Education As Change, Volume 15 Supplement Number S1, 2011, pp. S111–S122

Pre-service teacher development: A model to develop critical media literacy through computer game-play

Alan Amory
University of Johannesburg

Abstract

The primary objective of this study was to investigate the use of game-mediate learning with pre-service teachers, with the view to evaluating the use of a socially mediated knowledge construction to develop appropriate classroom pedagogical practices. Two instrumental case studies are presented in order to explore how pre-service teachers understand the use of computer games in teaching and learning. These cases are part of a collective case study to advance the theory of the use of video games in learning and teaching. Different groups of pre-service teachers participated in the study. The first group included third-year undergraduate education students who played a computer game on the biology of diseases. The second group of participants, postgraduate students reading for their teaching qualification, played computer games designed to address misconceptions related to genetics. The introduction of game puzzles into a learning activity acted as an explicit mediator of learning, and discussions between players implicitly mediated their understanding. Therefore, in a learning context it is argued that computer games as part of a lesson should never be the object of the activity, but should function as a tool that mediates learning outcomes. This approach can be used with any contemporary media that form part of a classroom lesson, to develop critical media literacy.

Key words: Computer games, critical media literacy, cultural historical activity theory, pre-service teachers, tool mediation

Introduction

This article investigates the use of contemporary media – computer games, in this instance – in teaching and learning by pre-service teachers. The primary objective is to develop an understanding of tool-mediation that integrates pedagogical knowledge and critical media literacy into the design of learning activities. However, in order to explore this, problems associated with integrating and embedding meanings associated with digital artefacts into classroom practices, need to be assessed. Digital artefacts include information and communication technologies (ICTs), software, media and computer games.

Many pre-service teachers lack basic computer and pedagogical skills and competencies (Enochsson & Rizza 2009; Russell & Finger 2007), access to appropriate tools and resources (Enochsson & Rizza 2009; Goktas, Yildirim & Yildirim 2009; Hammond, Reynolds & Ingram 2011), and motivation (Enochsson & Rizza 2009). In addition, there is a dearth of appropriate role models to guide pre-service teachers as regards the integration of technology and media into their teaching practices – during both formal instruction (Reid, Dawson & Forster 2006) and teaching practice (Larose, Grenon, Morin & Hasni 2009). In order to develop their own ICT resources, the pre-service teachers designed text-based web quests and added images to PowerPoint presentations that focused on lower-order thinking skills (Reid, Dawson & Forster 2006), but failed to understand the ideological dimensions that are inherently part of all media.

ISSN: Print 1682-3206, Online 1947-9417

http://dx.doi.org/10.1080/16823206.2011.643634

All media are created using symbols and signs that reflect a specific ideological view of the world, which is often related to power and/or profit; these signs and symbols are, then, decoded by individuals in many different ways (Kellner & Share 2005). Mass media are not politically neutral, objective or illustrative of a balanced position, and are often used to maintain and reproduce dominant cultural values (Torres & Mercado 2006). These ideas are supported by Mitchell (2008) who, in discussing McLuhan's 'the medium is the message', suggested that contemporary media theory is driven by an obsession with war machines; that technological innovations are concerned with coercion, aggression, surveillance and propaganda; and that we need to ask who is behind the media. But Gibson (2008) argues that the ways in which we use media determine their meaning or message. This is an important point that forms one of the core arguments presented in this article, which investigates how teachers can include media artefacts, that might be ideologically suspect, into their teaching practice, so that their students develop critical media literacy.

While Torres and Mercado (2006), and Kellner and Share (2005), propose that critical media literacy needs to be part of teacher education, it would be useful to provide teachers with appropriate thinking and with practical tools to support the use of ICTs, software, media and computer video games in the classroom. Therefore, the aim of this article is to explore how pre-service teachers understand and use computer video games in the classroom, so as to develop a theoretical framework for learning with video games/media/ICTs. Furthermore, this article supports the position taken by Amory (2010), who argued that the most appropriate theoretical framework for understanding the use of educational computer video games in the classroom is constructivist learning theories, as articulated variously by (among others) Vygotsky (1933/1978) and Piaget (1977). More specifically, the contemporary theoretical descendant of Vygotsky's work, namely cultural historical activity theory (CHAT) can be used as both an analytical frame to design learning tasks that include video games, and as a means to understand tool-mediated knowledge construction through game-play.

CHAT

CHAT, which originated from the earlier work of Vygotsky (1933/1978) and his follower Leont'ev (1978), is described as a first-generation activity system by Engeström (2001). Using Leont'ev's idea of individual and collective activity to overcome the individualistic focus of a first-generation activity system, Engeström (2001) expanded the system to include components to support social interactions (second generation – see Figure 1). To include cultural diversity, Engeström (2001) extended the system through the interlocking of a number of activity systems (third generation).

