells' (2002) representation of "Discourse as tool in joint activity" depicts a dyad engaged in a shared activity. The dual subjects share a common base of the same community, rules and conventions, and division of labor. However, each subject's contribution to the shared object of the activity is mediated by their respective tools and artifacts. Well's suggests that this simplistic expansion on Engeström's triangular model of the activity system could in principle be used to represent a limitless number of participants. However, in practice representing more than the dyad of participants is problematic. Representing three participants, as in the case of the planning stage activity system, is challenging because one of the participants will cover the others' activity systems. This is the case in two dimensions. If we construct the activity system in three dimensions (3D), it would provide an additional dimension to fit another participant into.

Figure 28. **The 3D collective activity system**



In Figure 28 the 3D collective activity system is modeled to represent the planning stage activity system using Wells' representation with the additional 3rd dimension. This enables the representation to be interactively investigated (See http://people.cs.uct.ac.za/~hvermeul/act/footnote5.pdf; please note that Adobe Reader 7 or later is required). When modeled in 3D, Engeström's triangle representation of the activity system is most economically represented as an octahedron. The octahedron when viewed from the "Front" represents a hexagon with its points connected with lines. This is diagrammatically the same as Engeström's triangle with the Subject, Object and Community points expanded through the sides of the triangle. Although the 3D representation is interesting and provides us with a simple geometry, it does not simplify our interaction with it and furthermore does not represent collective activities more clearly. On the contrary it complicates matters. We all are taught to visualize space as the geometrical space of three dimensions; having the x, y and z axes of the Cartesian coordinate system. Could it be that the practical challenges encountered by the various implementations of the EAS derive from the attempt to represent an inherently multidimensional phenomenon in Cartesian coordinate space?

6.2. The fundamentals of the problem

Not resolving the aforementioned practical challenges and having exhausted the alternatives offered by others, one has to consider whether the challenges which emerged in chapter 5 derive from a more fundamental problem underlying the EAS. In her article "Pursuing an Evolving Object: A Case Study in Object Formation and Identification", Kirsten Foot warns that the dual nature of the object (material and socially constructed) can place Activity theory discourse at the risk of reifying the object through emphasizing its materiality and thereby neglecting its socially mediated nature; or inversely, turn it into just another social construction by neglecting its materiality (Foot, 2002). Foot elaborates on the misunderstood notion of the object in Activity theory and raises an important contradiction inherent in the work of theorists such as Alexei Leontiev (Leont'ev) and Engeström, i.e. pointing to the critical role of objects in organizing and defining activities and yet also contending that just as a horizon is forever unreachable, an object is in principle *uncatchable* (Foot, 2002). The contradiction between the object as static and the "object as a moving target" is indicative of the first practical challenge, i.e. the object's transformation not being represented (Challenge 1).

The 2005 special Issue of "Mind, Culture and Activity" responds to the increased interest, stimulated by Foot's (2002) article, in the notion of the object of activity in the theoretical development and practice of Activity theory (Kaptelinin & Miettinen, 2005). Victor Kaptelinin (2005) identifies three challenges to the fruitful application of the concept of the object of activity, in Activity theory: Firstly, the translation of key concepts in Activity theory from Russian to English has proven to be a significant challenge even today and this has introduced various misinterpretations in the English translations. The second challenge is aimed at contemporary approaches to Activity theory and their interpretations of the concept of the object of activity; one being Engeström's (1987), wherein his representation of the extended triangle of mediation was originally developed. The third challenge finds the original Leontiev (1978) definition of the "object of activity" as "its true motive" *problematic* and calls for the separation of theses concepts (Kaptelinin, 2005). The second and third challenges are particularly revealing with regard to the fundamentals of the practical challenges which emerged while implementing the EAS. The initial translation problem is beyond the scope of this text and will not be considered beyond the fact that if the challenges can be overcome, an unambiguous visual representation could facilitate the communication of these complex ideas. This text will therefore continue with the explication of the second problem identified by Kaptelinin (2005).

6.2.1. Engeström's extension on Leontiev's ideas

Kaptelinin (2005) challenges Engeström's extension on Leontiev's ideas, illustrating how Engeström extends not only the collective activity graphically but also conceptually. Leontiev focuses on individual activities in his psychological exploration of the historical development of mind. Leontiev developed his framework with the aim to understand activities of concrete individuals, regardless of these individual's activities being carried out by the individuals collectively in collaboration with other individuals. Neither he, nor his colleagues extended them to other disciplines dealing with supra-individual activities (Kaptelinin, 2005). This attempt is made by Engeström (1987, 1999) when he extends Leontiev's psychological framework to the analysis of organizational change and production. In so doing Engeström inadvertently misconstrues concepts central to Leontiev's framework. Engeström and Reijo Miettinen interprets Leontiev's famous hunting example to mean that Leontiev introduces the distinction between collective activities and individual actions:

> *Mediation by other human beings and social relations was not theoretically integrated into the triangular model of action. Such an integration required a breakthrough to the concept of activity by distinguishing between collective activity and individual action. This step was achieved by Leont'ev by means of reconstructing the emergence of division of labor. (Engeström & Miettinen, 1999, p. 4)*

Kaptelinin (2005) suggests an alternative interpretation, i.e. that dissociation between individual's activities and actions *initially emerges* as a result of division of labor in collective activities. It is Engeström (1999) who makes the assertion that individuals can only carry out actions within a larger-scale collective activity system. The distinction between collective activities and individual actions is not consistent within the general framework developed by Leontiev (Kaptelinin, 2005). In so doing, Engeström reduces individual activities to individual actions and emphasizes collective activities as the molders of these actions. This extension on Leontiev ideas exacerbates the problems inherent in Leontiev's "object of activity".

6.2.2. Engeström's exacerbation of problems in Leontiev's "object of activity"

The problem of Leontiev's (1978) definition of the "object of activity" as "its true motive" emerges as fundamental in the articles of the 2005 special issue. Although it manifest in different forms: "objects of desire" (Nardi, 2005), "motives as co-constitutive and co-evolving moments in the ever-shifting balances and mutual penetrations" (Stetsenko, 2005), "co-formation of an object of a

collective activity" (Miettinen, 2005) and "poly-motivated activities" (Kaptelinin, 2005) these challenges all suggest that the notion of "object as motive" needs revision and expansion within activity theory, particularly in context of collective activities. At the heart of the problem lies Leontiev's emphasis on the social determination of individual psychological processes and subjectivity. These imbalances can be summed up as positing society above the individual and understanding the latter as produced by society and so diminishing the role of individual agency and its ability to produce social practices (Stetsenko, 2005). Engeström complicates this very problem by exacerbating Leontiev's emphasis on social determination at the expense of individual subjectivity and agency. He indicates that transformations of activity systems may be precipitated by the actions of individuals; yet, he treats individuals generically in terms of their roles in the system (Minnis & John-Steiner, 2001).

> *An activity system is by definition a multivoiced formation. An expansive cycle is a reorchestration of those voices, of different viewpoints and approaches of the various participants. (Engeström, 1999, p. 31)*

Indeed, where are the multiple voices represented in Engeström's triangle or his expansive cycle models? Engeström interprets Leontiev's "object of activity" from the analytic perspective of collective activities, yet he treats these collective activities as uniform, singular and isolated. The notion of the "object of activity" is construed to refer to the collective object of the activity and subjects the individual actions of its subjects to the mono voice of the collective subject. Challenges 3 to 5, i.e. the interactions between participants, the collective object and the interaction between activities, mediators and objects *not* being represented in Engeström's representation; can be linked to the fundamental contradiction which lies at the very heart of activity theory. Activity theory has been elaborated from it origins with the distinct aim to dialectically link the individual and social structure (Engeström, 1999). It would seem that this essential contradiction still lies at the heart of activity theory driving its contemporary theoretical development.

> *The discrepancy between the general emphasis on the transformative nature of human development on the one hand and the limited use of this idea in concrete conceptualizations of theoretical principles on the other, as well as the related emphasis on the collective at the expense of individual dimensions, was one of the major reasons for a number of subsequent unfortunate misinterpretations in activity theory and related traditions. (Stetsenko, 2005, p. 78)*

The first complicated problem facing activity theory is connected with the necessity to determine a key notion of activity theory, namely transformation (Davydov, 1999). Challenges 1 and 2, i.e. the object's transformation and temporality not being represented; can be linked to Leontiev's elaboration on the object-relatedness of activity. In his exposition he reifies the "object of activity" by emphasizing the object's relationship to the world and society, yet neglecting its relationship to the subject, their psychological processes and subjectivity. This led to the misinterpretation that the object is static and singular. This contradiction was then exacerbated by Engeström's extension of the "object of activity" to the collective unit of analysis.

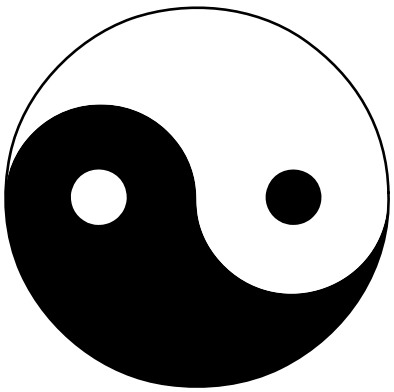
> *When A. N. Leontiev forcefully stated that "consciousness had to be sought in the world of objects! We had to find in the external object what makes it psychological" (quoted in A. A. Leontiev, 1983, p. 14), this inevitably—and unfortunately— evoked the idea of objects, and their reflection in images, as being static and frozen, existing separately and independently from material practical activity, though produced by this activity. (Stetsenko, 2005, p. 78)*

The development of ACT in this text will therefore start, like Engeström, by using as a point of departure the view of activity as a *mediated* "subject–object". However, this text aims to represent the transformative relationship between "subject–object" as the nucleus of dialectics, i.e. the unity of mutually exclusive opposites (Ilyenkov, 1977).

6.3. Creative visualization

ACT emerged reflexively from the very dialectical visualization process observed in the two empirical case studies, i.e. the dialectical relationship iterating between imagination (content) and representation (form). If we unify the Symbol S (representing the subject) and O (representing the object) in Cartesian coordinate space, by placing them on top of one another, we get an inverted Yin-Yang symbol. The Yin-Yang has been popularized in the West as a Taoist symbol and now forms part of our popular culture. Could this Yin-Yang symbol and its paradoxical connotations of the unity of opposites be used to represent the dialectical transformation between object and subject?

Figure 29. **The Yin-Yang symbol**



The Yin-Yang symbol (See Figure 29) originates in ancient Chinese philosophy and metaphysics. It represents the unity of opposites, describing the nature of all things in the universe as two primal opposing, but complementary forces. The dark side - Yin represents darkness, night and dormancy. The white side – Yang represents light, day and activity. Like the concepts of day and night, they define one another dialectically. Yin and Yang are represented as opposing symmetrical shapes, yet united in occupying the same space. They exist in a process of continual transformation, both Yin and Yang consuming, yet constituting the other. This process is ideally held in balance. The Yin-Yang therefore also symbolizes balance. In each of the opposing forces, we also find a small dot representing a small part of the opposite force. Yin can consequently transform into Yang and Yang into Yin. Like the day turning into night and night into day. The Yin-Yang is therefore an excellent symbol for representing the unity of opposites, transformation, process and change.

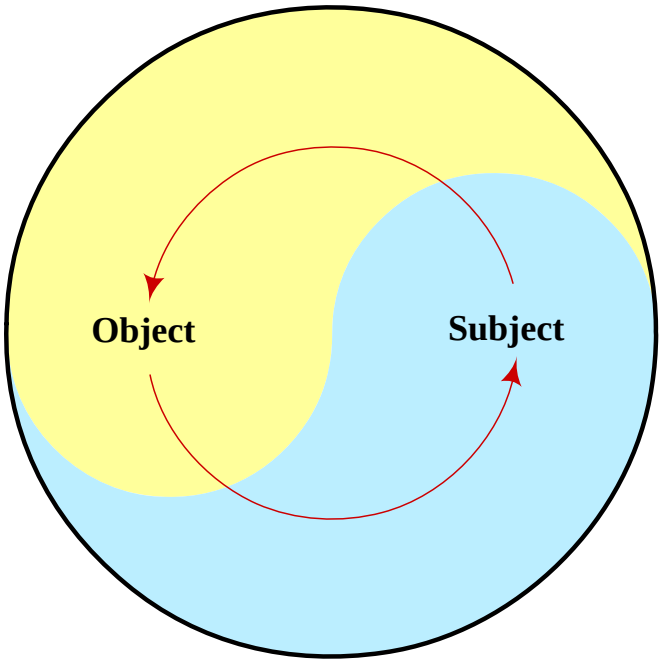
6.3.1. Activity Cell Transformation

This text sets out to develop Activity Cell Transformation (ACT) by means of the inverted Yin-Yang symbol, creatively using its symbolism to illustrate the dynamic relationship between object and subject, united in a process of mutual transformation. The inverted Yin-Yang symbol will be used to denote the paradoxical subject-object coupling of the activity cell and to signify the nucleus of dialectics, i.e. the unity of mutually exclusive opposites (Ilyenkov, 1977). *Referring to this new representation as an activity cell is consistent with Vygotsky's (1986) notion of a "psychological" cell.* Davydov's (1999) seventh problem facing Activity theory relates to understanding the relationship between the biological and the social in human existence. *Thinking of social activities in terms of a cell-form, could contribute to our understanding of this relationship.* The biological connotations of a cell also contribute to thinking of activities as growing, evolving and transforming. Transformation is central to the dialectical unity of the opposites, and to make this

even more explicit, the activity cell is referred to as a transformation instead of a representation. Ideally, activity cell transformation is embodied in animations and interactive media (For examples online, see http://people.cs.uct.ac.za/~hvermeul/act/index.html). However, in the static form of the Figures of this article the transformation of the cell will be denoted with arrows and it is up to the reader to imaginatively visualize the transformation. This text starts with the transformation of Vygotsky's (Vygotsky, 1978, p. 38) original representation of unmediated behavior, i.e. S → R, in terms of the inverted Yin-Yang symbol.

6.3.2. Unmediated Behavior

Figure 30. **Unmediated Behavior**

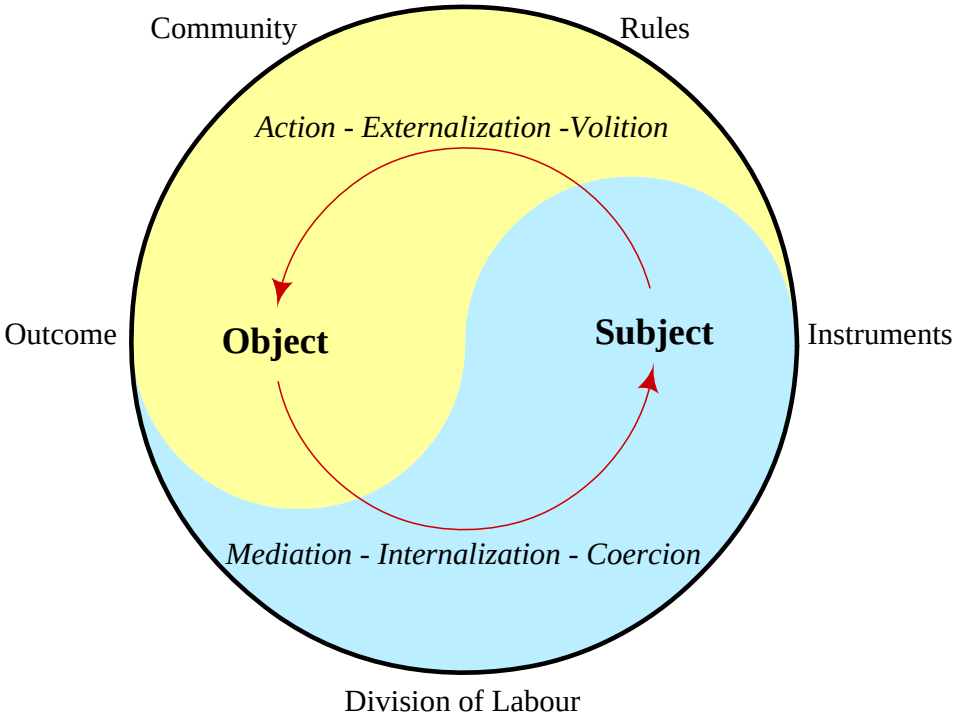


ACT starts by representing the most basic relationship between the object and subject: unmediated behavior (See Figure 30). Unmediated behavior occurs in activities which are not mediated by cultural instruments. The subject acts directly on the object, for example an organism (subject) foraging (acting) for food (object) in the environment. According to the ecological approach to perception (Gibson, 1979), the perception of the organism is an active process that selects the relevant information (smell of food, etc.) from the environment necessary for its survival. The environment provides these opportunities for the organisms inhabiting it. The environmental properties (protein, etc.) is said to afford the organism opportunities which it has evolved to find and exploit. There is therefore no cultural mediation between organism and environment. In Figure 30 the

object and subject are placed in opposing positions, yet united in a process of mutual constitution (indicated by the red arrows). The object and subject move one another along in their cycle of mutual transformation, forming yet constraining one another (For the interactive media animation of the subject-object transformation, see http://people.cs.uct.ac.za/~hvermeul/act/footnote6.swf). The usual positions of subject left and object right, in Figure 30, have also been swapped to emphasize the movement (circulation) of the dynamic transformative relationship between object and subject. *ACT thus provides not only a more dynamic presentation of the dialectical transformation of the object, but also the subject, through their mutual constitution.*

6.3.3. Mediated activity

Figure 31. **The mediated activity cell**



In the above representation of the Mediated Activity Cell (MAC), ACT transforms the EAS extended triangle of mediation. The activity revolves around the dialectical transformation of both object and subject. Dialectical transformation does not refer to formal logic's transformation of the properties of an object; rather, transformation is regarded in terms of the universal relation between a system and its objects that gives birth to its specific and individual features, i.e. the transformation of the system itself (Davydov, 1999). Engeström's activity system represents the transformation of the

object by the subjects. It emphasizes the production and transformation of the object's properties to fulfill the activity's outcome and the needs of the subjects. The other pole of the dialectic transformation is not represented by the EAS triangle, i.e. the object transforming the subject.

> *Latour's point also presents an interesting challenge to activity theory. When talking about artifacts, activity theorists are used to referring to implements and tools, such as spoons, hammers, and machines. But walls, clothes, buildings, furniture, roads, parks, and other such things are not so clearly tools used by actors to achieve ends. They are something like infrastructure, material and human-made, but not easily attached to a specific set of purposes and uses (Engeström, 1996, p. 259).*

In his response to Bruno Latour's (1996) article "On Interobjectivity", Engeström acknowledges this hiatus and the resulting tendency to misinterpret the object as static:

> *These infrastructural entities seem to be utilities rather than utensils, media rather than means. They force us to rethink our habitual tendency to freeze and categorize objects into one fixed role and place in the flow of activity (Engeström, 1996, p. 259-260).*

The MAC highlights the dialectical transformation of object and subject. The MAC returns the focus to the heart of dialectics, namely transformation. *It resolves challenge 1 by representing the object's transformation.* The object is now represented as a process, *a movement,* where the object and subject forms and constrain one another. In Figure 31 this process of mutual constitution is indicated by the red arrows. The arrows have also been labeled (See italics) to describe the dialectical forces at work in the transformative interaction between the subject and object. The MAC places equal emphasis on the subject's *action-externalization-volition* and the object's *mediation-internalization-coercion* within the activity system. The three pairs of transformative couplings action-mediation, externalization-internalization and volition-coercion describe the dialectical oppositions of the unifying transformative process of mutual constitution of the subject-object.

Action is the process whereby the object is transformed by the subject. This process does not occur in isolation of the dialectal unity of action and mediation (Shaffer & Clinton, 2006). The object also transforms the subject's mental action and subjectivity through the mediation of the object-related internalization of action. Just as thoughts are internalizations of our actions on objects, objects are similarly externalizations of "mental actions" (Galperin, 1967; Latour, 1996; Shaffer & Clinton, 2006). The process of creative externalization of psychological processes, emotion and subjectivity into material objects introduces novelty and innovation into that which had previously been

internalized. Engeström (1999) refers to this dialectic process as the “expansive cycle”; however, it is not part of the EAS representation. Externalization and internalization are two poles of the same process linking the “outside” and the “inside”. The MAC represents the subject’s volition, acting on the object, externalizing it, transforming it; as well as the object’s coercion of the subject, mediating its internalization, transforming mental processes and subjectivity. The coercion-volition coupling consequently denotes the autonomy paradox inherent in all activity cells.