In any activity system, outcomes result from actors interrogating objects by means of tools (physical – pencils and technological artefacts; psychological – signs and symbols or individuals). Tools mediate interactions through the activity context that includes the associated rules, the community and the division of labour (Barab, Evans & Baek 2004; Engeström 2000, 2001; Roth & Lee 2007). The prime units of analysis within an activity system are objects as cultural entities (Engeström 2001), which embody communal social practices, and are transformed and further developed during human activity (Stetsenko 2005). Socially created tools are inseparable from the associated activity, and are part of the purpose, relevance and value appropriated to them by the actor (Robbins 2005), and may become objects or outcomes of an activity (Roth & Lee 2007). The sub-system includes the social actions of consumption, production, distribution and exchange, that allow the exploration of complex social interactions (i.e. engagements) that are made up of multiple strings of actions that are neither linear nor aligned (Engeström 2008). The object of the activity and social tool-mediation are explored in the sections which follow.

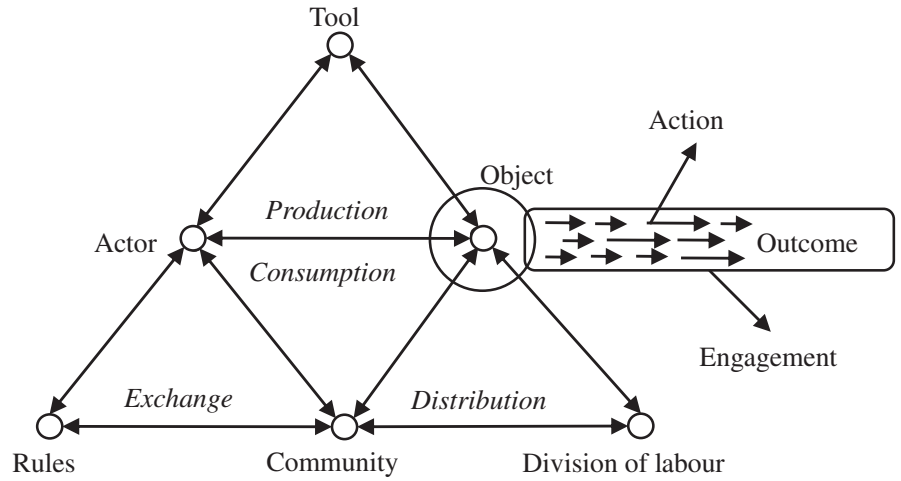

Figure 1: Activity system diagram (redrawn from Engeström 2008)

The object of the activity

While the 'object of activity' is key to activity theory, Nardi (1996) and Kaptelinin (2005) argue that different meanings are often attributed to the term 'object'. First, Kaptelinin (2005:6) explains that the Russian words *objekt* ('material things existing independently of the mind') and *predmet* ('target or content of a thought or an action') both translate to 'object' in English. Kaptelinin argues that the 'object of activity' refers to *predmet* that is more subjective, and with respect to the 'subject–object' interaction, the object refers to the *objekt*, which is more objective. Nardi (2005:39) states that the first meaning is related to that 'which is to be realized', while the second could be seen as the 'object of desire' (2005:40). Second, for Leont'ev the concept of the 'object of activity' is different from that of Engeström – the object of activity is acted upon predominantly by individuals and activities that are individually or collectively related to motivation, whereas for Engeström the object of the activity is always production (Kaptelinin 2005). Lastly, there is often confusion regarding the object and the motive associated with the activity. If the object and motive are separated (Kaptelinin 2005), then when we instantiate an object we formulate it, and we realise an object when we reach an outcome (Nardi 2005).

Social tool mediation

Mediation is one of the integral themes of Vygotsky's concepts of 'learning' and 'development'. Tool-mediation is grounded within socio-cultural practices (Doehler 2002), and supports human development (Stetsenko 2004). Human psychological and cultural tools are mediated learning (Levykh 2008). Wertsch (2007) categorises Vygotsky's formulation of mediation as either explicit or implicit: as regards explicit mediation, 'Vygotsky spoke in the idiom of psychology, especially about what we would today view as a form of behaviorism, or perhaps cognitivism', and it is when an individual 'overtly and intentionally introduces a "stimulus means" into an ongoing stream of activity' (Wertsch 2007:180) that is obvious and non-transitory. Implicit mediation, on the other hand, is less obvious and more difficult to detect, but 'it involves signs, especially naturally language, whose primary function is communication' (2007:181), and does 'not readily become the object of consciousness or reflection' (2007:185). Whether mediation operates through direct intervention or through language and signs, individual transformation, by necessity, includes both explicit and implicit modes of mediation. In addition, Edwards (2008) argues that mediation is hierarchical, where the tools range from simple and material to sophisticated (for example, technological systems and ideologies), and that tools support humans to master their world, thus transforming them.