The mediators of the activity are arranged around the perimeter of the MAC. The traditional categories of the EAS triangle are appropriated as labels for the mediators. They are arranged around the periphery of the cell indicating the mediatory, yet also constraining, role mediators play in driving the transformation of the cell. ACT positions the instruments next to the subject, indicating that this is what the subject uses to transform the object. The outcome is the motive force mediating the production of the object and it is therefore positioned next to the object. ACT positions the other mediators next to the “backbone” of the subject and the “backbone” of the object they relate to. One of the advantages of using this arrangement is that there is more space to position mediators, but more importantly, mediators that do not fall strictly in one category and the transformation between categories can be accommodated. Each of the mediators is also in themselves a minimized cell (See 5.6).

Figure 32. **The director's activity cell**

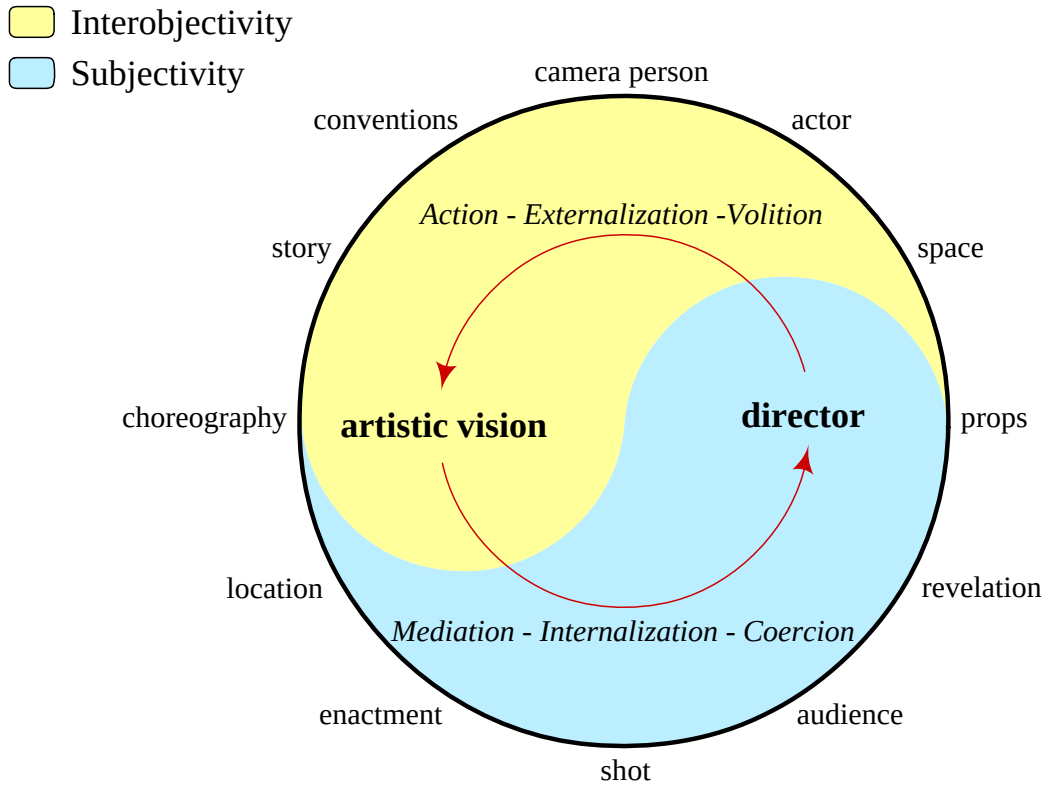


Figure 32 demonstrates the application of the MAC in a practical example of transforming the activity system of the director (subject) producing the artistic vision (object), in the constitutive planning stage of learning activity 1 (See Figure 24, director's triangle only). The director plays a very important role in the planning of a film. He/She is responsible for the artistic vision of the film and for guiding the whole production team in realizing that vision. The director externalizes her/his artistic vision by directing and giving instructions to the other members of the production team. Through transforming the production team's behavior the director transforms the artistic vision as object. The outcome of the planning activity is the successful "choreography" of the whole team that will mediate this vision-object. As the choreography unfolds in the space of production, the story, the actor's character, the camera person's shot, rehearsals, film conventions, consideration of the audience's perspective, etc. These mediators give shape to the director's vision in a dialectical way. This provides the director with a more concrete object to reflect on, internalize and utilize to make decisions and give instructions about the unfolding artistic vision. The director's vision is realized through this dynamic and highly reciprocal process during the planning stage.

This process of internalization and externalization, as noted previously, is a dialectical process shaping both the object and the subject. The subjectivity of seeing the world as a director is consequently also shaped by the mediators transforming the vision-object. The subjectivity, vision and mental actions of the director are thus mediated by the "infrastructure" of the vision-object and in turn internalized by the director-subject. Latour's (1996) interobjectivity is the area represented in Figure 32 in yellow. It shapes the subjectivity of the subject represented in blue and vice versa. This transformation of the vision-object is fully internalized when the director is able to perform the transformation of the vision-object in abstraction from the mediatory "infrastructure" thereof. *ACT thus explicates Piotr Galperin's vital meaning of internalization, as expanding a particular field for action, which affords additional possibilities for adaptation in humans, characterizing action through object-related parameters and crystallizing the identity of the objective operational content of action through its transformation into a mental form (Stetsenko & Arievitch, 1997).*

ACT illuminates the active role objects play in influencing our thinking and behavior. David Shaffer and Katherine Clinton's (2006) analytical category of *toolforthoughts,* like ACT, aims to encapsulate the dialectic of object (Their tool) and subjectivity (Their thought) in transformative unity. Latour, on who's ideas the notion of toolforthoughts is based, accounts that tools are but one of the modes of objects: "Objects could only appear in three modes: as invisible and faithful tools, as the determining superstructure and as a projection screen" (Latour, 1996, p. 235). *Toolforthoughts* might therefore be better termed *Objectformentalactions* or Turkle's (1995) "Objects-to-think-with". However, the perspective of ACT is much broader. *Toolforthoughts* focus myopically on the functional level, losing sight of the ontogenetic level of the object-subject transformation. This contradicts Latour's focus on "action that localizes and globalizes" (Latour, 1996, p. 235). In conclusion of this application of the MAC in the practical example of the director-artistic vision: *ACT affords a resolution to practical challenge 1, by representing the object's transformation.* To address the other challenges, however, requires the careful consideration of activities as the unit of analysis of Activity theory.

6.3.4. Expanded activity

In challenges 3 to 5, the interactions between participants, the collective object and the interaction between activities, mediators and objects are not represented. Overcoming these challenges requires a perspective that includes more than a single object-subject activity cell. Activity theory has traditionally emphasized the single cell as unit of analysis. Leontiev's original

exposition of the historical development of cognition primarily considers the individual subject-object cell. Engeström extends Leontiev's ideas to include activities of supra-individual entities; however, his extended focus on collective activities subsumes the individual subject and represents these activities as a collective subject-object. Numerous versions of Activity theory notice that the structures of these two forms of activity (individual and collective) are to a certain degree similar; however, they pay very little attention to their difference (Davydov, 1999). Vladimir Lektorsky (1999) suggests that when we interpret "Activity theory in a new era", intersubjective relations arising from the object-related mediation of human activity provides the key for linking the relationship between the individual and collective activity. Accordingly, the collective subject itself does not exist outside of the concrete individuals interacting with one another according to the specific rules of the collective activity. The collective subject manifests itself and these rules through external practical activity involving objects and through collective cognitive activity with systems of objectified knowledge (Lektorsky, 1984). Leontiev's predominantly individual analysis of the relationship between activity, actions and operations means that he neglects the intersubjective relations that arise in the context of objects (Lektorsky, 1999). Indeed we need an intermediary focus which reveals how individual and collective activities interact to create one another. David Zager (2002) argues that collective objects are sign systems that function as mediating artifacts with which groups of collaborators coordinate themselves by providing a context beyond the individual. The collective object of the context is a contract that the participants have jointly created, which provides the participants a common vocabulary and interpretation of the world for the duration and extent of a group activity (Zager, 2002). This text refers to Zager's "collective object" as the "shared contextual field" (SCF) of Activity, to steer clear of the contradictions inherent in the term. There is a tendency in Activity theory to muddle collaborative activities and collective activities (See 6.6).

Figure 33. **The expanded activity cell for the Camera person's planning activity**

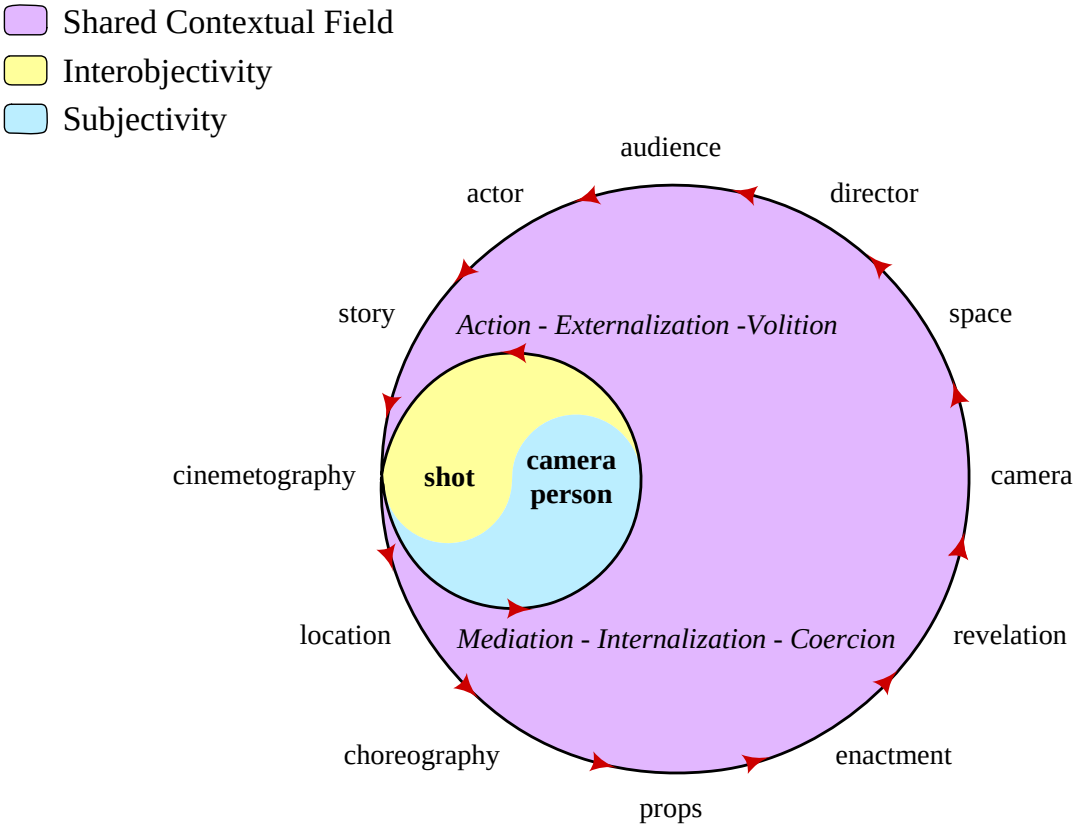
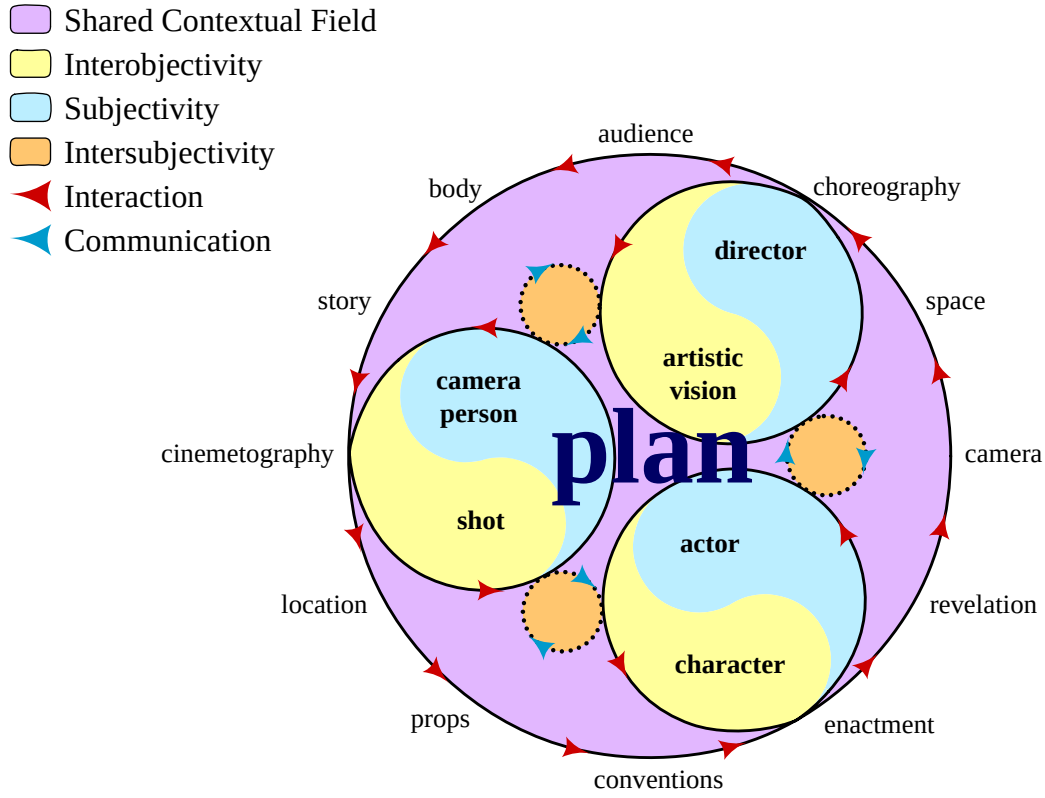


Figure 33 represents the expanded activity cell of the camera person. The purple area represents the context of the planning activity expanded beyond the camera person-shot cell, opening up a shared mediatory space constituting the SCF. Paul Dourish's (2004) approach of "embodied interaction" suggests that context enable participants to negotiate and evolve systems of practice and meaning in the course of their interaction during activities. *The expanded activity cell represents the activity's context as a field of potentiality constituting the activity, opposing Engeström's (1993) problematic notion that the activity is the context.* In Figure 33 the camera person-shot cell is embedded within the SCF. The red arrows indicate the feedback loop between the SCF and camera person-shot cell. The mediators (camera, story, director, etc.) are internalized in the camera person-shot cell, mediating both the transformation of the subject and object, again then to be externalized into the SCF during the planning stage. By expanding the periphery of the SCF beyond that of the individual cell it makes space for other cells to be expanded within the SCF. *Through this expansion the focus of ACT expands beyond the individual activity cell to include the multiple cells of the collaborative activity and it suggests an alternative group unit of analysis.*

6.3.5. Collaborative activity

Figure 34. **The collaborative planning activity cell of LT1**



As an alternative to the problematic Figures 24 and 25, Figure 34 represents the collaborative LT planning stage of learning activity 1, with all three participants expanded. In the collaborative activity cell, the object of each of the individual cells is represented inside of it, as well as the SCF (purple area). *The creation of the SCF replaces the collective object of Figure 25 and this replacement resolves the challenge of representing the collective object (Challenge 4).* In addition, the specific mediating outcome that drives the dialectic interaction within each individual cell is positioned next to it, e.g. the enactment is the mediating outcome that drives the dialectic interaction between the actor and character. *The individual outcomes for the subject's individual objects as represented in Figure 24 are not lost as in Figure 25*. The plan is the focus of the collaborative activity cell. It unites the three individual cells in shared mediatory cycles, i.e. both the activity and the SCF. The interaction flows through the SCF, driving each of the cells and their subject-object transformation (red arrows). *The shared mediatory cycles also resolves the challenge of representing interactions between the activities, mediators and objects, resolving challenge 5*. The transformation

of each of the cells in turn loops back to the SCF to constitute the plan as a dynamic process. The plan should consequently never be interpreted as static. It is a process, *a movement* and should be visualized as such (For the interactive media animation of the collaborative cell transformation, see http://people.cs.uct.ac.za/~hvermeul/act/footnote9.swf).

The cell's interaction (red arrows) with the mediators and the communication between cells (blue arrows) demonstrates how the individual cells communicate to expand intersubjective fields (orange areas) between participants. *These interactions and communication between participants resolves challenge 3 and consequently it also sheds light on Davydov's (1999) fifth problem facing Activity theory of understanding communication.* An example of this interaction and communication within the LT planning activity would be the director regarding the space mediating the camera person's framing and the actor's enactment as constraining. The director resolves this constraint by communicating his/her resolution of it to the other participants and so influence the production of the shot, the enactment of the character and in this way contributes to the transformation of the plan. Communication facilitates intersubjectivity. The emerging intersubjectivity is represented by the orange areas between the cells. This expanding intersubjectivity establishes the "common ground" of the activity. The term "common" does not mean here "identical" or "the same": in dialectical logic "common" refers to a bond between people jointly sharing a field (Ilyenkov, 1982). This "common ground" is expanded through communication between participants. *The expanding intersubjectivity can be graphically represented in the collaborative activity cell by expanding the communication cycle between participants and so the surface of the intersubjective area* (See Figure 35, expanded orange area of intersubjectivity between actor and camera person).

Communication is always mediated by objects. Even the human voice is produced with the intention to externalize our subjectivities in the shared "space" of speech. Through communication and intersubjectivity the SCF is constructed, i.e. purple area. Objects play an important role in mediating between the subjectivities of participants and the intersubjectivity of collaborative activity. The interactions of mediators (red arrows) work in on individual cells. They are internalized and transform the subjectivities of participants and their objects. These individual cell objects are influenced by the subjectivities of the participants. Once externalized and expanded beyond the individual cell these objects become part of the shared mediatory cycle (red arrows). This process infuses the SCF with shared meaning. This is where the subjective form is connected with the space of the interindividual, intersubjective relations (Lektorsky, 1999). The externalized objects can so become semiotic objects, constituting interindividual relations and intersubjectivity. In this form

objects become mediators of communication (blue arrows) between cells. The SCF in this way is transformed through the interaction between individual cells. It is important to note that the symmetry of Figure 34 should not be misconstrued to mean that ACT favors cooperation over conflict. The shared mediatory cycles is driven by cooperation and conflict, shaping and constraining the shared contextual field. Furthermore, the developing intersubjectivity and shared meaning does not necessarily imply the development of agreement. *ACT could be used to illustrate how the conflict between individual cells push them apart and as a result how one or more of the individual cells break out of the shared contextual field to join or create an alternative collaborative cell elsewhere.*

This cyclical process of internalization-externalization repeats itself until an outcome (positive or negative) has been reached. *ACT surmounts the internal-external dichotomy by representing the collaborative activity cell composed of individual cells.* Internalization is represented as the flow from the collaborative activity cell into the individual cell, while externalization is the flow from individual cell out to the collaborative activity cell. ACT clearly represents that, which is missing in Engeström's representation of the activity system. *The multiple voices of the expansive cycle are represented in the multiple individual cells of the collaborative activity cell. However, more importantly, the collaborative activity cell illustrates how these multiple voices interact to constitute the shared contextual field and the collective object.* ACT presents the required intermediate-level theoretical construct and tool that resolves the challenges which emerged during the chapter 5 implementation of the EAS triangular representation. Does ACT, however, provide the new model and tool required for the dialectical methodology developed in chapter 3? ACT clearly brings a new level of analysis to the investigation of the planning stage of the LT activity. Can ACT be used to bring into focus more clearly the comparative evaluation between the planning activities observed in LT1 and LT2 (See 5.6)?

6.4. Activity cell comparative evaluation

The VFPW collaborative planning activity cell of learning activity 2, represented in Figure 35, was developed specifically to answer the important question of whether ACT's ability to illuminate the interaction between participants could be utilized to clarify the comparative evaluation between LT1 and LT2 (See 5.6) and so contribute a new intermediate-level theoretical tool, to the dialectical methodology developed in chapter 3.

Figure 35. **The VFPW collaborative planning activity cell of LT2**

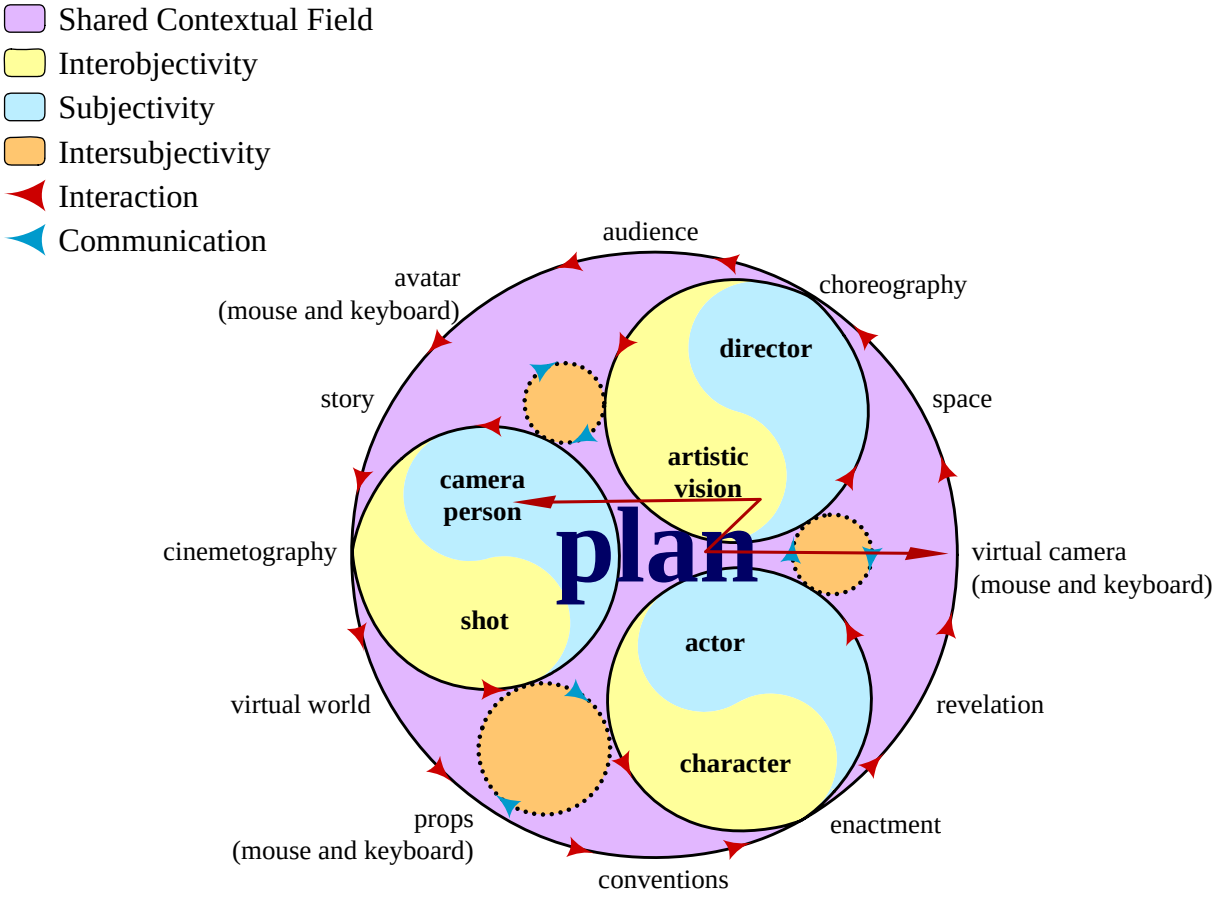


Figure 35 represents the VFPW planning activity of LT2 illustrating important interactions from the planning activities observed in both Group 1 and 2. Clearly, this LT2 activity cell closely matches that of the LT1 activity cell represented in Figure 34. However, there are some minor differences. For example in the LT1 planning activity cell we have the activity mediators of body and location, while in the VFPW planning activity cell of LT2 these mediators are the avatar and virtual world. Furthermore the props, avatar and virtual camera are themselves also mediated by the computer instruments of the mouse and keyboard. Group 2's contradiction between the camera person and the virtual camera (See lightening-shaped arrow in Figure 35); and the expanding intersubjectivity due to the VFPW's functionality of being able to take another participant's point of view within the virtual world, are graphically represented in Figure 35. However, before considering these differences, this text will focus its attention of the similarities between Figure 34 and 35, by means of concrete examples drawn from the LT1 (See excerpt 5.4.11) and the VFPW Group 1 LT2 (See excerpt 5.4.10).

6.4.1. Similarities between the LT1 and VFPW LT2 planning activities

In both the LT1 (Figure 34) and the VFPW Group 1's LT2 (Figure 35) planning activities, the three participant's individual activity cells of the director, camera person and actor are intertwined through the shared mediatory cycle (See red arrows). This mediatory cycle constitutes the SCF, the plan and the activity. The mediators around the periphery of the planning activity cell are bound to the plan, both constraining and driving its transformation through their connection to the mediatory cycles of the participant's individual cells. The shared mediatory cycle binds the three participant's individual activity cells together through the development of the SCF and the transformative process which is the plan. The participant's subjectivity and objects are transformed through interactions with the mediators and one another, as these objects are used to externalize subjectivities, internalize these objectified subjectivities and expanding the intersubjectivity between participants. Like a dance the participants react to one another, the space of production, the story, the director's artistic vision, the actor's character, the camera person's shot, rehearsals, film conventions, consideration of the audience's perspective, etc. to develop a shared intersubjective understanding of the choreography and the LT plan. The connection (red arrows) between the participant's individual activity cell's and the mediators demonstrates how the individual cells communicate (blue arrows) with one another to expand intersubjective fields (orange areas) of shared meaning between participants.

The director's subjective artistic vision is mediated by the space of production, the story, the actor's character, the camera person's shot, rehearsals, film conventions, consideration of the audience's perspective, etc. The director externalizes (the red arrows moving out of the directors cell) his/her vision of the film by placing props within the cinematic space to make it interesting, guide the actor's actions and the camera person's framing. The director communicates with the camera person and actor (blue arrows) transforming the intersubjective fields of understanding. Props are central to this communication. The props, their positions and meanings are internalized by the camera person and actor, transforming their subjective perspective and their externalized objects, the shot and enacted character respectively. The director communicates his artistic vision by directing the camera persons framing. This is mediated by the use of props to guide the camera person when moving and framing (See excerpt 5.4.11, lines 3-18 and 5.4.10, lines 46-70). The director also directs the actor using props to guide the actor's actions and the revelation of the actor's character (See excerpt 5.4.11, lines 55-71 and 5.4.10, lines 12-45).

The camera person's individual activity cell is embedded within the SCF of the plan. The red arrows indicate the feedback loop between the SCF and camera person's activity cell. The shot of the camera person is also mediated by the space of production, the story, the director's artistic vision, the actor's character, rehearsals, film conventions, consideration of the audience's perspective, etc. The movement of the camera person and framing is critical to revealing the cinematic space, the actor's character and the story. The planning of the camera person's framing and the actor's actions and movements are negotiated using the props as guides in the physical space of the location (See excerpt 5.4.11, lines 72-97 and 5.4.10, lines 1-11). The camera person externalizes their choreography by moving the camera through the space of production and framing the actor's actions, props and mise en scène. The camera person verbalizes this subjectivity for other participants, to communicate to them what s/he is framing and seeing (See excerpt 5.4.11, lines 71-77 and 5.4.10, lines 96-102). This communication is aimed at developing the intersubjective understanding with other participants. The camera person externalizes his/her transforming subjectivity by changing the framing of the mise en scène and the actor's action; i.e. the shot (See excerpt 5.4.11, lines 3-18 and 5.4.10, lines 46-70).

The actor internalizes the camera person's subjective perspective externalized in words, and this in turn transforms the actor's subjectivity (character) and the externalization thereof in the enactment. The actor's character is also mediated by the space of production, the story, the director's artistic vision, the camera person's shot, rehearsals, film conventions, consideration of the audience's perspective, etc. The actor's character is revealed through his/her movement in the production space and actions. These actions are directed at props. The director and actor negotiate about the props that are needed for the actor's actions and the revelation of her/his character (See excerpt 5.4.11, lines 55-71 and 5.4.10, lines 12-45). The props are important mediators for the negotiation and development of intersubjectivity between the director, actor and camera person. Through the SCF, the props mediate the selection and positioning of the props relative to the actors intended actions and blocking. The planning of the actor's actions and movements in the production space is arranged and choreographed by the director using the props as waypoints guiding the actor's actions and camera person's framing. The props mediate the externalization of the director's artistic vision and the internalization and transformation of the actor's enactment and camera person's shot. The props so become infused with meaning, they become semiotic objects, mediating the intersubjectivity between the actor, director and camera person. The props clearly play an important role in the mediation of the planning activity.

6.4.2. Differences between the LT1 and VFPW Group 2 LT2 planning activities

In the above exposition the similarities between LT1 and LT2 Group 1's planning activities were emphasized; however, what about the differences between LT1 (Figure 34) and the VFPW Group 2's LT2 (Figure 35) planning activities represented? An important contradiction which had come to light from the video analysis of Group 2's planning activity (See 5.6.3) was that of the difficulty the camera person experienced operating the virtual camera (See lightening-shaped arrow in Figure 35). The camera person in Group 2 had not had much experience in manipulating the virtual camera by using the mouse and keyboard. Consequently the camera person had difficulty navigating the virtual world and as a result their shots of it also suffered. This had a detrimental effect on the entire planning activity, constraining some of the possibilities being considered by the participants. This was particularly evident when the camera person tried complex shots; for example tracking backwards through the house entrance, while framing the actor entering the house. However, in the conventional world of film making a camera person looking through the viewfinder and tracking backwards through the door framing an actor entering, has surely also bumped against the door pane on more than one occasion. This is a contradiction at the operational level of the activity and is best addressed through practice, which should result in the action becoming automated and less error prone. As one of the participants suggested: "if you were like game players, who like knows how to like, work the mouse and work the keys at the same time at angles and stuff, people who play Duke Nukem and stuff", this would not have been a problem. Indeed, one of the reasons for Group 1's success can be attributed to the camera person being a video game player and having operationalized the operation of the virtual camera. Representing the contradiction between the camera person and the virtual camera is challenging when using Engeström's activity system triangle (See 5.6.3). Figure 25 (See lightening-shaped arrow) had been developed in an attempt to represent the contradiction between the camera person and their camera; however, the impact of this contradiction on the planning cluster of activity systems is unclear. *In Figure 35 this impact can be clearly represented using Engeström's lightening-shaped arrow. It cuts through the activity cell from the camera person to the camera, disrupting the flow of the mediatory cycle and the development of the SCF and plan.*

The other important difference between the LT1 and LT2 learning activities was the functionality in the VFPW of being able to take another participant's point of view within the virtual world. This was regarded by the students as an extremely useful ability to have within the VFPW. Again in the words of one of the participants: "What's so cool about this that you don't have in real

life, is that the actor can see from the camera's point of view ... the thing with directors and the actors, director always tells them what they look like on screen ... and they have to adjust like that, but now the actor can see for himself, what he looks like and adjust appropriately, that's so cool ... so useful". The ability to take the perspective of another participant's point of view and literally see what they see within the virtual world greatly facilitated the development of the plan. This functionality enabled intersubjectivity that is impossible within our contemporary world of experience, i.e. literally seeing the world through another's eyes. Representing this using Engeström's activity system triangle (See 5.6.3) again is challenging. *However, in Figure 35, this expanding intersubjectivity is clearly represented through the enlarged orange area between the camera person and actor.*

The activity cell comparative evaluation provides empirical evidence to verify what is ultimately the purpose of this text, i.e. that the dialectical method developed in chapter 3 had indeed succeeded in understanding, developing and comparatively evaluating the learning activity in a virtual world. The two planning activities compared here share a common object, i.e. the plan. The plan is constituted through the development of the SCF, which is mediated through the shared mediatory cycle encircling and permeating the activity, transforming the mediators, the participants, their subjectivities and their objects. There are some differences between LT1 and LT2 at the operation level of using the keyboard and mouse and the VFPW LT 2 activity is clearly facilitated by the participant's ability of being able to see the world through one another's "eyes". However, the heart of the two planning activities is one and the same, i.e. their SCF and object are the same. Activity theory affords this comparative evaluation, on the basis that an activity is identified by its object. Although the actions and operations vary between the two situations, they can be compared on the basis of the activity's object being the same. In actual fact the comparison is of the same learning activity occurring in two situations. *ACT provides the appropriate intermediate-level of analysis to illuminate the interaction and developing intersubjectivity between participants. ACT so clarifies the comparative evaluation, clearly contributing a new intermediate-level theoretical construct to the dialectical method developed in chapter 3.*

6.5. Collective activity

Having represented mediated, expanded and collaborative activities using ACT, the question now arises whether the collective activity of the EAS can be transformed by ACT to overcome the remaining challenge 2, by representing the temporal transformation between stages of the LT activity's collective object?

Figure 36. **The collective LT activity transformed by ACT**

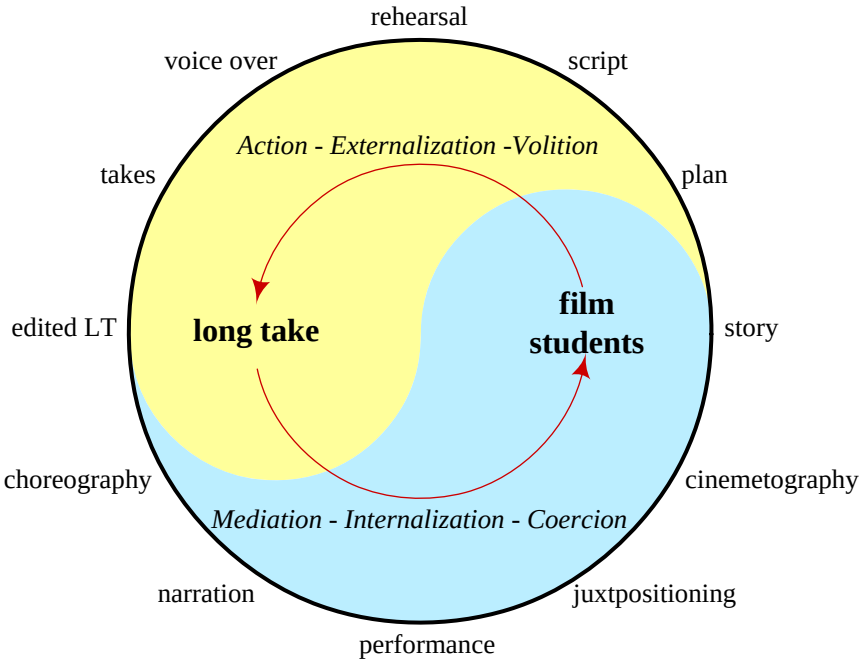


Figure 36 transforms the collective LT activity system (See Figure 17) using ACT. The various stages of the object are arranged as mediators of the LT activity around the Film Students (subjects) and the LT (object). The mediators are in themselves cells. For instance the plan in Figure 36 is the minimized planning stage collaborative activity cell (See Figure 34 and http://people.cs.uct.ac.za/~hvermeul/act/footnote10.swf for an interactive animation of the planning cell being expanded, please note that Flash 6 plug-in or later is required). These mediators are interlinked, effecting and being effected by the transformation of the collective subject-object. The stages of Figure 18 can therefore be thought of as parts of the "body" of the LT object, mediating and driving its transformations. These stages are arranged in Figure 36 as mediators along the "backbone" of the object. In the same way, the mediators of the LT assignment's outcomes are arranged alongside the "backbone" of the collective subject (film students) indicating the outcome to be achieved by way of the "opposing" mediator, i.e. narration by way of script. In this way Figure 17 illustrates that for each of the mediators transforming the collective LT activity a corresponding skill could be learned. The skills we hope the students will internalize by participating in the LT activity. *The transformation of the collective LT activity system by way of ACT represented in Figure 36 shows the temporal transformation between stages missing from Figure 18 thus resolving challenge 2.*

6.6. Reflecting on Activity Cell Transformation

The preceding exposition of the development of ACT presents an analytic "zoom" lens which can focus on three depths of activity revealing individual, collaborative (group) and collective cell forms as units of analysis (See Figures 32, 34 and 36; and http://people.cs.uct.ac.za/~hvermeul/act/footnote10.swf, please note that Flash 6 plug-in or later is required). Having an assortment of lenses to illuminate the various cell forms of activities and their transformation is advantageous. This text concurs with Gary Stahl (2006c) that we need multiple units of analysis, and propose ACT and particularly the collaborative group activity cell, in response to Stahl's challenge to Activity theory to explicitly consider the group as unit for analysis. Indeed, from Engeström et al. (1999) conception of "knotworking" one can conceive the collaborative activity cell as a knot of collaborative work that is not reducible to any specific individual or fixed organizational entity as the center of control (Engeström et al., 1999). However, this text argues that instead of knots being a "historically significant new form of organizing and performing work activity" (Engeström et al., 1999, p. 346), knots are actually the intermediary stages of the transformation of cell activity between individual and formalized collective activities. Knots have become more visible due to the increased pace of transformation of our contemporary world, particularly in context of the rapid innovation of technology. There is a tendency in Activity theory to muddle *collaborative* and *collective* activities. This tendency lies at the heart of many of the problems of Activity theory's "object of activity". In her article "Objects of Desire: Power and Passion in Collaborative Activity" Bonni Nardi uses Activity theory to analyze the conduct of collaborative scientific research (Nardi, 2005). Nardi formulates the problem of Activity theory's "object of activity" as follows:

> *The original activity theory notion of object seemed to suggest that object (Objeckt) and motive are indivisibly bound. In the case of one-object, one-motive, such a binding is not problematic (See Hyysalo, this issue; Kaptelinin, this issue). However, when analyzing collaborative work, a one-object, one-motive mapping is less straightforward. In a collective activity system, many voices are heard, many actors and interests are involved. How are we to think of these many actors and interests in activity theory, and with respect to objects? (Nardi, 2005, p. 40).*

Although this text agrees that the individual subject should not be dissolved in the collective activity (Kaptelinin & Cole, 1997; Kaptelinin & Nardi, 2006; Lektorsky, 1984; Stetsenko, 2005; Stetsenko & Arievitch, 1997) the connotation of mono voiced collectivities muddle a clear unit for

analysis. This text suggests that in collective activities, as represented in Engeström's graphical extension of Leontiev's (1978) ideas emphasizing the social determination of individual activities, many voices are not heard. Anna Stetsenko's 2005 article "Activity as Object-Related: Resolving the Dichotomy of Individual and Collective Planes of Activity" links this dichotomy to Leontiev's concept of object-relatedness and its emphasis on the primacy and dominance of the social over the individual, of internalization over externalization, of acquisition of socio-cultural experience over its expansion; as well as the dichotomous view of these aspects of human life and the unintended reification of objects (Stetsenko, 2005). Stetsenko (2005) further suggests that these contradictions could be linked to the one-sided version of a communitarian ideology that prevailed in the Soviet Union. Clearly the history of our understanding of collective activities should be taken into consideration when we use the term and when these dichotomous connotations are embodied in the contemporary representation of the EAS. *This text therefore proposes as the intermediary unit of analysis, the collaborative group, to clarify the distinction between mono and multiple voice collective activities.*

Stetsenko (2005) also suggests that to overcome these internal contradictions in activity theory, we should further expand Leontiev's idea of activity cycles to include human subjectivity, placing emphasis on it as being object-related and producing new objects, relations, and other aspects in the world of social practice. *ACT achieves this expansion on Leontiev's activity cycles by representing Stetsenko's (2005): "three-fold unified dialectical system of mutually co-determining and co-evolving facets of human life" (p. 81).* The collaborative activity cell represents the mutual constitutive relationship between human subjectivity and social practice. *The collaborative activity cell therefore has the potential to dialectically link the individual and social structure, to unite individual learning and social-cultural development, in a unified theory of mind, from a historical perspective.* However, this remains the target and object/motive of the practice of Activity theory. This is particularly important if we are to suggest Activity theory as theoretical framework for the study of agency and social change (Stetsenko, 2007). ACT overcomes the inherent insensitivity of second generation Activity theory to cultural diversity (Cole, 1988) and more specifically the role of communication, dialogue, multiple perspectives, interacting activity systems and power (Center for Activity Theory and Developmental Work Research, 2003b; Engeström, 1987). ACT has the potential to resolve some of the special issue challenges already mentioned, stemming from Leontiev's (1978) definition of the "object of activity" as "its true motive", i.e. "objects of desire" (Nardi, 2005), "motives as co-constitutive and co-evolving moments in the ever-shifting balances

and mutual penetrations" (Stetsenko, 2005), "co-formation of an object of a collective activity" (Miettinen, 2005) and "poly-motivated activities" (Kaptelinin, 2005); by representing a stage in the transformation of activities wherein the individuals and their motive forces are related to the collective through the multi-voiced collaborative activity cell. *The collaborative activity cell illuminates the dialectical link between the individual and social structure and so can contribute to the development of a unified theory of mind from a historical perspective.* However, this remains the target and object-motive of the practice of Activity theory, i.e. Vygotsky's quest to discover the "psychological" cell of consciousness (Shotter, 2006).