Edwards adds, however, that 'mediation not only refers to the nature of what goes on between people . . . but also to the process of co-creation between the social world and the internal world of idea, feelings, and personal development' (2008:174). Therefore, mediation is an integral part of social transformation. For Edwards mediation includes two aspects: it explains how the 'social becomes internalized within the personal' and 'describes how these internalizations are related to the developmental dynamics of human consciousness . . . All social mediation is a cultural process passed on from one generation to another' (2008:175). Collective mediation forms part of the zone of proximal development, defined as the 'distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers' (Vygotsky 1933/1978:86).

Therefore, the outcome on the object of an activity is socially constructed through tool-mediated activity that can only be situated within an individual's culture. Therefore, as Gibson (2008) argues, the meaning made from media is related to how the artefact is used to socially construct meaning. In the next section, the use of meaning making through computer game-play is explored.

Education video game analysis

The use of video games in the classroom could be viewed either as a material object that exists independently of the mind (*objekt*), or as a target of an action or thought (*predmet*), especially when the game functions as a tool to mediate understanding.

A meta-analysis of existing research on the use of computer games in the classroom shows that such research tends to be anecdotal, descriptive or judgmental, and provides little support for the idea that playing games leads to learning (Ke 2008). However, these findings should be analysed in the context of the research studies reviewed in the meta-analysis. In total, 73 per cent of the articles analysed compared conventional instructional methods to stand-alone pedagogical instruments, or drill-and-practice (i.e. trivial) 'games'. Another example comes from the work of Akl, Gunukula, Mustafa, Wilson, Symons and Moheet (2010), who found that the use of games was ineffective in the teaching of medicine. But the games used in this study with medical students could be defined as trivial, and were played individually by the students. A number of problems are associated with this research (Akl et al. 2010; Ke 2008). First, the games were used as a material thing that exists independently of the mind (i.e. as the *objekt*). Second, the consumption of video games supports the reproduction and maintenance of dominant cultural values, as suggested by Torres and Mercado (2006). Third, these studies made use of empirical testing methodologies (i.e. comparing students who played video games with those who did not) rather than other more appropriate approaches, such as design experiments (see Amiel & Reeves 2008). It is, therefore, not surprising that when video games function as the *objekt* of a learning exercise and, primarily, as a delivery mechanism (Jonassen & Reeves 1996; Schrader & McCreert 2008), students develop visual intelligence (Greenfield 2009) and ludic skills (Oliver & Carr 2009), rather than critical thinking, imagination and reflective skills.

There are other examples from the literature, however, where the use of video games in the classroom resulted in meaningful learning. Game-play led to learning when students were part of a game development design team (Waraich & Brna 2008); when the design of the game narratives, competition and challenge related in some way to the social dynamics of the daily relationships of the children participants (Rieber, Davis, Matzko & Grant 2009); or when they created their own games (Robertson & Howells 2008). In the aforementioned report, participants were enthusiastic, determined to complete the tasks, they worked both individually and collectively, and applied what they had learnt to other situations. Verenikina, Herrington, Peterson and Mantei (2008) showed that group play supported imaginative make-believe as an important learning strategy used by young children. Seagram and Amory (2006) reported

that groups of players who discussed the puzzles during collective game play developed a deep understanding of the embedded concepts. The longer the participants discussed certain knowledge domains, the richer their descriptions were. Similarly, the use of quests in a virtual cyber-world improved performance and knowledge acquisition (Barab et al. 2005). Kim, Park and Baek (2009) showed that meta-cognitive strategies such as recording, modeling and thinking aloud influenced social problem-solving abilities and academic performance in a 'massively multiple online role playing game'. In each of these examples the computer games were part of the learning activity, but did not function as the *objekt*. Rather, the 'object of the activities', viz. the *predmet*, was to design or make a game (Robertson & Howells 2008; Waraich & Brna 2008), which stimulated imagination (Verenikina et al. 2008); mediated problem solving through discussion (Barab et al. 2005; Seagram & Amory 2005); and employed heuristic tools in a virtual world (Kim et al. 2009). Therefore, the learning outcomes were mediated through the use of a video game, a game environment, or through the puzzles/quests embedded in a game. Shaffer and Clinton (2006:289) argue that tool-mediation (in their case, a computer game acting as the tool) is 'the fundamental ontological unit of activity'. Not only did children learn when the games acted as tools, but also when social interaction was part of the learning design – this appeared to be an important part of the educational gaming experience (Rieber Davis, Matzko & Grant 2009).

Foko and Amory (2008) support the importance of social collaboration during game-play. Students from disadvantaged educational backgrounds showed improvement only in understanding photosynthesis and respiration when they played an educational game in pairs, and when the game puzzles stimulated social dialogue. Schrader and McCreert (2008), on the other hand, argue that collaboration and mentoring are more likely to support novice game-play, and are of little importance in achieving the game objectives of players with advanced game competence.