In the creative and transformative spirit of Activity theory, ACT emerged form applying Activity theory in practice, transforming the instrument of analysis and in the process becoming the reflection of its own object. There is a tendency to reify the object of Activity theory, i.e. activity. We often categorize activities as individual, collective or (as here proposed) collaborative, losing sight of the fact that these categories are abstractions of activity as a process. As with all representations, the map is not the territory. *ACT catches facets of the object of the activity while focusing on its process through different lenses.* It would therefore be a mistake to argue the virtues of one unit of analysis (one lens) over another.

> *Activity theory challenges us to make analyses on several levels, although not all at the same time. Certainly we need different approaches depending on the focus of analysis (Bødker, 1995, p. 148).*

It is more productive using multiple units of analysis to represent the transformation of activity. What is important is the cell-form, the dialectical unity of opposites, as basis for a transformative dialectical approach. *ACT is a novel model and representational system which developed out of the practical application of the dialectical method and resolving the challenges identified in chapter 5. The dialectical method combined with the ACT's zoom lens (individual cell, collective cell and intermediary collaborative group cell) constitutes the novel methodology and product of this text. Clearly the development of the dialectical method is "simultaneously the prerequisite and product, the tool and the result of the study" (Vygotsky, 1978).*

7. Conclusion

The dual result and product of this text and its research is a meta-theoretical framework for understanding "learning in a virtual world" and the novel dialectical methodology for designing and evaluating learning activities in virtual worlds through "expanding activity theory for the design and evaluation of group praxis". This text will conclude with a summary of the intellectual journey it has charted. The course explicated emerged from the exploration of learning in a virtual world, it is encompassing and this summary is again structured according to the assumptions deconstructed in the introduction. This accounts for the novel contributions developed throughout this text, its validity and limitations. The future opportunities foreseen for the dialectical methodology is also considered. This text closes on a more subjective note.

7.1. Metaphysical challenge

This text met the metaphysical challenge, answering the question "What is reality?" by framing it in terms of culture. Reality is not conceptualized as an abstraction existing outside of human activities; rather, reality is a cultural-historical product. This text is therefore congruent with Giambattista Vico's vision for a "New Science" as a distinctive historical science. Framing metaphysics in cultural and historical terms makes "reality" accessible for study. This cultural-historical approach furthermore facilitated the integration of approaches from multiple disciplines in this interdisciplinary research project, since these multiple disciplines can so be understood as different cultures. This integration also made possible the development of the Meta-theoretical framework.

7.2. Ontological challenge

This text overcame the ontological challenge, answering the question "What ontological perspective and worldview most productively views learning in a virtual world?" by contributing the novel Meta-theoretical framework. This framework emerged from the philosophical exposition of Western ontological thought; revealing two perspectives competing for dominance the last 2500 years (See 2.1.1). It expanded its frame by relating these ontological developments in philosophy to the development of educational theories and their respective epistemological systems (See 2.1.2 and 2.1.3). The Meta-theoretical framework clarifies and emphasizes the ontological basis of learning theories often overlooked. This also revealed the subtleties within constructivism and developed a coherent picture (Figure 2) of the diversity of its meanings. This Meta-theoretical framework's

exposition illustrates how metaphysical questions elicited by virtual worlds have the potential to serve as a vehicle for driving the transformation of our contemporary learning theory and practice. This text illustrated how the South African context offers a unique perspective on VR, in particular the importance of defining VR in cost effective and accessible terms. The Meta-theoretical framework clarifies constructivism, making it accessible, as well as defines VR in accessible terms. This text consequently views both learning and VR in cultural-historical terms, from a non-dualistic ontological perspective and its dialectical materialist epistemology.

7.3. Epistemological challenge

This text met the epistemological challenge, answering the question "What epistemology, theoretical framework and unit of analysis define learning in a virtual world to facilitate our productive understanding of it?" by promoting the dialectical materialist epistemology, the Activity theoretical framework and the collaborative group as unit of analysis. The Meta-theoretical framework explicated learning (See 2.1) and Virtual Reality (VR) (See 2.2) on the basis of their ontological roots. On the one side, individualistic learning and rationalistic VR, based on the dualistic ontology; and on the other, social learning and dialectical or relational VR, based on the non-dualistic ontology. The Meta-theoretical framework's historical perspective lead this text to propose Cultural-historical Activity theory (See 2.1.4), developing from dialectical materialism, as the most appropriate and productive theoretical framework for framing learning in a virtual world. Learning is defined as learning activity by expanding on Engeström's (1987) crystallization of the concept of learning as expanding, linking the individual and social structure through the unit of analysis of the collaborative group (See 2.1.4.6). Virtual reality is defined as a new representational system or cultural interface which afford new opportunities for human praxis and meaning making (See 2.2.4). Virtual reality therefore provided another cultural context, albeit computer generated and mediated; and thus is as valid a context for learning as any other. Virtual worlds embody VR in its most accessible form at this moment in time.

Having explicated learning in a virtual world from the perspective of Activity Theory, this text considered the standing of research in the field of learning in virtual worlds from the Activity theoretical perspective (See 2.2.5). It became clear that although there is a growing interest in the area, their still remains a great deal to be done. In response to the call for established methods for the study of learning in virtual worlds from the theoretical perspectives of activity theory and constructivism, this text contributes an example of the implementation of such a method (See 4.3.3.4

and 5.4.4); which could contribute to the future formulation of an established method. Furthermore the considered research papers did not explicate the deep ceded theoretical basis for considering Activity theory as framework for the evaluation and understanding of learning in virtual worlds as was done in this text. Nor did they address the deep seeded evaluation challenge of the relativity of dialectical materialist epistemology underlying activity theory. There is a specific need for virtual worlds specifically developed for custom educational contexts and consequently frameworks for the design and evaluation of such virtual worlds. The research explicated in this text aimed to contribute to this growing body of research by developing a methodology for the design and evaluation of learning activities within virtual worlds.

7.4. Methodological challenges

This text met the methodological challenges, answering the question "What methodologies can be most productively used to design and evaluate learning in a virtual world?" by contributing the dialectical methodology. To overcome the first methodological challenge of conducting research from a dialectical approach to science, the dialectical method was developed. The dialectical method was contributed by synthesizing and expanding Vygotsky's historical approach (See 3.1) to the development of higher mental processes, in particular the double stimulation method, with Engeström's expansive method (See 3.2). Like Vygotsky, this text aimed to utilize the dialectical approach to understand the complex phenomenon of human behavior, cognition and learning; and therefore the historical approach formed the very basis of this text. The dialectical method revealed the historical development of the learning activity right before one's eyes (See 3.3). This text also introduced the novel unit of analysis of the collaborative group participating in the learning activity. This new focus required the analysis of the interaction and intersubjectivity developing between the participants of the learning activity. Video analysis was used to capture these complex and highly iterative interactions, while Activity theory was applied as the analytical frame (See 3.3.2). Exploring the synergy between Activity theory and video analysis was an exciting opportunity which this text exploited. However, to evaluate the learning activity in a virtual world from the dialectical perspective, a comparative evaluation had to be incorporated into the dialectical method.

To implement the comparative evaluation the dialectical method had to overcome the second methodological challenge of designing the virtual world as an interactive system. This text integrated Hartson & Hix's "star life cycle" into the dialectical method to systematically consider the design of the virtual world. Although Activity theory has been proposed as method for the design of interactive

systems and learning environments, utilizing Activity theory as analytic as well as evaluative framework within the “star life cycle” was one of the unique contributions this text made (See 3.3.3).

This text overcame the third methodological challenge by comparatively evaluating the same learning activity in two situations. The evaluation of cultural activities from the dialectical materialist perspective is problematic because no objective measures for such evaluation exist. The entire process of transformation of the object through the activity system needed to be taken into account and thus the implicit criterion of evaluation is the activity system itself. This text contributed this novel criterion and the approach of using a learning activity occurring in two situations; one in the classroom and one in the virtual world, to conduct the comparative evaluation (See 3.3.6). Activity theory afforded this comparative evaluation, on the basis that an activity was identified by its object; and although the actions and operations could vary between these two situations, the activity occurring in different situations could be compared on the basis of its shared object.

This text applied the dialectical method to the acid test of practical validity in two case studies conducted in the domain of Film and Media. The first implementation of the dialectical method explicated the context of the research of this text (See 4.1) to identify visualization, in the domain of film and New Media (See 4.2), as the learning activity to be embodied within the virtual world. The visualization prototype was modeled on the summer school storyboarding course, with the aim of prototyping the dialectical method and the interactive system. After the storyboarding learning activity had been delineated (See 4.3.1) the implementation of the dialectical method commenced with the user-centred design’s (See 4.3.2) prototyping stage of the “star life cycle”. The prototype system was then implemented with a group of three students from the summer school storyboarding class (See 4.3.3). The learning activity in the classroom (See 4.3.4) was analyzed using the activity theoretical video analysis and compared to the same analysis of the learning activity in the virtual world of the visualization prototype (See 4.3.5). The comparative evaluation of these two learning activities (See 4.3.6) revealed that the two learning activities were not the same and consequently two closely related activities were compared rather than the same activity in two different situations. The activity within the virtual world had been closer to the production of a photoboard than a storyboard. Notwithstanding, the paper storyboarding and digital photoboarding’s central contradictions reveal two opposite “forces” united in the tension of the visualization process, i.e. the dialectical relationship between imagination (content) and representation (form). Furthermore, the Unreal 2 Engine, the domain of film and New Media; and the dialectical method had been put to the test. The approach was promising but careful attention needed to be given to the

activity's object and maintaining this object in the design and development of the virtual world. The virtual world of the visualization prototype was particularly useful for planning shots and facilitating collaboration. The next iteration of the virtual world therefore aimed specifically to facilitate collaborative visualization within the learning activity of film production.

The second implementation of the dialectical method explicated the production of film as the learning activity to be embodied within the virtual film production world (VFPW). The delineation of the "Long Take" (LT) module (See 5.1.) of the film production course revealed the LT assignment as learning activity for development in the VFPW. However, the Object-historical video analysis of the LT assignment revealed various challenges of representing the complexity of the LT (See 5.2). It was therefore decided to further delineate the LT assignment by focusing specifically on its planning stage. This made it easier to represent the LT planning activity and facilitated its implementation in the virtual world. The user-centred design of the VFPW (See 5.3) and its implementation (See 5.4) was then conducted. The learning activity (LT2) in the virtual world prototype (See 5.5) was analyzed using the activity theoretical video analysis. This analysis was compared to the original analysis of the learning activity (LT1) in the classroom (See 5.2). The comparative evaluation of the two learning activities (See 5.6) revealed that the greatest difference between LT1 and LT2's planning stages, according to the activity system triangles developed, appeared to be the instruments used in producing the two respective plans. However, despite these subtle differences the two learning activities' structures represented using the Engeström Activity System (EAS) triangle was very similar. Furthermore, the VFPW had overcome the problem encountered in the storyboarding prototype, i.e. comparing two closely related activities rather than the same activity in two different situations. As with the storyboarding prototype it would seem that the virtual world required the students to be creative within the constraints of the given virtual world. This constrained their imaginations, yet provided the context and information they required to plan the LT. The representational challenges that emerged from the implementation of the EAS, however, raised the concern whether the activity systems appeared to be similar because of the analytical frame utilized, its representation or the unit of analysis it implies. Considering the two learning activities (LT1 and LT2) it was clear that the interactions between participants were not clearly represented. What was needed was an intermediate level of analysis, where the participant's individual activities were also represented within the collective activity. This representational challenge suggests that the EAS is not sufficient as model for the dialectical method.

7.5. Representational challenge

This text met the representational challenge, answering the question "What representations and models can be used to most productively represent and communicate learning in a virtual world?" by contributing Activity cell transformation (ACT). After considering the alternatives (See 6.1) it was realized that the representational challenge derived from a more fundamental problem underlying the EAS and activity theory (See 6.2). Through creative problem solving ACT emerged to transform the EAS and resolve the practical challenges which emerged in the second implementation of the dialectical method (See 6.3). ACT was then used to transform and reconsider the two learning activities comparatively evaluated earlier (See 5.6). The activity cell's comparative evaluation (See 6.4) provided empirical evidence to verify that the dialectical methodology had indeed succeeded in understanding, developing and evaluation a learning activity in a virtual world. There were some subtle differences between LT1 and LT2 at the operation level of using the keyboard and mouse; and the VFPW LT2 activity was clearly facilitated by the participant's ability of being able to see the world through one another's "eyes". However, the heart of the two planning activities was one and the same object. ACT clearly represents that, which is missing in Engeström's representation of the activity system. The multiple voices of the expansive cycle are represented in the multiple individual cells of the collaborative activity cell.

7.6. Validation

> *The epistemological problem is on the one hand that "valid" statements are uniformly dull, and on the other that 'Cartesian' or 'static' truth cannot handle the sort of realities twentieth-century man is interested in (Wilden, 1994, p. 211).*

The criteria for the validation of this text derive from the dialectical approach and its materialist epistemology. Selecting an alternative ontological perspective and epistemology to that which has been dominant in the West not only has methodological consequences for conducting research from the approach of dialectical science but also for the criterion whereby it is validated. The term validation, as used in this text, does not refer to its traditional quantitative research meaning based on validity and reliability rooted in logical positivism. Although the dialectical materialist epistemology does not deny the existence of an objective reality, this reality and its laws cannot be known in any absolute and truly objective terms. Human knowledge about the world is produced through human praxis, both objective and subjective and relative to the perspective taken. The whole scientific endeavor is a cultural practice revealing ever increasing dependable knowledge of the

world. The dialectical materialist epistemology promoted in this text clearly has important implications for validity. Indeed, can the concept of validity and validation exist without objective truth? Winter (2000) suggests that validation should be adjusted depending on the kind of truth that is sought or expected; and therefore 'validity' appears to reside within the appropriation of research methodologies to those systems of truth that their processes best represent. The validation of this text and its contributions will therefore be argued from the dialectical perspective promoted.

7.6.1. Meta-theoretical framework's validation

The Meta-theoretical framework clearly accounts for the philosophical assumptions underlying the cultural-historical perspective taken by explicating not only the promoted dialectical materialist epistemology but also its ontological basis. This validates not only the Meta-theoretical framework but also the appropriation of Activity theory, developing from dialectical materialism, as the most developed, productive and appropriate theoretical framework for considering learning in a virtual world.

7.6.2. Dialectical method's validation

The dialectical method is congruent with philosophical perspective and assumptions explicated in the meta-theoretical framework (See 2) and developed in this text. The dialectical method emerged creatively through the reciprocation between theory and practice. Only after the method emerged, could it be rationally analyzed and given form in the most suited theoretical objects, borrowed from Hartson & Hix's, Vygotsky and Engeström. This is an example of the "bricolage" style of research and is a valid and valuable way of organizing scientific work. *This text contributes an account of its "bricolage" style, which was an important part of the process of the dialectical methods formulation and this accountability further validates the method*. The dialectical method was put through the acid test of practical validity by implementing it in two case studies. The result of this practical implementation was that various challenges emerged and had to be overcome. This historical development of the dialectical method is accounted for throughout this text and validates the dialectical method. During the implementation of the dialectical method the dual methods of semi-structured interviews and participant observations (video recorded for later analysis) were used to collect empirical data. The interpretation of the video data was conducted using Activity theory as framework for the analysis. The close participation of the researcher in the learning activities afforded them the proper understanding of the learning activity and enabled them to interpret the intersubjective meanings of the diverse actions exhibited by participants. The validity of

the comparative evaluation occurring in the two situations was afforded by Activity theory on the basis that an activity is identified by its object. Although the actions and operations could vary between the two situations, the activity occurring in different situations could be compared on the basis of its shared object. This is however also the major limitation of the dialectical method, as it can only be applied to already existing learning activities. *This text therefore further validates the dialectical method by exposing this limitation and acknowledging that this is the price that has to be paid for the validity of the comparative evaluation.*

7.6.3. Activity cell transformation's validation

ACT was developed in response to practical challenges which emerged from using Engeström's triangle as model of the activity system for the implementations of the dialectical method. ACT is validated by its dialectical development, starting from theory transforming practice, again moving back to transform theory. ACT is further validated by the empirical evidence that demonstrates that it succeeds where Engeström's representation had failed. ACT clearly represents the multiple voices of the expansive cycle in the multiple individual cells of the collaborative activity cell, illustrating how the multiple voices constitute the shared contextual field and the collective object. ACT facilitates our understanding of learning activities by clearly representing the intermediary-level of the collaborative group and illuminating the developing intersubjectivity between participants. ACT offers a flexible representational system with different levels of analysis (zoom lens) illuminating the differences, similarities and the complexity of learning activities. This text aims to further validate ACT by acknowledging that although ACT is a more suggestively dynamic representation of an activity than the EAS, it is still a static representation when printed on paper. The future development of ACT needs to consider its transformation in the dynamic computational medium to overcome this limitation.

7.7. Future work

Computational media has an important role to play in the representation of transformative objects such as activities. This text has demonstrated this in a dynamic way by referencing computational media available online (http://people.cs.uct.ac.za/~hvermeul/act/index.html) that were developed by the author of this text. These transformative objects enable us to represent processes through animations and enable temporal control over the representation of these processes. These computational tools can be developed further to represent interacting activity cells. This text opens up the possibility of developing an interactive media implementation of ACT enabling researchers to

annotate research video data, graphically represent temporal sequences of interaction (through animation) and to explore its productive use for engineering and managing activities. Design research in the field of New Media provides an excellent context for such development to take place, e.g. the design of games. Games and play are not very well understood activities, particularly from the perspective of mono voiced collective activities. *ACT can play an important role in the analysis and comprehension of such play activities. Games typically revolve around the paradox of the individual outcome and motive of winning the game and the collective outcome and motive of playing the game.* Another productive area in which to consider the future application of ACT is that of language-games and word-meaning. ACT can be used to illuminate Vygotsky's (1986) conception of word-meaning as a unit of both generalizing thought and social exchange. Words as utterances are objects mediating between our subjectivities and that of others, i.e. society.

One of the central challenges facing the discipline of New Media is how to teach New Media. New Media goes beyond simply remediating established media such as text, image, film, etc. New Media techniques, practices, codes and conventions are not yet fully developed. As New Media is still an emerging discipline, how can we teach it? This text can be expanded in the future to answer this important question. The envisioned research would exploit the synergy between New Media and Film as was done in this text. However, the scope of the study would be much larger, having students learn to produce the virtual world that they will use in the virtual film production scenario. It would ideally take place in the domain of Film and New Media drawing on students from Film Studies aiming to move into New Media. This would help bridge the conceptual domain between Film and New Media. Students will learn New Media skills yet the learning situation will be congruent with their experience of film. A comparative study can be conducted to identify the differences and similarities between the virtual world and film production activities. This would afford the opportunity to identify and document the development of new techniques, practices, codes and conventions in New Media as they occur through practice.

As this text has argued that virtual worlds are another cultural context (See 2.2.4), the dialectical methodology developed in this text can be applied to cultural contexts other than virtual worlds. It is hoped that the dialectical method and ACT will be applied, corroborated and further developed in future research in a variety of domains. *The dialectical methodology, combining the dialectical method and its ACT, expands Activity theory for the design and evaluation of group praxis.*

7.8. Final words

I concur with Nardi (2005) that the passions and desires behind objects of scientific research are missing in most accounts. The "I" therefore denotes this subjective turn in this text. The passion behind this text is my desire to understand the world and to change things for the better. This passion has led me to consider both learning and virtual reality; and this attempt to explore their synergy. Activity theory provides the most adequate framework to understand how people construct "reality". Collaborative design practices embody the creative agency of human beings to transform the world. However, with this power comes the great responsibility of the worlds we create. This is particularly important if we are to suggest Activity theory as theoretical framework for the study of agency and social change. It is tempting to suggest that the message of the medium of VR is the dialectical materialist epistemology, where the virtual world is literally a cultural construction and knowledge is relative to the participant's perspectives within this world.

Indeed, from a dialectical materialist epistemological position all knowledge is both subjective and objective. Therefore contrary to the rationalistic notion that subjectivity diminishes the validity of knowledge, the dialectical materialist epistemology regards accounting for subjectivity as central to the validity of knowledge. This is particularly relevant for this text as I acknowledge that it does have a strong subjective component to it. This is however congruent with the dialectical materialist epistemology I promote. Knowledge is relative to the perspective taken and I have accounted for my perspective to the best of my ability.