Video games and media, as part of a contemporary classroom, are cultural artefacts that support learning when they are not the object (*objekt*) of a lesson (a learning *from* position), but when they function as a tool to mediate the learning task or *predmet* (a learning *with* position). In addition, social collaboration fosters independent knowledge construction when the technological artefact functions as a heuristic tool. This framework is referred to as an object-tool-social framework, in this article. The primary object of this study is to investigate the use of game-mediated learning with pre-service teachers, so as to evaluate the use of a socially mediated knowledge construction, where computer games function as explicit mediators.

Materials and methods

Case studies, depending on the aim of a study, can be divided into three types: intrinsic studies which investigate the uniqueness of the cases; instrumental studies which are concerned with advancing theory; and collective studies that make use of any number of cases as part of an instrumental case (Stake 1995). This study makes use of a collective case study approach to evaluate the use of the object-tool-social framework in the use of video games in learning and teaching. The unit of analysis for the individual cases is pre-service teachers' understanding of the use of video games in the classroom. The unit of analysis of the collective case is to build theory on how to use video games in teaching and learning. Two individual cases studies (Creswell 1998) form part of this study. In the first case, third-year undergraduate BEd students played an educational adventure game as the final authentic task (Reeves, Herrington & Oliver 2004) in their professional development course. In the second case, postgraduate students reading for their professional teaching diploma played another educational game as part of the practical component of their course.

In each case study the educational game was used as part of a collaborative learning process, as suggested by Amiel and Reeves (2008), and not as the artefact (or tutor) for instruction. The unit of analysis is, thus, not the technological artefact itself (the game, in this case), but rather the process of students engaging

with the technological tool to develop insights into the biology of cancer, malaria, tuberculosis and HIV/AIDS (Seagram 2005) [case 1], or to address misconceptions related to Mendelian genetics (Baxter 2008) [case 2]. The study was bounded by time (participants played the game for a minimum of ten hours), place (a computer laboratory at the University of Johannesburg), and by the participants themselves. The research inquired into the techniques and approaches of the use of games for teaching and learning, to improve the design of such learning events (Amiel & Reeves 2008).

The research methodology in this study makes use of an eclectic mixed-methods pragmatic approach (Reeves & Hedberg 2003), and thus includes qualitative and quantitative methods. Students' texts were coded using content analysis, and descriptive statistical analyses were done using PASW Statistics (SPSS) version 18.

With respect to the first case, the third-year students (n = 184) were introduced to theories related to authentic learning and the object-tool-social framework. Both of these theoretical frameworks were used in the design of the course. Playing the educational game on diseases was the final authentic task of the course, and students were asked to install the game, play in pairs, and to try and complete the game. They were also told that they needed to solve all the puzzles in order to obtain four cards and four keys along the way. During game-play they were asked to think about the motive for playing the game (in other words, they had to identify the object of the activity) and, using the frameworks they had employed in the course, they were asked to analyse the activity associated with their game-play. The final examination assessment was a portfolio of work. One of the components of the portfolio was their selection of three course tasks and the use of frameworks, to detail what they had learned during the course. Their performances in a number of authentic tasks, the relationship between their performances in these tasks (ANOVA and associated Levene test and Tamhane post-hoc test), and the tasks they selected for their portfolio were counted for this research. Their written submissions on the game-play tasks, as well as their examination portfolio submissions, were quantitatively analysed deductively against the frameworks to gain insight into what they had learned through their game-play.

A small group (n = 11) of postgraduate students (case 2) played an educational game on genetics (Baxter 2008) over five weeks, playing two hours per week. During game-play two faculty members supported the students by guiding their path through the game, and facilitating discussions between the participants. After the students had finished the game, a focus-group interaction was held. During this session the students were introduced to the object-tool-social framework developed by Vygotsky, and were asked how this framework related to the game-play and the design of their learning experience. This case study made use of a pre- and post-test instrument (Baxter 2008) to measure participants' misconceptions about genetics – the quantitative part of this case study – so as to determine whether collective game-play helped students overcome those misconceptions. During classroom interactions and the focus-group sessions the author kept notes that form part of the qualitative analyses of this case study.

Results and discussion

Case one

Third-year students performed best in the mid-semester test (72.0 ± 1.7%), followed by the design of a computer local area network for a school (69.2 ± 1.2%), evaluation of the educational game (65.3 ± 1.2%), the use of an interactive whiteboard in a classroom (64.9 ± 1.2), and the review of a chapter for publication (63.1 ± 1.9%) (see Table 1). Their performances in authentic learning and classroom design tasks were poor (less than 60%). However, many students selected these tasks (mind map – 14.2%; authentic learning – 13.6%; and classroom design – 10.8%) to illustrate what they had learnt. In addition, 19.2 per cent of the students selected the interactive whiteboard, and 16.4 per cent

the design of a computer laboratory, to illustrate their knowledge. Only 8.2 per cent of the group selected the game as one of the tasks that served the knowledge they gained during the course.