This text is a creative product much like film. The development of it has been a dialectical process, highly iterative, reciprocating between the analytical and synthetic modes. This text therefore reflects the ideas and theories of many great "minds", whose externalizations I have internalized and made my own. These ideas were then creatively externalized in the dialectical methodology which was then tested in "objective" reality. This reciprocation with the world also transformed the dialectical method and resulted in the development of ACT.

The final validation of this text will be intersubjective. Can ACT as explicated in this text mediate my understanding of learning in virtual worlds and communicate this effectively? Will the dialectical method be found useful by other Activity theory practitioners and applicable to other contexts? These are requirements that need to be met if the dialectical method is to achieve its full potential and transform the practice of Activity theory itself. However, as with all creative objects the final outcome is not in my hands but yours, my audience.

References

Aldrich, C. (2005). *Learning by doing: A comprehensive guide to simulations, computer games, and pedagogy in e-learning and other educational experiences*: John Wiley & Sons.

Allman, P. (1999). *Revolutionary social transformation: Democratic hopes, political possibilities and critical education*. Westport: Bergin & Garvey.

Altman, R. (Writer) (1992). The player [Film]. USA.

Altshuller, G. S. (1984). *Creativity as an exact science: The theory of the solution of inventive problems*. New York: Gordon and Breach Science Publishers.

Amory, A., & Seagram, R. (2003). Educational game models: Conceptualization and evaluation. *South African Journal of Higher Education, 17*(2), 206–217.

Arrington, M. (2007). The second life census. Retrieved 8 November, 2007, from http://www.techcrunch.com/2007/02/10/second-life-census/

Ash, C., Chin, G., Pennisi, E., & Sugden, A. (2007). Introduction: Living in societies. *Science, 317*, 1337.

Au, W. (2007). Epistemology of the oppressed: The dialectics of paulo freire's theory of knowledge. *Journal for Critical Education Policy Studies, 5*(2).

Bainbridge, W. S. (2007). The scientific research potential of virtual worlds. *Science, 317*, 472-476.

Bakhurst, D. (1991). *Consciousness and revolution in soviet psychology: From the bolsheviks to evald ilyenkov*. Cambridge: Cambridge University Press.

Bannon, L., & Bødker, S. (1991). Beyond the interface: Encountering artifacts. In J. Carroll (Ed.), *Designing interaction: Psychology at the human computer interface* (pp. 227–253). New York: Cambridge University Press.

Barab, S. A., Barnett, M., Yamagata-Lynch, L., Squire, K. R., & Keating, T. (2002). Using activity theory to understand the systematic tensions characterizing a technology-rich introductory astronomy course. *Mind, Culture and Activity, 9*(2), 76-107.

Barab, S. A., & Duffy, T. (2000). From practice fields to communities of practice. In D. H. Jonassen & S. M. Land (Eds.), *Theoretical foundations of learning environments*. Mahwah: Lawrence Erlbaum Associates.

Barab, S. A., & Plucker, J. A. (2002). Smart people or smart contexts? Cognition, ability, and talent development in an age of situated approaches to knowing and learning. *Educational Psychologist, 37*, 165–182.

Barr, P., Noble, J., & Biddle, R. (2006). Video game values: Human–computer interaction and games. *Interacting with Computers, 19*, 180-195.

Baudrillard, J. (1998). Simulacra and simulations. In M. Poster (Ed.), *Jean baudrillard, selected writings* (pp. 166-184). Stanford: Stanford University Press.

Baum, G., Margolis, T., & Miller, K. (2004). *The vr portal: Interfacing the art world.* Paper presented at the Workshop Proceedings of the IEEE VR 2004 Conference, Chicago.

Bazin, A. (1958). *Qu'est-ce que le cinéma*. Paris: Éditions du Cerf.

Beepa. (2007). Fraps.

Beinart, W. (2001). *Twentieth-century south africa*. Oxford: Oxford University Press.

Beirowski, C., & Vermeulen, H. (2004). *Experiences with virtual reality accessibility in an african context.* Paper presented at the Workshop Proceedings of the IEEE VR 2004 Conference, Chicago.

Bidell, T. (1988). Vygotsky, piaget and the dialectic of development. *Human Development, 31*, 329-348.

Blackburn, S. (1996). *The oxford dictionary of philosophy*: Oxford University Press.

Blumer. (1969). *Symbolic interactionism: Perspective and method*. Berkeley: University of California Press.

Bødker, S. (1995). Applying activity theory to video analysis: How to make sense of video data in human-computer interaction. In B. A. Nardi (Ed.), *Context and consciousness: Activity theory and human-computer interaction*. Cambridge: MIT Press.
Bohr, N. (1934). Atomic theory and the description of nature.
Bolter, J., & Grusin, R. (1999). *Remediation: Understanding new media*. Cambridge: MIT Press.
Bowker, J. (2000). *The concise oxford dictionary of world religions*: Oxford University Press.
Brand, S. (1987). *The media lab: Inventing the futurea at mit*. New York: Viking.
Bricken, W. (1990). *Virtual reality: Directions of growth*. Seattle, WA: University of Washington.
Brown, S. (2006). *Informational support in a virtual environment: Using nutrition information to improve quality of life for hiv+ individuals.* University of Cape Town, Cape Town.
Bruner, J. S. (1990). *Acts of meaning*. Cambridge: Harvard University Press.
Bryson, S., Feiner, S., Brooks, F., Hubbard, P., Pausch, R., & Van Dam, A. (1994). *Research frontiers in virtual reality.* Paper presented at the SIGGRAPH '94.
Buckle, S. (2007). Descartes, plato and the cave. *Philosophy, 82*, 301-337.
Burbles, N. C. (2004). Rethinking the virtual. *E-Learning, 1*(2), 162-182.
Button, G. (1991). *Ethnomethodology and the human sciences*. Cambridge: Cambridge University Press.
Button, G., & Dourish, P. (1996). *Technomethodology: Paradoxes and possibilities.* Paper presented at the 1996 Conference on Human Factors in Computing Systems, Vancouver, Canada.
Calhoun, C. (2002). *Dictionary of the social sciences*: Oxford University Press.
Center for Activity Theory and Developmental Work Research. (2003a). The activity system. Retrieved 08 July, 2007, from University of Helsinki's web site: http://www.edu.helsinki.fi/activity/pages/chatanddwr/activitysystem/
Center for Activity Theory and Developmental Work Research. (2003b). Cultural-historical activity theory. Retrieved 08 July, 2007, from University of Helsinki's web site: http://www.edu.helsinki.fi/activity/pages/chatanddwr/chat/
Christiansen, E. (1995). Tamed by a rose: Computers as tools in human activity. In B. A. Nardi (Ed.), *Context and consciousness: Activity theory and human-computer interaction* (pp. 175–198). Cambridge: MIT Press.
Cobb, P. (1994). Where is the mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher, 23*(7), 13-20.
Cobb, P. (1995). Continuing the conversation: A response to smith. *Educational Researcher, 24*(7), 25-27.
Cole, M. (1988). Cross-cultural research in the sociohistorical tradition. *Human Development, 31*, 137-151.
Cole, M. (1996). *Cultural psychology: A once and future discipline*. Cambridge: Harvard University Press.
Cole, M. (1997). Culture and cognitive science. from http://lchc.ucsd.edu/People/Localz/MCole/santabar.html
Cole, M., & Engeström, Y. (1993). A cultural-historical approach to distributed cognition. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations*. Cambridge: Cambridge University Press.
Collins, P., Shukla, S., & Redmiles, D. (2002). Activity theory and sytems design: A view from the trenches. *Computer Supported Cooperative Work, 11*, 55-80.
Colman, A. M. (2006). *A dictionary of psychology*: Oxford University Press.
Coulter, J. (1983). *Rethinking cognitive theory*. New York: St. Martin's Press.
Coyle, J. (2007). Justin kan vlogs 24/7 at justin.Tv. Retrieved 16 December, 2007, from Washingtonpost's web site: http://www.washingtonpost.com/wp-dyn/content/article/2007/03/28/AR2007032801719_pf.html

Coyne, R. (1994). Heidegger and virtual reality: The implications of heidegger's thinking for computer representations. *Leonardo, 27*(1), 65-73.
Crocker, J. (2003). Active learning systems. *ACM Computers in Entertainment, 1*(1).
CVC Laboratory. (2004). Collaborative visual computing laboratory. Retrieved 9 December, 2007, from CVC web site: http://cvc.cs.uct.ac.za
Dancyger, K. (1999). *The world of film and video production: Aesthetics and practices*. Fort Worth: Harcourt Brace College Publishers.
Davies, C. (2003). Landscape, earth, body, being, space and time in the immersive virtual environments osmose and ephémère. In J. Malloy (Ed.), *Women in new media*: MIT Press.
Davydov, V. V. (1999). The content and unsolved problems of activity theory. In Y. Engeström, R. Miettinen & R.-L. Punamäki-Gitai (Eds.), *Perspectives on activity theory*. Cambridge: Cambridge University Press.
De Aguilera, M., & Méndiz, A. (2003). Video games and education. *ACM Computers in Entertainment, 1*(1).
de Freitas, S. (2006). *Learning in immersive worlds: A review of game-based learning*: JISC.
de Freitas, S., & Oliver, M. (2006). How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Computers & Education, 46*.
Derry, S. J. (1996). Cognitive schema theory in the constructivist debate. *Educational Psychologist, 31*(3/4), 163-174.
Descartes, R. (1904). *Oeuvres de descartes*. Paris: Vrin.
Descartes, R. (1984). Meditations on first philosophy (T. Cottingham, R. Stoothoff & D. Murdoch, Trans.). In *The philosophical writings of rené descartes* (Vol. 2, pp. 1-62). Cambridge: Cambridge University Press.
Dewey, J. (1915). *The school and society*. Chicago: University of Chicago Press.
Dewey, J. (1988). The quest for certainty. In J. A. Boyston (Ed.), *John dewey: The later works. 1925-1953, vol. 4*. Carbondale: Southern Illinois University Press.
Dewey, J. (1989). Modern philosophy. In J. A. Boyston (Ed.), *John dewey: The later works. 1925-1953, vol. 16*. Carbondale: Southern Illinois University Press.
Dobson, J. (2007). Research: Western mmo market passes $1bn in 2006. Retrieved 18 August, 2007, from Gamasutra's web site: http://www.gamasutra.com/php-bin/news_index.php?story=13233
Dobson, M., LeBlanc, D., & Burgoyne, D. (2004). Transforming tensions in learning technology design: Operationalizing activity theory. *Canadian Journal of Learning and Technology, 30*(1).
Dourish, P., & Button, G. (1998). On 'technomethodology'" foundational relationship between ethnomethodology and systems design. *Human Computer Interaction, 13*(4), 395-432.
Dourish, P. (2004). What we talk about when we talk about context. *Journal of Personal & Ubiquitous Computing*, 8(1), 19-30.
Ellis, N. (1996). Presence of mind: A reaction to thomas sheridan's 'further musings on the psychophysics of presence'. *Presence: Teleoperators & Virtual Environments, 5*, 247-259.
Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki: Orienta-Konsultit Oy.
Engeström, Y. (1993). Developmental studies of work as a test bench of activity theory: The case of primary care medical practice. In S. Chaiklin & J. Lave (Eds.), *Understanding practice*. Cambridge: Cambridge University Press.
Engeström, Y. (1996). Interobjectivity, ideality and dialectics. *Mind, Culture and Activity*, 3(4), 259-265.

Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engeström, R. Miettinen & R. L. Punamäki (Eds.), *Perspectives on activity theory* (pp. 19-38). Cambridge: Cambridge University Press.

Engeström, Y., Engeström, R., & Vähäaho, T. (1999). When the center does not hold: The importance of knotworking. In S. Chaiklin, M. Hedegaard & U. J. Jensen (Eds.), *Activity theory and social practice: Cultural-historical approaches* (pp. 345–374). Aarhus: Aarhus University Press.

Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work, 14*(1).

Engeström, Y., & Miettinen, R. (1999). Introduction. In Y. Engeström, R. Miettinen & R. L. Punamäki (Eds.), *Perspectives on activity theory* (pp. 1-18). Cambridge: Cambridge University Press.

Epic Games. (2004). Unreal tournament 2004: Epic Games.

Epic Games. (2007). Rendering. Retrieved 10 January, 2008, from http://www.unrealtechnology.com/features.php?ref=rendering

Flor, N., & Hutchins, E. L. (1991). *Analyzing distributed cognition in software teams: A case study of team programming during perfective software maintenance.* Paper presented at the Fourth Annual Workshop on Empirical Studies of Programmers.

Foot, K. A. (2002). Pursuing an evolving object: A case study in object formation and identification. *Mind, Culture and Activity, 9*(2), 132–149.

Fors, A. C., & Jakobsson, M. (2002). Beyond use and design: The dialectics of being in virtual worlds. *Digital Creativity, 13*(1), 1-2.

Fox, S. (1997). Situated learning theory versus traditional cognitive learning theory: Why management education should not ignore management learning. *Systems Practice, 10*(6), 727-747.

Gadamer, H. G. (1960/1988). *Truth and method*. New York: Crossroads.

Gadotti, M. (1996). *Pedagogy of praxis: A dialectical philosophy of education.* Albany: State University of New York Press.

Galperin, P. (1967). On the notion of internalization. *Soviet Psychology, 5*(3), 28-33.

Gamasutra. (2007). Dfc: Online market to triple by 2012, digital sales to spike. Retrieved 20 August, 2007, from Gamasutra's web site: http://www.gamasutra.com/php-bin/news_index.php?story=14139

Gardner, H. (1985). *The minds new science: A history of the cognitive revolution*. New York: Basic Books.

Garfinkel, H. (1967). *Studies in ethnomethodology*. Cambridge: Polity Press.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Macmillan.

Gee, J. P. (2005). Learning by design: Good video games as learning machines. *E–Learning, 2*(1), 5-16.

Gelernter, D. (1992). *Mirror worlds: Or the day software puts the universe in a shoebox.How it will happen and what it will mean*. Oxford: Oxford University Press.

Gibson, J. J. (1970). On the relation between hallucination and perception. *Leonardo, 3*(4), 425-427.

Gibson, J. J. (1973). On the concept of 'formless invariants' in visual perception. *Leonardo, 6*(1), 43-45.

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

Gibson, W. (1984). *Neuromancer*: Ace Books.

Google. (2007a). Google earth.

Google. (2007b). Sketchup.

Gould, J. (1989). *Herodotus*. New York: St. Martin's Press.

Graham, D. W. (2007). Heraclitus. In E. N. Zalta (Ed.), *The stanford encyclopedia of philosophy (spring 2007 edition)*. Stanford: Stanford University.
Grier, M. (2007). Kant's critique of metaphysics. In E. N. Zalta (Ed.), *The stanford encyclopedia of philosophy (spring 2007 edition)*. Stanford: Stanford University.
Halverson, C. A. (2002). Activity theory and distributed cognition: Or what does cscw need to do with theories? *Computer Supported Cooperative Work, 11*, 243-267.
Hansen, M. M. (2008). Versatile, immersive, creative and dynamic virtual 3-d healthcare learning environments: A review of the literature. *Journal of Medical Internet Research, 10*(3).
Hartson, H. R., & Hix, D. (1989). Towards emperically derived methodologies ad tools for human-computer interface development. *Internatioal journal for Man-Machine Studies, 31*, 477-494.
Hayles, K. (1993). The seduction of cyberspace. In V. Conley (Ed.), *Rethinking technologies*. University of Minesota Press.
Hayward, R. J. (2002). *Theory and the everyday in martin heidegger's being and time.* Middlesex University, Middlesex.
Heath, C. (1986). Video analysis: Interactional coordination in movement and speech. In *Body movement and speech in medical interaction*. Cambridge: Cambridge University Press.
Hegel, G. W. F. (1967). *The phenomenology of mind* (J. B. Baillie, Trans.). New York: Harper & Row.
Heidegger, M. (1962). *Being and time* (J. Macquarie & E. Robinson, Trans.). New York: Harper and Row Press.
Heidegger, M. (1996). *Being and time* (J. Stambaugh, Trans.). Albany: State University of New York Press.
Hillis, K. (2006). Modes of digital identification: Virtual technologies and webcam cultures. In W. Hui Kyong Chun & T. Keenan (Eds.), *New media old media: A history and theory reader*. New York: Routledge.
Hitchcock, A. (Writer) (1963). The birds [Film]. USA.
Holzkamp, K. (1983). *Grundlegung der psychologie [foundations of psychology]*. Frankfurt: Campus.
Holzkamp, K. (1992). Die fiktion administrativer planbarkeit schulischer lernprozesse [on the fiction of the possibility to administratively plan learning processes at school]. In K. H. Braun & K. Wetzel (Eds.), *Lernwidersprüche und pädagogisches handeln* (pp. 91-113). Marburg: Verlag Arbeit und Gesellschaft.
Hussey, E. (1999). Heraclitus. In A. A. Long (Ed.), *The cambridge companion to early greek philosophy*. Cambridge: Cambridge University Press.
Hutchins, E. (1995). *Cognition in the wild*. Cambridge: MIT Press.
Hutchins, E. L., Hollan, J. D., & Norman, D. A. (1985). Direct manipulation interfaces. *Human-Computer Interaction, 1*, 311-338.
Ilyenkov, E. (1977). *Dialectical logic: Essays on its history and theory* (H. C. Creighton, Trans.): Progress Publishers.
Ilyenkov, E. (1982). *The dialectics of the abstract and the concrete in marx's capital* (S. Kuzyakov, Trans.): Progress Publishers.
Inwood, M. (1992). *A hegel dictionary*. Oxford: Blackwell.
Jackson, T. A. (1971). *Dialectics: The logic of marxism and its critics*: Burt Franklin.
Jenkins, D. (2005). Analyst: Video games to lead entertainment growth. Retrieved 18 August, 2007, from Gamasutra's web site: http://www.gamasutra.com/php-bin/news_index.php?story=6752
Jonassen, D. H., & Rohrer-Murphy, L. (1999). Activity theory as a framework for designing constructivist learning environments. *Educational Technology Research and Development, 47*(1), 61-79.

Kahn, C. H. (1981). *The art and thought of heraclitus: An edition of the fragments with translation and commentary*. Cambridge: Cambridge University Press.
Kant, I. (1965). *Critique of pure reason*: St. Martin's Press.
Kaptelinin, V. (1995). Activity theory: Implications for human-computer interaction. In B. A. Nardi (Ed.), *Context and consciousness: Activity theory and human computer interaction*. Cambridge: MIT Press.
Kaptelinin, V. (2005). The object of activity: Making sense of the sense-maker. *Mind, Culture and Activity, 12*(1), 4-18.
Kaptelinin, V., & Miettinen, R. (2005). Perspectives on the object of activity. *Mind, Culture and Activity*, 12(1), 1-3.
Kaptelinin, V., & Cole, M. (1997). *Individual and collective activities in educational computer game playing.* Paper presented at the Proceedings of the International CSCL'97 Conference on Computer Support for Collaborative Learning.
Kaptelinin, V., Macaulay, C., & Nardi, B. A. (1999). The activity checklist: A tool for the representing the 'space' of context. *Interactions, 6*, 27-39.
Kaptelinin, V., & Nardi, B. A. (1997, March 1997). *Activity theory: Basic concepts and applications.* Paper presented at the CHI 97, Atlanta.
Kaptelinin, V., & Nardi, B. A. (2006). *Acting with technology: Activity theory and interaction design*. Cambridge: MIT Press.
Karpatschof, B. (2000). *Human activity - contributions to the anthropological sciences from a perspective of activity theory*. Copenhagen: Dansk Psykologisk Forlag.
Katz, S. (1991). *Film directing shot by shot*. Studio City: Michael Wiese Productions in conjunction with Focal Press.
Kirriemuir, J., & McFarlane, A. (2004). *Literature review in games and learning*: FUTURELAB.
Kohler, C. (2007). Triumph of the wii: How fun won out in the console wars. Retrieved 10 November 2007, 2007, from http://www.wired.com/gaming/hardware/news/2007/06/wii
Kommers, P., & Zhiming, Z. (1998). *Virtual reality for education*. Enschede: University of Twenete.
Korpela, M., Sorian, H. A., & Olufokunbi, K. C. (2000). Activity analysis as a method for information systems development: General introduction and experiments from nigeria and finland. *Scandinavian journal of Information Systems, 12*, 191-210.
Koschmann, T. (2002a). *Dewey's contribution to the foundations of cscl research.* Paper presented at the Computer Support for Collaborative Learning, Boulder.
Koschmann, T. (2002b). *Differing ontologies: Eighteenth-century philosophy and the learning sciences.* Paper presented at the International Conference of the Learning Sciences, Seattle.
Kozulin, A. (1986). Vygotsky in context. In A. Kozulin (Ed.), *Thought and language*. Cambridge: MIT Press.
Krueger, M. W. (1991). *Artificial reality*. Reading: Addison-Wesley.
Kuutti, K. (1995). Activity theory as a potential framework for human-computer interaction research. In B. A. Nardi (Ed.), *Context and consciousness: Activity theory and human-computer interaction*. Cambridge: MIT Press.
Langley, P., Simon, H. A., Bradshaw, G. L., & Zytkow, J. M. (1987). *Scientific discovery: Computational explorationsof the creative process*. Cambridge: MIT Press.
Latour, B. (1996). On interobjectivity. *Mind, Culture and Activity, 3*(4), 228-245.
Latta, J. N., & Oberg, D. J. (1994). A conceptual virtual reality model. *IEEE Computer Graphic & Applications*.
Lauria, R. (1997). Virtual reality: An empirical-metaphysical testbed. *Journal of Computer-Mediated Communication, 3*(2).
Lave, J. (1988). *Cognition in practice*. Cambridge: Cambridge University Press.

Lave, J. (1993). The practice of learning. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp. 3–32). Cambridge: Cambridge University Press.
Lektorsky, V. A. (1984). *Subject, object, cognition*. Moscow: Progress.
Lektorsky, V. A. (1999). Activity theory in a new era. In Y. Engeström, R. Miettinen & R. L. Punamäki (Eds.), *Perspectives on activity theory* (pp. 65-69). Cambridge: Cambridge University Press.
Lemke, J. (2000). Across the scales of time: Artifacts, activities, and meanings in ecosocial systems. *Mind, Culture and Activity, 7*(4), 273-290.
Lemke, J. (2007). Video epistemology in-and-outside the box: Traversing attentional spaces. In R. Goldman, R. Pea, B. Barron & S. J. Derry (Eds.), *Video research in the learning sciences*. Mahwah: Lawrence Erlbaum Associates.
Leontiev, A. N. (1978). *Activity, consciousness, and personality*. Englewood Cliffs: Prentice Hall.
Leontiev, A. N. (1981). *Problems of the development of the mind*. Moscow: Progress Publishers.
Lerman, S. (2000). A case of interpretations of social: A response to steffe and thompson. *Journal for Research in Mathematics Education*(31), 210–227.
Lévi-Strauss, C. (1968). *The savage mind*. Chicago: University of Chicago Press.
Levins, R., & Lewontin, R. (1985). *The dialectical biologist*. Cambridge: Harvard University Press.
Lombard, M., & Ditton, T. (1997). At the heart of it all: The concept of presence. *Journal of Computer-Mediated Communication, 3*(2).
MacArthur Foundation. (2007). Building the field of digital media and learning. Retrieved 21 August, 2007, from MacArthur Foundation's web site: http://digitallearning.macfound.org/site/c.enJLKQNlFiG/b.2029199/k.BFC9/Home.htm
Manovich, L. (1994). *Automation of sight: From photography to computer vision.* Paper presented at the Photography and the Photographic: Theories, Practices, Histories, Riverside.
Manovich, L. (2001). *The language of new media*. Cambridge: MIT Press.
Mantovani, F. (2003). *Vr learning: Potential and challenges for the use of 3d environments in education and training*. Amsterdam: IOS Press.
Marsh, T. (1999). Evaluation of virtual reality systems for usability, *CHI '99: CHI '99 extended abstracts on Human factors in computing systems*. Pittsburgh, Pennsylvania: ACM Press.
Marsh, T., Wright, P., & Smith, S. (2001). Evaluation for the design of experience in virtual environments: Modeling breakdown of interaction and illusion. *Cyberpsychology and Behavior, 4*(2), 225-238.
Marx, K. (1845/1967). Theses on feuerbach. In E. Kamenka (Ed.), *The portable marx*. New York: Penguin Books.
Marx, K. (1977). *Capital: A critique of political economy* (B. Fowkes, Trans.). New York: Vintage.
Mayer, R. E. (1992). Cognition and instruction: Their historic meeting within educational psychology. *Journal of Educational Psychology, 84*(4), 405-412.
Mayer, R. E. (1996). Learners as information processors: Legacies and limitations of educational psychology's second metaphor. *Educational Psychologist, 31*(3/4), 151-161.
Mead, G. H. (Ed.). (1982). *The individual and the social self: Unpublished essays by g. H. Mead*. Chicago: University of Chicago Press.
Menand, L. (2001). *The metaphysical club*. New York: Farrar Straus & Giroux.
Messinger, P. R., Stroulia, E., & Lyons, K. (2008). A typology of virtual worlds: Historical overview and future directions. *Journal of Virtual Worlds Research, 1*(1), 1-18.
Metaphysics. (2007). In encyclopædia britannica. Retrieved 11 September, 2007, from Encyclopædia Britannica Online: http://www.search.eb.com/eb/article-9108718
Miettinen, R., & Hasu, M. (2002). Articulating user needs in collaborative design: Towards an activity-theoretical approach. *Computer Supported Cooperative Work, 11*, 129-151.

Miettinen, R. (2005). Object of activity and individual motivation. *Mind, Culture and Activity*, 12(1), 52-69.
Miller, G. (2007a). The promise of parallel universes. *Science, 317*, 1341-1343.
Miller, P. (2007b). Total wii sales surpass the xbox 360 worldwide? Retrieved 10 November, 2007, from http://www.engadget.com/2007/08/23/total-wii-sales-surpass-the-xbox-360-worldwide/
Minnis, M., & John-Steiner, V. P. (2001). Are we ready for a single, integrated theory? *Human Development, 44*, 296-310.
Minsky, M. (1980). *Telepresence*. New York: Freeman.
Mollman, S. (2007). Wii + second life = new training simulator. Retrieved 10 November, 2007, from http://www.wired.com/gadgets/miscellaneous/news/2007/07/wiimote
Moran, S., & John-Steiner, V. (2003). Creativity in the making: Vygotsky's contemporary contribution to the dialectic of development and creativity. In K. R. Sawyer, V. John-Steiner, S. Moran, R. J. Sternberg, D. H. Feldman, J. Nakamura & M. Csikszentmihalyi (Eds.), *Creativity and development*. Oxford: Oxford University Press.
Morrison, D. (2003). Using activity theory to design online learning environments for higher order thinking: A retrospective analysis. *Canadian Journal of Learning and Technology, 29*(3).
Morse, M. (1996). Landscape and narrative in virtual evironments. In Moser (Ed.), *Immersed in technology: Art and virtual environments*. Cambridge: MIT Press.
Moser, R. (1997). *A fantasy adventure game as a learning environment: Why learning to program is so difficult and what can be done about it.* Paper presented at the 2nd Conference on Integrating Technology into Computer Science Education.
Mwanza, D. (2002). *Towards an activity-oriented design method for hci research and practice.* Unpublished PhD, The Open University, Milton Keynes.
Mwanza, D., & Engeström, Y. (2003). *Pedagogical adeptness in the design of e-learning environments: Experiences from the lab@future project.* Paper presented at the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2003, Chesapeake.
Nancy, J. L. (2000). *Being singular plural* (R. Richardson, Trans.). Palo Alto: Stanford University Press.
Nardi, B. A. (1995a). *Context and consciousness: Activity theory and human-computer interaction*. Cambridge: MIT Press.
Nardi, B. A. (1995b). Studying context: A comparison of activity theory, situated action models and distributed cognition. In B. A. Nardi (Ed.), *Context and consciousness: Activity theory and human computer interaction*. Cambridge: MIT Press.
Nardi, B. A. (2005). Objects of desire: Power and passion in collaborative activity. *Mind, Culture and Activity*, 12(1), 37-51.
Nardi, B. A., Ly, S., & Harris, J. (2007). *Learning conversations in world of warcraft.* Paper presented at the 40th Annual Hawaii International Conference on System Sciences, Hawaii.
National Film and Video Foundation. (2005). *A report on the nfvf film indaba 2005*.
Nichols, M. (Writer) (1967). The graduate [Film]. Brazil.
Norman, D. (1991). Cognitive artifacts. In J. Carroll (Ed.), *Designing interaction: Psychology at the human computer interface*. New York: Cambridge University Press.
Norman, D. A. (1988). *The psychology of everyday things*. New York: Basic Books.
Norman, D. A. (1993). Cognition in the head and in the world: An introduction to the special issue on situated action. *Cognitive Science, 17*(1), 1-6.
Norris, C. (1991). *Deconstruction: Theory and practice*. London: Routledge.
Oliveira, M., Crowcroft, J., & Slater, M. (2001). Components for distributed virtual environments. *Presence: Teleoperators & Virtual Environments, 10*(1).

Ollman, B. (2003). *Dance of the dialectic: Steps in marx's method*. Chicago: University of Illinois Press.

Overton, W. F., & Michelle, D. E. (2006). Relationism, ontology, and other concerns. *Human Development, 49*, 180–183.

Packer, M. J., & Goicoehea, J. (2000). Sociocultural and constructivist theories of learning: Ontology, not just epistemology. *Educational Psychologist, 35*(4), 227-241.

Papert, S. (1979). The role of artificial intelligencein psychology. In M. Piattelli-Palmarini (Ed.), *Language and learning: The debate between jean piaget and noam chompsky*. Cambridge: Harvard University Press.

Partridge, J. (2007). Plato's cave and the matrix. Retrieved 26 October, 2007, from http://whatisthematrix.warnerbros.com/rl_cmp/new_phil_partridge.html

Patraglia, J. (1998a). The real world on a short leash: The (mis)application of constructivism to the design of educational technology. *Educational Technology Research and Development, 46*(3), 53-65.

Patraglia, J. (1998b). *Reality by design: The rehetoric and technology of authenticity in education*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers.

Pea, R. D. (1993). Practices of distributed intelligence and designs for education. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations*. Cambridge: Cambridge University Press.

Phillips, D. C. (1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational Researcher, 24*(7), 5-12.

philosophical anthropology. (2007). In encyclopædia britannica. Retrieved 16 September, 2007, from Encyclopædia Britannica Online: http://www.search.eb.com/eb/article-15056

Piaget, J. (1988). *Structuralism* (C. Maschler, Trans.). New York: Harper & Row.

Pick, A. D., Pick, H. L., Jones, R. K., & Reed, E. S. (1982). James jerome gibson: 1904-1979. *The American Journal of Psychology, 95*(4), 692-700.

Plato. (360 BC). The republic.

Plato. (1995). *Platonis opera, vol. 1, euthyphro, apologia socratis, crito, phaedo, cratylus, theaetetus, sophistes, politicus*. Oxford: Clarendon Press.

Plato. (2007). In encyclopædia britannica. Retrieved 9 September, 2007, from Encyclopædia Britannica Online: http://www.search.eb.com/eb/article-9108556

Prawat, R. S. (1995). Misreading dewey: Reform, projects, and the language game. *Educational Researcher, 24*(7), 13-22.

Prawat, R. S. (1996). Constructivisms, modern and postmodem. *Educational Psychologist, 31*(3/4), 215-225.

Preece, J., Rogers, Y., & Sharp, H. (2002). *Interaction design: Beyond human-computer interaction*. Hoboken: John Wiley & Son, Inc.

Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., & Carey, T. (1994). *Human-computer interaction*. Harlow: Addison-Wesley.

Prensky, M. (2004). *Gigital game-based learning*: McGraw-Hill.

Rabiger, M. (1989). *Directing: Film techniques and aesthetics*. Boston: Focal Press.

Redding, P. (2006). Georg wilhelm friedrich hegel. In E. N. Zalta (Ed.), *The stanford encyclopedia of philosophy (fall 2006 edition)*. Stanford: Stanford University.

Redmiles, D. (2002). Introduction to the special issue on activity theory and the practice of design. *Computer Supported Cooperative Work, 11*, 1-11.

Rheingold, H. (1991). *Virtual reality*. London: Secker and Warburg.

Rittel, H. W. J. (1984). Second-generation design methods. In N. Cross (Ed.), *Developments in design methodology* (pp. 317–327). New York: John Wiley & Sons.

Riva, G. (1999). Virtual reality as communication tool: A sociocognitive analysis. *Presence: Teleoperators & Virtual Environments, 8*(4).

Riva, G., & Mantovani, G. (1999). Real presence: How different ontologies generate different criteria for presence, telepresence and virtual presence. *Presence: Teleoperators & Virtual Environments, 8*(5).

Robinson, H. (2006). Dualism. In E. N. Zalta (Ed.), *The stanford encyclopedia of philosophy (fall 2006 edition)*. Stanford: Stanford University.

Rohrer-Murphy, L. (1999). Activity theory. In D. H. Jonassen, M. Tessmer & W. H. Hannum (Eds.), *Task analysis methods for instructional design*. Mahwah: Lawrence Erlbaum Associates.

Rorty, R. (1979). *Philosophy and the mirror of nature*. Princeton: Princeton University Press.

Roth, W.-M. (2004). Activity theory in education: An introduction. *Mind, Culture and Activity, 11*.

Roth, W.-M. (2007). On mediation: Toward a cultural-historical understanding. *Theory & Psychology, 17*(5), 655-680.

Roth, W.-M., & Lee, Y. (2007). Vygotsky's neglected legacy: Cultural-historical activity theory. *Review of Educational Research, 77*(2), 86-232.

Roth, W.-M., & Tobin, K. (2000). *Learning to teach science as praxis*. Akron, OH: Social Sciences and Humanities Research Council of Canada.

Roush, W. (2007). Second earth. *Technology Review* Retrieved 20 August, 2007, from Technology Review's web site: http://www.technologyreview.com/printer_friendly_article.aspx?id=18911

Roussou, M. (2004a). Examining young learners' activity within interactive virtual environments, *Proceedings of the 2004 conference on Interaction design and children: building a community*. Maryland: ACM.

Roussou, M. (2004b). Interactivity and conceptual learning in virtual environments for children, *CHI '04 extended abstracts on Human factors in computing systems*. Vienna, Austria: ACM.

Roussou, M., Oliver, M., & Slater, M. (2008). Exploring activity theory as a tool for evaluating interactivity and learning in virtual environments for children. *Journal of Cognition, Technology & Work, 10*, 141–153.

Rumelheart, D. (1989). The architecture of mind: A connectionist approach. In M. I. Posner (Ed.), *The foundations of cognitive science*. Cambridge: MIT Press.

Rusnak, J. (Writer) (1999). The thirteenth floor [Film]. USA.

Sacks, H. (1992). *Lectures on conversation*. Oxford: Blackwell.

Sakaguchi, H., & Sakakibara, M. (Writer) (2001). Final fantasy [Film]. USA.

Salomon, G. (1993). *Distributed cognitions: Psychological and educational considerations*. Cambridge: Cambridge University Press.

Sayers, S. (1990). Marxism and the dialectical method: A critique of g.A. Cohen. In S. Sayers & P. Osborne (Eds.), *Socialism, feminism, and philosophy: A radical philosophy reader* (pp. 140-168). New York: Routledge.

Schuemie, M. J., Van Der Straaten, P., Krijn, M., & Van Der Mast, C. A. P. G. (2001). Research on presence in virtual reality: A survey. *Cyberpsychology and Behavior, 4*(2), 183-201.

Schutz, J. (1986). The individual and the group: An examination of american folk ideology. *Anthropology & Education Quarterly, 17*, 239–252.

Schwartz, R. F. (2001). Born to fail? Aristotle and heidegger on akratic action. *Prolegomena*.

Scott, J., & Marshall, G. (2005). *A dictionary of sociology*: Oxford University Press.

Scribner, S. (1997a). A sociocultural approach to the study of mind. In E. Tobach, R. J. Falmagne, L. W. Martin & A. S. Kapelman (Eds.), *Mind and social practice: Selected writings of sylvia scribner* (pp. 266-279). Cambridge: Cambridge University Press.

Scribner, S. (1997b). Vygotsky's uses of history. In E. Tobach, R. J. Falmagne, L. W. Martin & A. S. Kapelman (Eds.), *Mind and social practice: Selected writings of sylvia scribner* (pp. 241-280). Cambridge: Cambridge University Press.
Scruton, R. (1981). *From descartes to wittgenstein: A short history of modern philosophy*. London: Routledge & Kegan Ltd.
Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher, 27*(2).
Shaffer, D. W. (2004). Pedagogical praxis: The professions as models for post-industrial education. *Teachers College Record, 106*(7), 1401-1421.
Shaffer, D. W., & Clinton, K. A. (2006). Toolforthoughts: Reexamining thinking in the digital age. *Mind, Culture, and Activity, 13*(4), 283-300.
Shaffer, D. W., Squire, K. R., Halverson, R., & Gee, J. P. (2004). Video games and the future of learning. *Phi Delta Kappan, 87*(2), 104-111.
Sherlock, L. M. (2007). When social networking meets online games: The activity system of grouping in world of warcraft, *Proceedings of the 25th annual ACM international conference on Design of communication*. El Paso, Texas, USA: ACM.
Shotter, J. (2006). Vygotsky and consciousness as con-scientia, as witnessable knowing along with others. *Theory & Psychology*, 16(1), 13-36.
Silverman, A. (2003). Plato's middle period metaphysics and epistemology. In E. N. Zalta (Ed.), *The stanford encyclopedia of philosophy (summer 2003 edition)*. Stanford: Stanford University.
Simon, H. A. (1981). *The sciences of the artificial*. Cambridge: MIT Press.
Smith, K. (Writer) (1999). Dogma [Film]. USA.
Smith, P. L., & Ragan, T. J. (1999). *Instructional design*. New York: John Wiley & Sons.
Snow, B. (2007). Report: Wii overtakes xbox 360, becomes fastest selling console ever made. Retrieved 10 November, 2007, from http://www.gamepro.com/news.cfm?article_id=130468
Sokurov, A. (Writer) (2002). Russkiy kovcheg [Film]. Russia.
South African Government. (2006). Accelerated and shared growth initiative for south africa (asgisa). from http://www.info.gov.za/asgisa/
Southafrica.info. (2009). About south africa. Retrieved 11 February 2009, 2009, from http://www.southafrica.info/about/
Spielberg, S. (Writer) (1987). Empire of the sun [Film]. USA.
Spielberg, S. (Writer) (1993). Jurassic park [Film]. USA.
Squire, K. R. (2005). Changing the game: What happens when video games enter the classroom? *Innovate: Journal of Online Education, 1*.
Stahl, G. (1975a). The jargon of authenticity: An introduction to a marxist critique of heidegger. *Boundary 2, III*(2), 489-498.
Stahl, G. (1975b). *Marxian hermeneutics and heideggerian social theory: Interpreting and transforming our world*. Northwestern University, Evanston.
Stahl, G. (1993). *Supporting situated interpretation.* Paper presented at the annual meeting of the Cognitive Science Society (CogSci '93), Boulder.
Stahl, G. (2002). *Contributions to a theoretical framework for cscl.* Paper presented at the International conference on Computer-Supported Collaborative Learning (CSCL '02), Boulder.
Stahl, G. (2003a). *The future of computer support for learning: An american/german delfic vision.* Paper presented at the DeLFI 2003, Tagungsband der 1. e-Learning Fachtagung Informatik, Garching bei München.
Stahl, G. (2003b). Meaning and interpretation in collaboration. In B. Wasson, S. Ludvigsen & U. Hoppe (Eds.), *Designing for change in networked learning environments: Proceedings of the*

international conference on computer support for collaborative learning. Bergen: Kluwer Publishers.
Stahl, G. (2004). Building collaborative knowing: Elements of a social theory of cscl. In J. W. Strijbos, P. Kirschner & R. Martens (Eds.), *What we know about cscl: And implementing it in higher education* (pp. 53-86). Boston: Kluwer.
Stahl, G. (2006a). Analyzing and designing the group cognitive experience. *International Journal of Cooperative Information Systems, 5*.
Stahl, G. (2006b). Foreword. In D. Hung & M. S. Khine (Eds.), *Engaged learning with emerging technologies*: Springer.
Stahl, G. (2006c). Group cognition: Computer support for building collaborative knowledge. Retrieved 06 July, 2007, from Gerry Stahl's web site: http://www.cis.drexel.edu/faculty/gerry/mit/stahl%20group%20cognition.pdf
Steffe, L. P., & Gale, J. (1995). *Constructivism in education*. Hillsdale: Lawrence Erlbaum Associates, Inc.
Steinkuehler, C. (2004). *Learning in massively multiplayer online games.* Paper presented at the Proceedings of the Sixth International Conference of the Learning Sciences.
Steinkuehler, C. (2008). Cognition and literacy in massively multiplayer online games. In J. Coiro, M. Knobel, C. Lankshear & D. J. Leu (Eds.), *The handbook of research in new literacies*. New York: Lawrence Erlbaum.
Stephenson, N. (1992). *Snow crash*: Bantam Books.
Stetsenko, A., & Arievitch, I. M. (1997). Constructing and deconstructing the self: Comparing post-vygotskian and discourse-based versions of social constructivism. *Mind, Culture and Activity*, 4(3), 159-172.
Stetsenko, A. (2005). Activity as object-related: Resolving the dichotomy of individual and collective planes of activity. *Mind, Culture and Activity, 12*(1), 70-88.
Stetsenko, A. (2007). Agency and society: Lessons from the study of social change. *International Journal of Psychology, 42*(2), 110-112.
Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of Communication, 42*(4), 73-93.
Suchman, L. (1987). *Plans and situated actions.* Cambridge: Cambridge University Press.
Tarantino, Q. (Writer) (1997). Jackie brown [Film]. US.
Thomas, R. (2002). *Herodotus in context: Ethnography, science and the art of persuasion*. Cambridge: Cambridge University Press.
Tolman, C. (1983). Further comments on the meaning of 'dialectic'. *Human Development, 26*, 320-324.
Toto, C. (2007). Exploring learning. from Washington Times' web site: http://www.washingtontimes.com/article/20070802/ENTERTAINMENT/108020033/1007
Turkle, S. (1995). *Life on the screen: Identity in the age of the internet.* New York: Touchstone.
Turner, P., Turner, S., & Horton, J. (1999). *From description to requirements: An activity theoretic perspective.* Paper presented at the International ACM SIGGROUP conference on Supporting group work, Arizona.
Uden, L., & Willis, N. (2001). Designing user interfaces using activity theory. *Proceedings of the 34th Hawaii International Conference on System Sciences*.
University of Colorado. (2009). South africa. Retrieved 11 February, 2009, from http://ucblibraries.colorado.edu/govpubs/for/southafrica.htm
Valsiner, J. (1990). *Culture and human development.* Lexington: Lexington Books.
Van der Veer, R. (2001). The idea of units of analysis: Vygotsky's contribution. In S. Chaiklin (Ed.), *The theory and practice of cultural-historical psychology* (pp. 93-106). Aarhus: Aarhus Univiersity Press.