To better understand the relationship between student performance and the tasks they selected, their average performance on each task was analysed using ANOVA. Average performance was found to be significantly different. The significance of the Levene test was less than 0.05, showing that the variances in performance for tasks were significantly different. Consequently, the Tamhane post-hoc test was used to determine those tasks that were similar, and those that were statistically different in terms of performance. Each task was, therefore, compared with all the other tasks, and those that were similar are shown in Table 1 (Similarity). Student task performance appears to be grouped into two categories, with one task – the chapter review – forming part of both categories. The first category included those tasks with above-average performance that were cognitively more challenging, and the second category included those where task performance was less satisfactory. Apart from the interactive whiteboard and the design of the computer laboratory tasks, most students selected the tasks in the second category, to illustrate what they had learnt in the course.

Table 1: Performance by third-year students in coursework authentic tasks and examination portfolio tasks. Column 1 lists authentic task, column 2 lists average percentage and standard error obtained by group for the task, and the last column the statistical similarity in performance of the different tasks (ANOVA $F = 22.61$, $p < 0.001$; Levene $= 13.71$, $p < 0.001$; Post-hoc test = Tamhane. The bold symbols represent the source item of the comparison.)

Task	Mean ± SE	%	Similarity							
Test	72.0 ± 1.7	4.0	**a**	b	c		e			
Computer LAN	69.2 ± 1.2	16.4	a	**b**	c	d	e			
Educational game	65.3 ± 1.2	8.2	a	b	**c**	d				
Interactive Whiteboard	64.9 ± 1.2	19.2	a	b	c	**d**	e			
Chapter review	63.1 ± 1.9	7.8	a	b		d	**e**	f	g	
Authentic learning	56.0 ± 1.4	13.6					e	f		h
SA classroom design	55.3 ± 1.4	10.8					e	f	g	h
Course design mindmap	49.0 ± 1.1	14.2							g	**h**
Other		6.0								

These results suggest that participants could be divided into two general groups, based on the assessment of each task and their opinions as to what they had learnt from the different tasks. Students who understood the two theoretical frameworks were more likely to select the cognitively difficult tasks, which included the game evaluation activity. However, many students selected tasks that were directly related to their professional practices. It is interesting to note that a small percentage selected the test as an example of what they had learned. This might be due to the nature of the test, where they had to analyse teaching activities described in a first-year textbook with relation to the various theoretical frameworks.

Content analyses of the students' game assignments and examination scripts highlighted a number of interesting points. While they were specifically asked to identify the object of the activity, many students included comments regarding tool mediation, collaborative learning and authentic tasks.

A number of different positions were taken regarding the object of activity. Many students indentified playing the game – to learn about the diseases – as the object of the activity. For example, '[t]he object of the game was/is to teach about the cause, effect and symptoms of diseases such as HIV/AIDS, TB and malaria', and '*is om leerders deur middel van "praktiese" metodes meer te leer oor siektes*' [is to teach students more about diseases using 'practical' methods]. Also, solving puzzles was seen as the object of the activity: '*Deur die voltooing van die puzzles is die speler besig om te leer en navorsing te doen, sonder om dit te besef*' [By completing the puzzles, the players – without being aware – are learning and undertaking research], and '[t]he motive of playing this game, being the object of the activity, is that our minds were stimulated, because when we were playing we came across puzzles where we had to fill in missing answers'. Only one student realised that the primary object of the activity was to 'evaluate [the] game for learning'.

Comments such as 'the game also mediates one's learning process, as we had to figure how to play it without any instructions', and 'this game is a very good learning tool', illustrate that some students extrinsically understood the role of tools in the process of mediating learning.

Statements such as '[t]he game was not easy though because it challenged our mental agility in a lot of instances. But because we did it as a pair the activity was manageable and we got to learn a lot from each other', 'was an opportunity to interact socially as well as cognitively', and 'social collaboration appears to be an integral part of the development of insights and knowledge development', show that the students clearly understood the importance of working together to solve complex problems.

Many participants identified the game as authentic, since it was set in Africa and was 'applicable in any context; because the diseases addressed in the game are the same chronic illnesses that continue to affect our communities', and 'it uses a real life example of an intern treating patients in a village'.

Third-year pre-service teachers clearly appreciated the importance of social interaction in solving problems and the use of authentic tasks, but they did not fully understand tool mediation as an ancillary process of learning. However, they saw the value of using the game as a tool to interact with the puzzles that led to knowledge construction.

This case study highlighted students' understanding of authentic tasks and object-tool-social frameworks as important components of learning and teaching. Many participants clearly understood collaborative puzzle solving and argued that educational games could play an important role in the learning process. However, this case study did not investigate the learning that takes place during collaborative game-play, which is the primary focus of the next case study.

Case two

The multiple choice instruments used in the pre- and post-test in this case study were developed and evaluated by Ivala (1999), to identify the misconceptions about genetics held by first-year university students. The identified misconceptions were later used by Baxter (2008) to develop a set of learning objectives for the design and development of an adventure video game. Baxter designed the game story, puzzles and environment to specifically address these misconceptions. The testing instrument included 18 questions to test misconceptions about genetics.