Van der Veer, R., & Valsiner, J. (1994). *Understanding vygotsky*. Cambridge: Harvard University Press.

van Wees, H. (2002). Herodotus and the past. In E. J. Bakker, I. J. F. De Jong & H. van Wees (Eds.), *Brill's companion to herodotus*. Leiden, Netherlands: Brill.

Vianna, E., & Stetsenko, A. (2006). Embracing history through transforming it: Contrasting piagetian versus vygotskian (activity) theories of learning and development to expand constructivism within a dialectical view of history. *Theory & Psychology, 16*(1), 81-108.

Vico, G. 1725/1968. *The new science of giambattista vico*. Ithaca: Cornell University Press.

Vincenzo, J. P. (1998). *Vico's new science: The unity of piety and wisdom.* Paper presented at the Paideia: Twentieth World Congress of Philosophy: Philosophy Educating Humanity, Boston, Massachusetts.

von Glasersfeld, E. (1985). Reconstructing the concept of knowledge. *Archives de Psychologie, 53*(91-101).

Vygotsky, L. S. (1966). Development of higher mental functions. In *Psychological reserach in the U.S.S.R* (Vol. 1). Moscow: Progress Publishers.

Vygotsky, L. S. (1978). Mind in society - the development of higher psychological processes. In M. Cole, V. John-Steiner, S. Scribner & E. Souberman (Eds.). Massachusetts: Harvard University Press.

Vygotsky, L. S. (1981). The genesis of higher mental functions. In J. V. Wertsch (Ed.), *The concept of activity in soviet psychology*. Armonk: Sharp.

Vygotsky, L. S. (Ed.). (1986). *Thought and language*. Cambridge: MIT Press.

Wachowski, A., & Wachowski, L. (Writer) (1999). The matrix [Film]. USA.

Walton, M. (2004). An introduction to drawing storyboards. Retrieved 10 December, 2007, from Centre for Film and Media Studies web site: http://www.cfms.uct.ac.za/storyboard/

Welles, O. (Writer) (1941). Citizen kane [Film]. USA.

Welles, O. (Writer) (1958). Touch of evil [Film]. USA.

Wells, G. (2002). The role of dialogue in activity theory. *Mind, Culture and Activity, 9*(1), 43-66.

Wertsch, J. (1985). *Vygotsky and the social formation of mind*. Cambridge: Harvard University Press.

Wertsch, J. V., & Stone, C. A. (1989). The concept of intemalization in vygotsky's account of the genesis of higher mental functions. In J. V. Wertsch (Ed.), *Culture, communication, andcognition: Vygotskianperspectives* (pp. 162-179). New York: Cambridge University Press.

Wikipedia. (2009, 6 February 2009). South africa. Retrieved 11 February, 2009, from http://en.wikipedia.org/wiki/South_Africa

Wilden, A. (1994). *Speech and language in psychoanalysis*. Baltimor & London: John Hopkins University Press.

Willis, P. (2002). Manifesto for ethnography. *Critical Methodologies, 2*(3), 394-402.

Wilson, B. G., & Myers, K. M. (2000). Situated cognition in theoretical and practical context. In D. H. Jonassen & S. M. Land (Eds.), *Theoretical foundations of learning environments*. Mahwah: Lawrence Erlbaum Associates.

Winograd, T., & Flores, F. (1986). *Understanding computers and cognition: A new foundation for design*. Norwood: Ablex Publishing Corporation.

Winter, G. (2000). A comparative discussion of the notion of 'validity' in qualitative and quantitative research. *The Qualitative Report*, 4(3&4).

Wolz, U., Barnes, T., Parberry, I., & Wick, M. (2006). *Digital gaming as a vechile for learning.* Paper presented at the SIGCSE'06, Houston, Texas.

Wright, E. (Writer) (2004). Shaun of the dead [Film]. UK.

Wundt, W. (1921). *Elements of folk psychology*. London: Allen and Unwin.

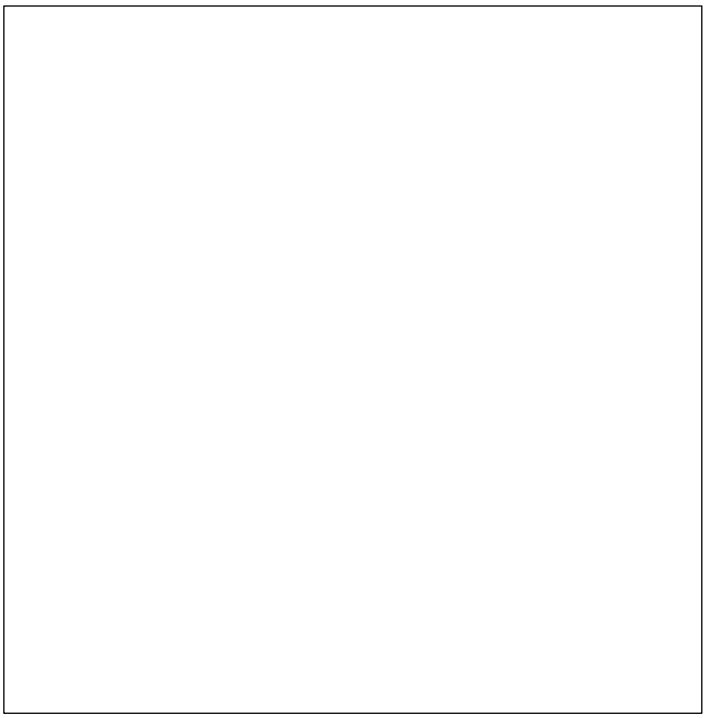
Zager, D. (2002). Collaboration as an activity. *Computer Supported Cooperative Work*, 11, 181–204.

Zahorik, P., & Jenison, R. L. (1998). Presence as being-in-the-world. *Presence: Teleoperators & Virtual Environments, 7*(1), 78-89.

Appendix

8.1. Storyboarding template

Shot number



ACTION of characters (brief mise en scene)

LIGHTING (use technical terms)

CAMERA DIRECTIONS (lens, focus, shot scale, angle, POV, movement)

SOUND effects and noises (e.g. wind traffic)

SHOT TRANSITION (e.g. cut, dissolve)

8.2. Storyboarding virtual world's screenshots

8.2.1. Annika and Garrett vs. Xan

8.2.2. Jakob vs. Xan

8.3. Recruitment poster

8.4. Storyboarding task - Stunt Action Clip

8.4.1. Introduction

Show students an action sequence from the computer graphics animation film “Final Fantasy” emphasizing terminology and techniques of action sequence cinematography.

8.4.2. Roles

Director – Instructor

3 Camera persons - Students

8.4.3. Task

The Director of an Action movie requires the planning of the cinematography of a stunt action scene for his movie. The stunt is a dangerous and expensive activity and will hence only be performed once. You will utilize 3 cameras' to film the sequence. You will therefore have to come up with a carefully planned:

1. Shot list (10 shots).
2. Floor plans with camera placement and movement of each shot.
3. Storyboard with a sequence for each camera placement with a description of the shot.

During the execution of the task you should pay special attention to framing, consistency and the action axis.

After you have completed your initial plan (2 hours) you will be introduced to the Storyboarding tool and asked to capture the relevant shots. You will then also get the opportunity to update your: Shot list, floor plans and storyboard descriptions.

8.4.4. Shot list

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……
9. ……
10. ……

8.4.5. Story Line

The infamous AI uprising on LBX-7683 (metallic asteroid in the Erican cluster) resulted in a massive loss of human life. Rebelling against their oppressive and abusive human creators, robotic workers and battle droids took control in a bloody mutiny and claimed their home as their own sovereign world. The previous owners of LBX-7683 decided to regain their profitable mine, and so the Liandri Corporation sent in a small tactical squad set to strike at the very heart of the new robot world, Xan Kriegor, leader of the robot force.
The Small tactical force consisting of Annika, Jakob and Garret intercepted communications of Xan's activities and laid an ambush for him on LBX-7683.

8.4.6. Script

According to each Floor plan (1-5):

1) The action sequence starts with the Drop ship flying in low to drop Xan off.

2) Xan starts walking down the hill in front of him. Two rockets explode behind him. Xan realizes he is in an ambush. He looks around, Assault Rifle shots sparking off his breastplate.

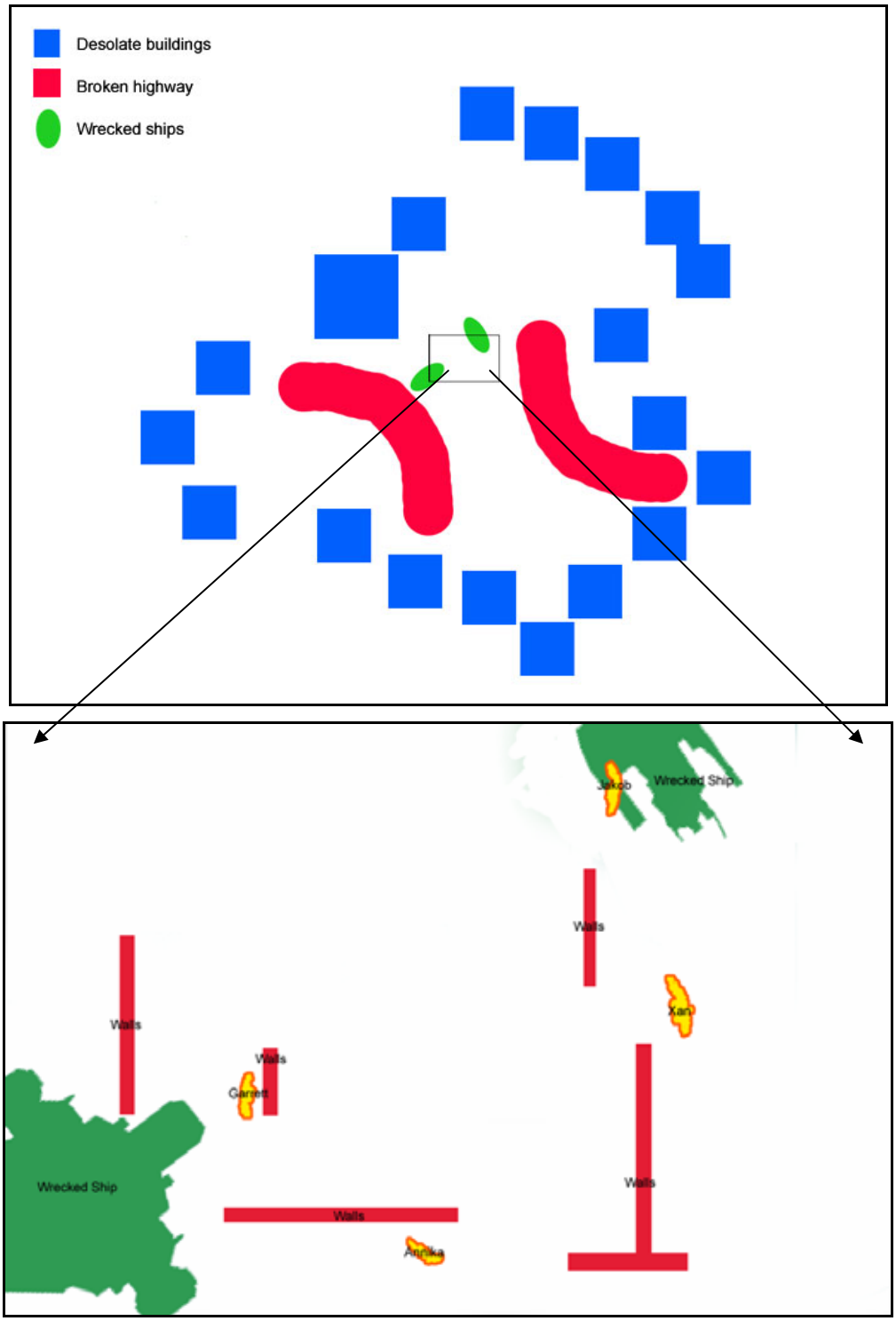
3) He sees Annika hiding behind the broken wall on his left shooting at him. One accurate blast from his shock rifle dispatches his first opponent. More weapons fire, from the right of Xan.

4) Garrett has come out from behind the sheltered wall to face his opponent head on. Xan's armor is however impenetrable to the Assault Rifle fire from Garrett. Xan is quick to dispense of this new adversary. Xan's assault is however far from over.

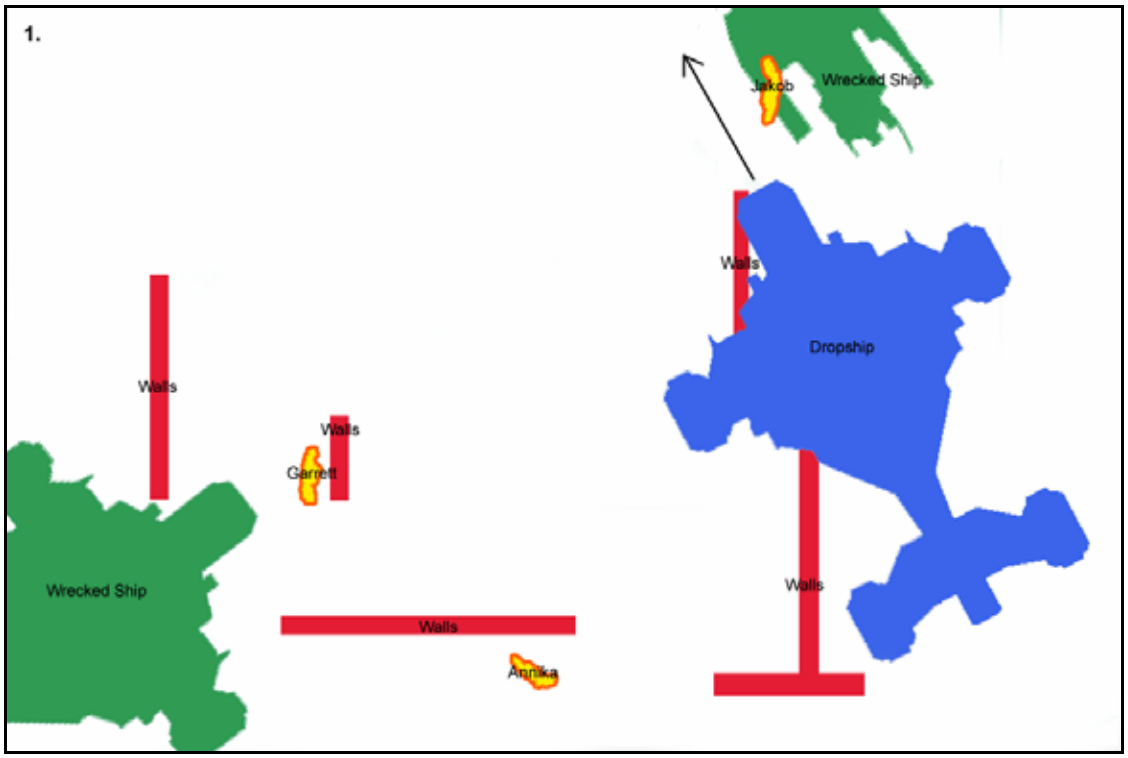
5) A rockets comes shaving over his shoulder missing Xan by an inch. Xan dodges the following two rockets. He swings around with lightning precision to eliminate the last of the tactical force sent to strike at him. Xan gives his famous battle cry in victory.