For this case study, the pre-testing scores of postgraduate participants ($n = 11$) (all biology graduates) were poor ($29.8 \pm 4.7\%$ correct responses). After ten hours of game-play, eight participants remained and they overcame some of their misconceptions related to genetics ($44.4 \pm 6.5\%$ correct responses). The

improvement in their scores was statistically significant (t-test = −3.69%, $p(T <= t)$ one-tailed < 0.001). While the participants increased their understanding of many concepts, there was no improvement in some of the instrument items that were testing misconceptions (for example, questions 1 and 2), and in two there was a decrease in understanding (questions 10 and 11) (see Figure 2).

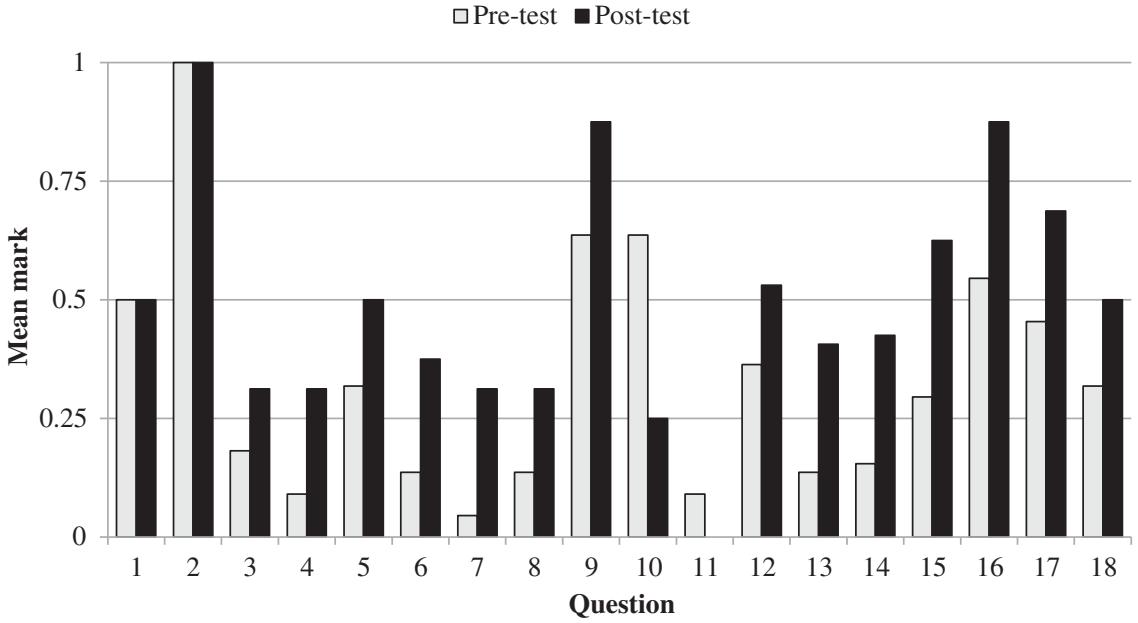

Figure 2: Pre- and post-test results of the individual question use to identify misconceptions related to Mendelian genetics

During the post-test focus-group discussion, the design of the learning with the video games was discussed. The puzzles acted as a device or tool to facilitate discussion between pairs of team players, and thereby successfully mediated learning. One student noted that the faculty facilitators helped them solve one of the particularly difficult puzzles. But, in analysing what the facilitators did, the participants realised that they were not given the answer, but were shown a way in which they could solve the puzzle for themselves. The participants understood the concept of tool-mediated learning, and one said the game design was an 'effective establishment and maintenance of Vygotsky's zone of proximal development'. When asked if it was appropriate to upload PowerPoint lectures onto the university's online learning management system, most participants answered that the presentation was not about mediating learning, but about the consumption of information and rote learning. This showed that they understood the concept of tool mediation in a different situation.

Misconceptions are often deep-seated and difficult to overcome. However, game-play, in this case study, allowed students to overcome some of their misconceptions pertaining to genetics, and to understand the use of tool-mediation in the learning process. It is argued that for such learning to take place during game-play, the game (or components, such as the puzzles) facilitated learning through the establishment of a zone of proximal development, and that social collaboration supported problem solving. In other words, the game and game puzzle functioned as tools to mediate knowledge construction.