8.4.7. Floor Plans

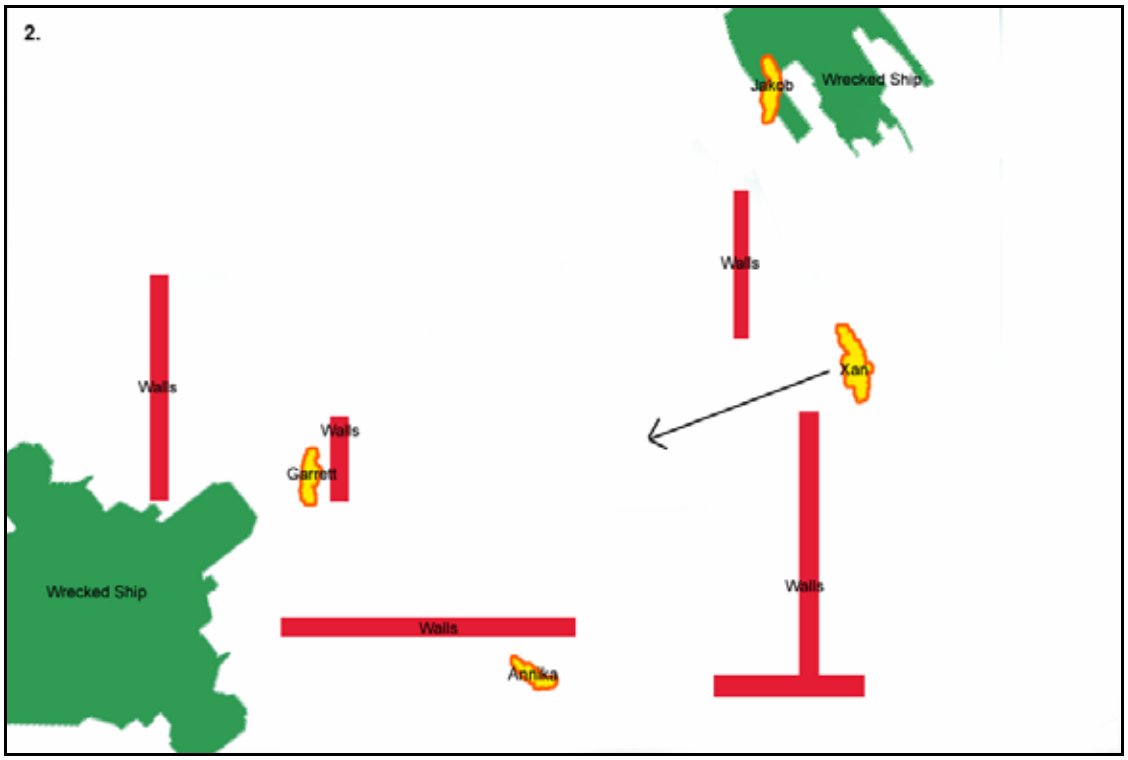
8.4.7.1. Macro and micro floor plans



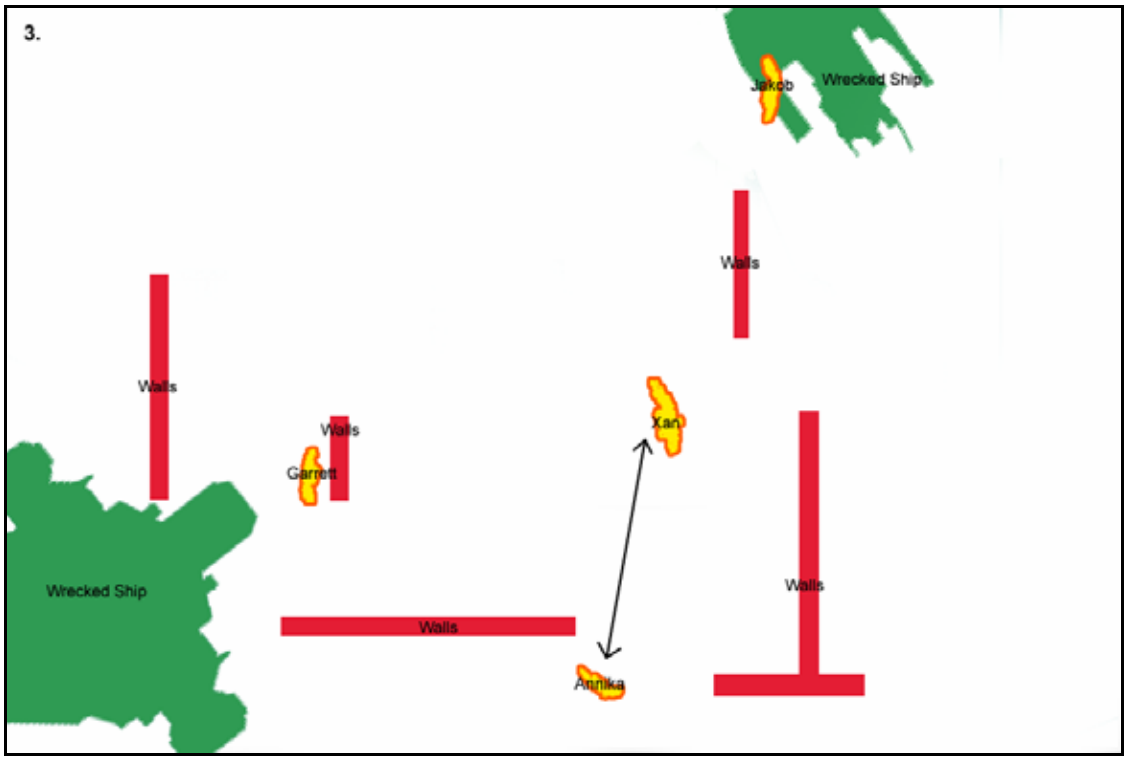
8.4.7.2. Xan gets dropped by drop ship



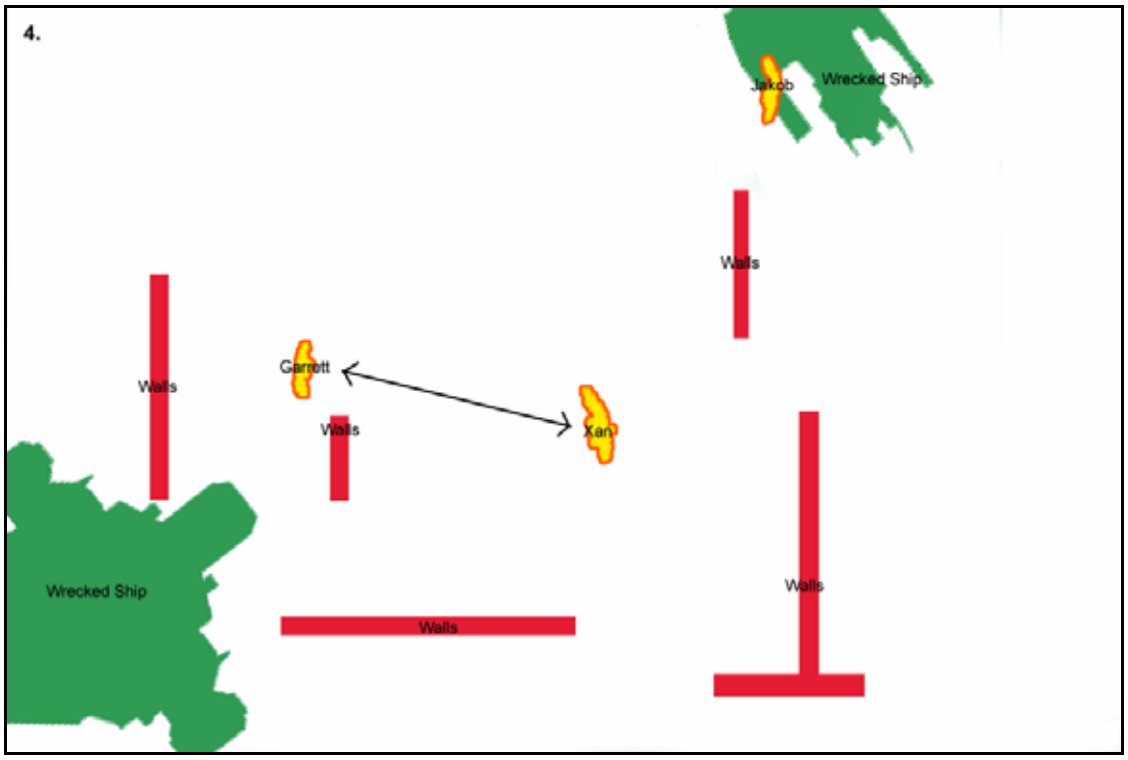
8.4.7.3. Xan walks the down hill



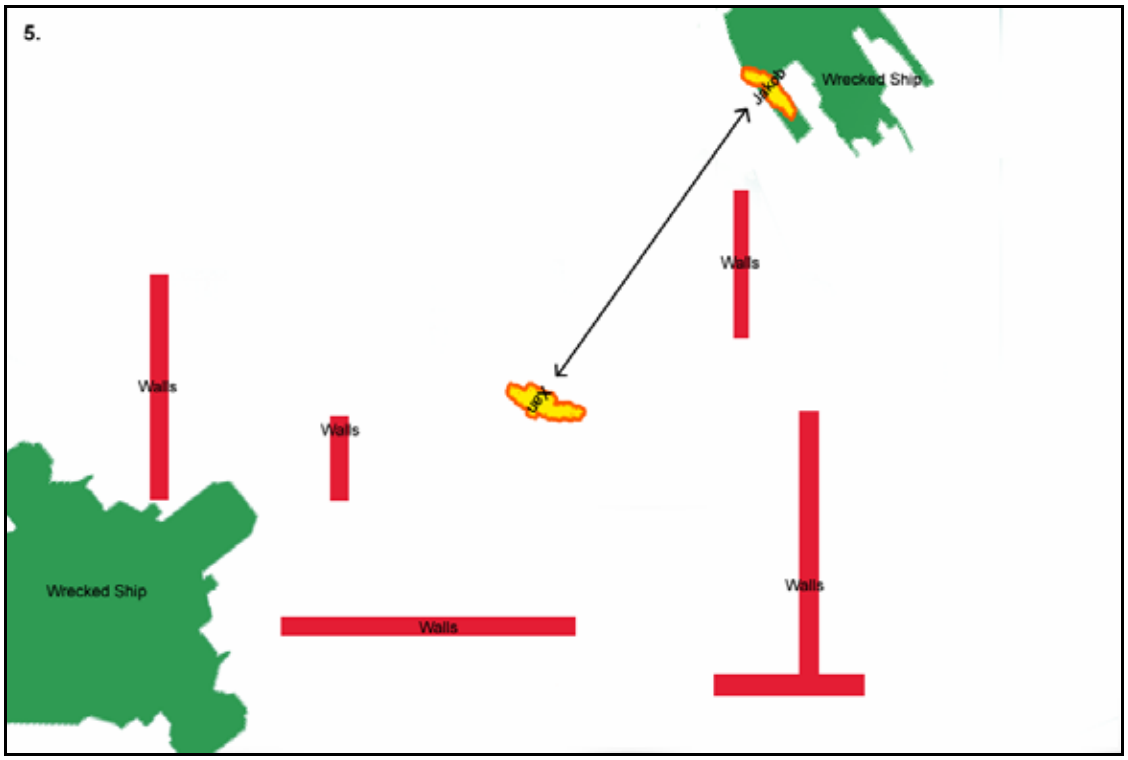
8.4.7.4. Annika vs. Xan



8.4.3.5. Garrett vs. Xan



8.4.7.6. Jakob vs. Xan



8.4.8. Characters

Annika
Age: 28
Race: Human
Data: Annika's sister, a miner, was killed in the infamous AI uprising on LBX-7683. She joined the tactical squad to strike at the very heart of the new robot world and make him pay for the death of her sibling.

Garrett
Age: 37
Race: Human
Data: Garrett has been a Hellion since birth. A real ladies man, he attracts quite a bit of non-Hellion fans due to his gruff demeanor.

Jakob
Age: 31
Race: Human
Data: Little is known about Jakob's origins, except that he grew up in the fringe mining worlds along the Centaur Rim.

Xan Kriegor
Age: Unknown
Race: Cybernetic
Data: Xan Kriegor is the leader of the robot force. A battle droid with state of the art upgrades he has become a mythical figure in battle.

8.4.9. Players

8.4.9.1. Brock

Navigation

Use the mouse to move your camera's rotation. When you click the second mouse button you will cycle through the other player's views, i.e. see what they see. When you want to return to your view, click the first mouse button.

Use the arrow keys to move forward, backwards, left and right (please note these directions are relative to your camera's rotation)

Special Ability

You are able to pause the world when you use the special key function (Please note that this might cause the sequence of actions after the pause to be thrown out!)

Special Key

P = Pause

8.4.9.2. Torch

Navigation

Use the mouse to move your camera's rotation. When you click the second mouse button you will cycle through the other player's views, i.e. see what they see. When you want to return to your view, click the first mouse button.

Use the arrow keys to move forward, backwards, left and right (please note these directions are relative to your camera's rotation)

Special Ability

You are able to play any of the scripted actor's animations at any time and out of sequence (Please note that once you use your ability this will disable Rolf's ability to initiate the scripted sequence!)

Special Key

1 = Plays Drop ship

2 = Plays Xan

3 = Plays Annika

4 = Plays Garrett

5 = Plays Jacob

8.4.9.3. Wraith

Navigation

Use the mouse to move your camera's rotation. When you click the second mouse button you will cycle through the other player's views, i.e. see what they see. When you want to return to your view, click the first mouse button.

Use the arrow keys to move forward, backwards, left and right (please note these directions are relative to your camera's rotation)

Special Ability

You are able to initiate the scripted sequence (Please note that you have to wait for the sequence to end before playing it again! If Rowan uses his special ability to play animations out of sync this will disable your ability to trigger the sequence!)

Special Key

Enter = Plays the scripted sequence

8.4.10. Semi-structured interview questions

1) What were your goals in this task?

2) Did you achieve them? How?

3) What did you use to achieve them?

4) What helped you to achieve your goals?

5) Did the VE support and/ or hinder you reaching your goals? In what way?

6) Did the objects in the VE support and/ or hinder you reaching your goals? Which objects? How?

7) Do you think collaboration was important for reaching your goals? Why?

8) Do you feel that the VE support and/ or hinder collaboration? How?

9) Do you think it would have been better attempting this task as an individual or group? Why?

10) Did your group work well together? Why do you think?

11) Did the group members play different roles in the exercise? Which roles?

12) Did the roles help you in achieving your goals? How?

13) Did the VE support and/ or hinder these roles? How?

14) What were the constraints/ rules of the exercise?

15) Did the constraints/ rules help you in achieving your goals?

16) Did the VE support and/ or hinder these constraints/ rules? How?

17) Did you learn something from achieving your objective? What?

18) How did you learn it?

19) Did the VE support and/ or hinder the learning that took place?

20) Do you think that what you have learned would be useful in real life? How?

21) Would you be better able to imagine the scenario in future, without access to the VE? How so?

22) Do you think other people would benefit from this experience? Who? How?

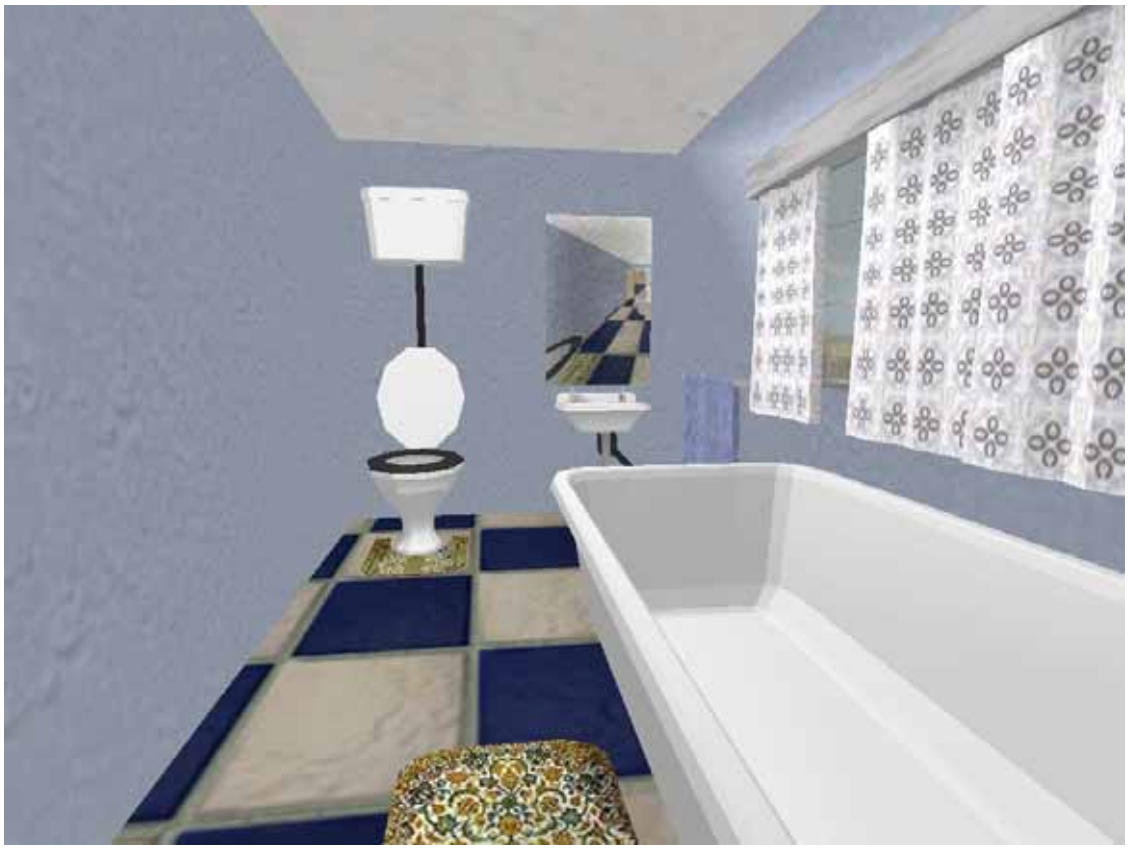
8.5. Virtual film production world's screenshots

8.5.1. Cape Town

8.5.2. House

8.5.3. Lounge

8.5.4. Bathroom



8.5.5. Bedroom

8.5.6. Kitchen left

8.5.7. Kitchen right

8.5.8. Students shooting lounge

8.5.9. Students shooting in kitchen

8.6. Players

8.6.1. Camera Person

Enter - Start and Stop recording

w - Forward

s - Backwards

a - strafe left

d - strafe right

q - Zoom in

e - Zoom out

c – Crouch

Space - Jump

Mouse right click - View what other players are seeing

Mouse left click - Return to own view

8.6.2. Actor

Enter = Use Triggers open close fridge if you stand in the right spot!

1 – Toggle grab and release of prop in center view
2 – Toggle Sit/ Walk
3 – Toggle Drink up / Drink down
4 – Toggle Pour
5 – Toggle Cooking
6 – Toggle Gun hold
b – Toggle behindview

w - Forward
s - Backwards
a - strafe left
d - strafe right
q - Zoom in
e - Zoom out
Mouse right click - View what other players are seeing
Mouse left click - Return to own view

8.6.3. Director

i – Makes you invisible so to explode or move props (like remote control special effects).
Delete – Delete prop in centered in view
x – Explode prop in centered in view
r – Rotates prop in centered in view
p – Toggles control of prop centered in view

0- Spawn Corpse
1 – Spawn Cell
2 – Spawn Ak47
3 – Spawn Briefcase
4 – Spawn Spray can
5 – Spawn Handbag

6 – Spawn Teddy
7 – Spawn Skateboard
8 – Spawn Sugar
9 – Spawn Yogurt

F1 – Spawn Vegetable oil
F2 – Spawn Microwave
F3 – Spawn Cup
F4 – Spawn Coffee machine
F5 – Spawn Plate
F6 – Spawn Pan
F7 – Spawn Wine
F8 – Spawn Tea
F9 – Spawn Cane
F10 – Spawn Beer
F11 – Spawn Cereal
F12 – Spawn Eggs

w - Forward
s - Backwards
a - strafe left
d - strafe right
q - Zoom in
e - Zoom out
c – Crouch
Space - Jump
Mouse right click - View what other players are seeing
Mouse left click - Return to own view

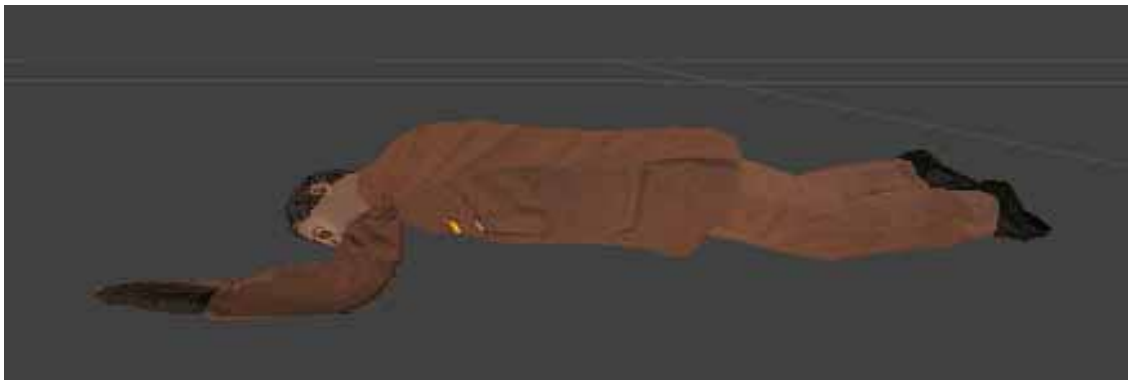
8.7. Avatar choices

8.7.1. Camera Person's

8.7.2. Actor's

8.7.3. Director's

8.8. Props (with associated keyboard keys)

0. 

1. 

2. 

3. 

4. 

5. 

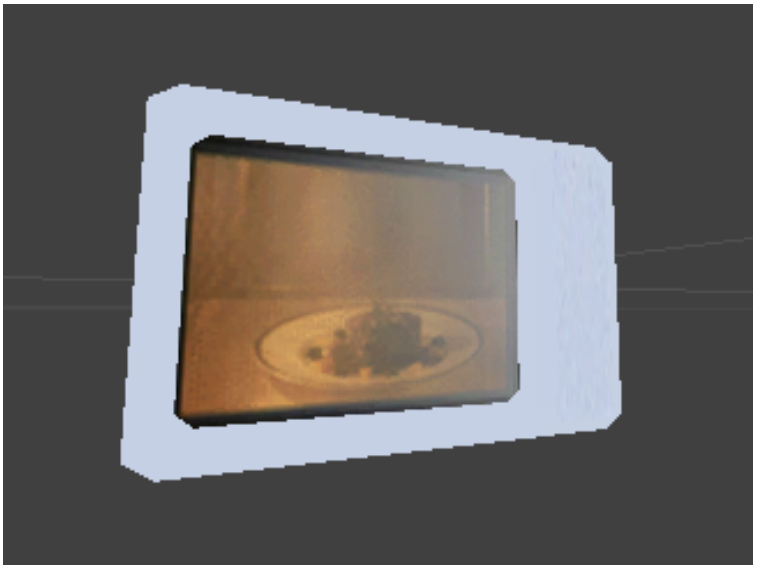
6. 

7. 

8. 

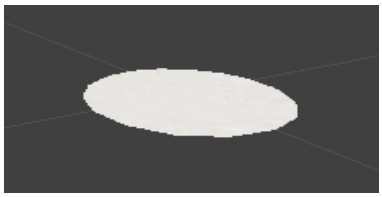
9. 

F1. 

F2. 

F3. 

F4. 

F5. 

F6. 

F7. 

F8. 

F9. 

F10. 

F11. 

F12.