Conclusion

The two individual intrinsic cases reported here form part of a collective instrumental case study, undertaken to advance the theory of the use of video games in learning and teaching. First, pre-service

teachers found the object-tool-social and authentic frameworks useful for the development of their professional teaching skills. Second, the use of these frameworks helped students overcome some of their misconceptions about genetics. Vygotsky's concept of social tool-mediated knowledge construction provided an appropriate framework for the use of video games in teaching and learning. The introduction of game puzzles into a learning activity acted as the explicit mediator, while the discussions between players acted as the implicit mediator, thereby enhancing their understanding and affecting their zone of proximal development. Therefore, while the activity diagram (Figure 1) provides a useful heuristic tool for exploring learning and the design of learning activities, the production subsystem is one of the most important components in relation to learning with technology and media. The use of a core component of Vygotsky's theories, namely mediation, provides contemporary educators with a construct that can easily be applied to any teaching situation that aims to include ICTs, software, media or computer games. Such artefacts should be used to mediate lesson outcomes (i.e. knowledge production), rather than the object of the lesson (consumption). In this way, all the ideological and power issues inherent in any media can be critically explored in the classroom, to allow students to transform their understanding of the world, and through it, to transform the world itself – one of the basic functions of human activity.

References

Akl, E.A., S. Gunukula, R. Mustafa, M.C. Wilson, A. Symons, A. Moheet and H.J. Schünemann. 2010. Support for and aspects of use of educational games in family medicine and internal medicine residency programs in the US: A survey. *BMC Medical Education* 10(1):26.

Amiel, T. and T.C. Reeves. 2008. Design-based research and educational technology: Rethinking technology and the research agenda. *Educational Technology & Society* 11(4):29–40.

Amory, A. 2010. Learning to play games or playing games to learn? A health education case study with Soweto teenagers. *Australasian Journal of Educational Technology* 26(6):810–829.

Barab, S.A., M.A. Evans and E.O. Baek. 2004. Activity theory as a lens for characterizing the participatory unit. In *Handbook of research on educational communities and technology*, ed. D.H. Jonassen, 199–214. Washington, D.C: Association for Educational Communication and Technology.

Barab, S., M. Thomas, T. Dodge, R. Carteaux and H. Tuzun. 2005. Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research and Development* 53(1):86–107.

Baxter, D. 2008. Addressing genetics misconceptions with an educational game. Unpublished Master's dissertation, University of KwaZulu-Natal, Durban, South Africa.

Creswell, J.W. 1998. *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, London, New Delhi: Sage Publications, Inc.

Doehler, S.P. 2002. Mediation revisited: The interactive organization of mediation in learning environments. *Mind, Culture, and Activity* 9(1):22–42.

Edwards, M.G. 2008. 'Every today was a tomorrow': An integral method for indexing the social mediation of preferred futures. *Futures* 40(2):173–189.

Engeström, Y. 2000. Activity theory as a framework for analyzing and redesigning work. *Ergonomics* 43(7):960–974.

Engeström, Y. 2001. Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work* 14(1):133–156.

Engeström, Y. 2008. Enriching activity theory without shortcuts. *Interacting with Computers* 20(2):256–259.

Enochsson, A.B. and C. Rizza. 2009. *ICT in initial teacher training: Research review*. OECD Education Working Papers, No. 38. Paris: OECD Publishing.

Foko T. and A. Amory. 2008. Social constructivism in games based learning in the South African context. *World conference on Educational Multimedia, Hypermedia and Telecommunications 2008*, ed. J. Luca and E. Weippl, 5757–5764. Vienna, Austria: ACCE.

Gibson, T. 2008. Double vision: Mc Luhan's contributions to media as an interdisciplinary approach to communication, culture, and technology. *MediaTropes* 1:143–166.

Goktas, Y., S. Yildirim and Y. Yildirim. 2009. Main barriers and possible enablers of ICTs' integration into pre-service teacher education programs. *Educational Technology & Society* 12(1):193–204.

Greenfield, P.M. 2009. Technology and informal education: What is taught, what is learned. *Science* 232(5910):69–71.

Hammond, M., L. Reynolds and J. Ingram. 2011. How and why do student teachers use ICT? *Journal of Computer Assisted Learning* 27(1):191–203.

Ivala, E. 1999. Identifying learning misconceptions in genetics. Unpublished Master's thesis, University of Natal, Durban, South Africa.

Jonassen, D.H. and T.C. Reeves. 1996. Learning with technology: Using computers as cognitive tools. In *Handbook of research on educational communications and technology*, ed. D.H. Jonassen, 693–719. New York: Macmillan.

Kaptelinin, V. 2005. The object of activity: Making sense of the sense-maker. *Mind, Culture, and Activity* 12(1):4–18.

Ke, F. 2008. A qualitative meta-analysis of computer games as learning tools. In *Handbook of research on effective electronic gaming in education*, vol. 1, ed. R. Ferdig, 1–32. Paris: IGI Global.

Kellner, D. and J. Share. 2005. Toward critical media literacy: Core concepts, debates, organizations and policy. *Discourse: Studies in the Cultural Politics of Education* 26(3):369–386.

Kim, B., P. Park and Y. Baek. 2009. Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning. *Computers & Education* 52(4):800–810. DOI:10.1016/j.compedu.2008.12.004

Larose, F., V. Grenon, M-P. Morin and A. Hasni. 2009. The impact of pre-service field training sessions on the probability of future teachers using ICT in school. *European Journal of Teacher Education* 32(3):289–303.

Leont'ev, A.N. 1978. *Activity, personality, and consciousness*. Englewood Cliffs: Prentice-Hall.

Levykh, M.G. 2008. The affective establishment and maintenance of Vygotsky's zone of proximal development. *Educational Theory* 58(1):83–101.

Mitchell, W.J.T. 2008. Addressing media. *MediaTropes* 1:1–18.

Nardi, B.A. 1996. *Context and consciousness: Activity theory and human-computer interaction*. Cambridge, MA: MIT Press.

Nardi, B.A. 2005. Objects of desire: Power and passion in collaborative activity. *Mind, Culture and Activity*. 12(1):37–51.

Oliver, M. and D. Carr. 2009. Learning in virtual worlds: Using communities of practice to explain how people learn from play. *British Journal of Educational Technology* 40(3):444–457.

Piaget, J. 1977. *The development of thought: Equilibration of cognitive structures*. New York: Viking Press.

Reeves, T.C. and J.G. Hedberg. 2003. *Interactive learning systems evaluation*. Englewood Cliffs, New Jersey: Educational Technology Publications.

Reeves, T.C., J. Herrington and R. Oliver. 2004. A development research agenda for online collaborative learning. *Educational Technology Research & Development* 52(4):53–65.

Reid, D., V. Dawson and P. Forster. 2006. Trends in the design of ICT teaching resources created by pre-service science teachers. *Teaching Science* 52(4):28–33.

Rieber, L.P., J.M. Davis, M.J. Matzko and M.M. Grant. 2009. Children as critics of educational computer games designed by other children. In *Handbook of research on effective electronic gaming in education*, ed. R.E. Ferdig, 1234–1256. Herskey: Information Science Reference.

Robbins, J. 2005. Contexts, collaboration and cultural tools: A sociocultural perspective on researching children's thinking. *Contemporary Issues in Early Childhood*. 6(2):140–149.

Robertson, J. and C. Howells. 2008. Computer game design: Opportunities for successful learning. *Computers & Education* 50(2):559–578.

Roth, W.M. and Y.J. Lee. 2007. Vygotsky's neglected legacy': Cultural-historical activity theory. *Review of Educational Research* 77(2):186–232.

Russell, G. and G. Finger. 2007. ICTs and tomorrow's teachers: Informing and improving the ICT undergraduate experience. In *Handbook of teacher education*, eds. T. Townsend and R. Bates, 625–640. The Netherlands: Springer.

Schrader, P.G. and M. McCreert. 2008. The acquisition of skill and expertise in massively multiplayer online games. *Educational Technology Research and Development* 56(5):557–574.

Seagram, R. 2005. Use of constructivism in the development and evaluation of an educational game environment. PhD thesis, University of KwaZulu-Natal, South Africa.

Seagram, R. and A. Amory. 2006. An assessment of learning through the use of a constructivist learning environment. In *World Conference on Educational Multimedia, Hypermedia and Telecommunications 2006*, eds. E. Pearson and P. Bohman, 2165–2172. Chesapeake, VA: AACE.

Shaffer, D.W. and K.A. Clinton. 2006. Toolforthoughts: Re-examining thinking in the digital age. *Mind, Culture, and Activity* 13(4):283–300.

Stake, R.E. 1995. *The art of case study research*. London: Sage Publications, Inc.

Stetsenko, A. 2004. Tool and sign in the development of the child. In *The essential Vygotsky*, eds. R.W. Rieber, D.K. Robinson, J.E. Bruner, M.E. Cole, J. Glick, C. Ratner and A. Stetsenko, 501–512. New York: Kluwer Academic/Plenum Publishers.

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.

Torres, M. and M. Mercado. 2006. The need for critical media literacy in teacher education core curricula. *Educational Studies* 39(3):260–282.

Verenikina, I., J. Herrington, R. Peterson and J. Mantei. 2008. The affordances and limitations of computers for play in early childhood. In *World Conference on Educational Multimedia, Hypermedia and Telecommunications*, 3091–3100. Presented at the ED-MEDIA, Chesapeake, VA: AACE.

Vygotsky, L. 1933/1978. *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Waraich, A. and P. Brna. 2008. A narrative-centred informant design approach for interactive learning environments. *International Journal of Continuing Engineering Education and Life Long Learning* 18(2):181–196.

Wertsch, J. 2007. Mediation. In *The Cambridge companion to Vygotsky*, eds. H. Damiels, M. Cole and J.V. Wertsch, 178–192. New York: Cambridge University Press.

Corresponding author

Alan Amory
Science and Technology Education
Faculty of Education
University of Johannesburg
P.O. Box 524
Auckland Park 2006
South Africa
E-mail: aamory@uj.ac.za