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To cite this article: Khaled Sabry & Jeff Barker (2009) Dynamic Interactive Learning Systems, *Innovations in Education and Teaching International*, 46:2, 185-197, DOI: [10.1080/14703290902843836](https://doi.org/10.1080/14703290902843836)

To link to this article: <https://doi.org/10.1080/14703290902843836>



Published online: 18 May 2009.



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Dynamic Interactive Learning Systems

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This paper reviews and discusses the notions of interactivity and dynamicity of learning systems in relation to information technologies and design principles that can contribute to interactive and dynamic learning. It explores the concept of dynamic interactive learning systems based on the emerging generation of information as part of a continuous research process in the area of Learning Systems Design. It proposes the addition of a *dynamicity* dimension to interactive learning systems design to reflect the continuous changes in information technologies, learners' needs and increasing availability of information. The paper concludes with a proposed model that reflects the concept of a dynamic feedback and adjustment mechanism that is generally missing from many learning systems.

Keywords: Learning Systems; interactive design; dynamic design; ICT; dynamic feedback

Introduction

Perhaps one of the most ongoing and complex questions in education is how educational organisations can deal simultaneously with multiple types of learner without ignoring their differences. Many universities and colleges have students with considerable differences in age, past experience, gender, culture, language, level of attendance, ability and needs. Learners may also have different learning styles and preferences that may be distinct from those planned by educators. Adding to this complexity are many technological changes and the new era of information related to Information and Communication Technology (ICT). Further, many students have limited time available for studying due to work or other social responsibilities, while most time spent travelling to/from university/college/school and on campus is related to physical attendance rather than the actual learning process. It is important for students to learn how to learn, how to be an independent learner and how to communicate with others to find relevant information. Through the use of ICT, learning costs and time may be reduced through the reduction of physical attendance and its consequences. This is not to eliminate entirely face-to-face interaction but to minimise it through complementing it with technology. How can such differences be accommodated while providing dynamic, enjoyable and interactive learning? While different education experts will provide different answers, consequent knowledge will emerge to help guide design decisions for relevant, effective and efficient learning systems. An essential step will be undoubtedly be better understanding of the advances in information technologies as well as learners' increasingly changing needs.

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As we have progressed to the information era, the amount of information has become greater, access is much faster, the information has become global, the information is more accessible, different search parameters can be used, dynamic information is replacing static information and ICT increasingly provides the 'electronic nervous system' for many organisations through the increasing use of mobile technologies such as 'smart' phones, data-capture technologies such as Radio Frequency Identification (RFID) and Internet usage. According to recent statistics, the world usage of the Internet increased approx 245% between 2000 and 2007 (Internet World Stats, 2007). Statistics show that the number of Internet devices reached 600 million in 2006 compared with 1 million in 1992. Many of today's college subjects did not exist 10 years ago (eg new media, e-business, nanotechnology, etc); the amount of technical information is doubling every two years and in 2010 is predicted to double every 72 hours; and 3rd generation fiber optics have recently been tested that push 10 trillion bits per second down a fiber (equal to approx 1,900 CDs or 150 million simultaneous phone calls every second), meaning that marginal cost of those improvements is effectively zero (Glumbert, 2008). Further, increasingly accessing the Internet for information is on the increase (Office of National Statistics, 2007). However, currently, a large gap exists between the information available and the use of that information (Barker, 2005; Barker, 2007; Barker & Finnie, 2004). Most current systems (in government, law, finance, economics, business, management, manufacturing, etc) were designed in the old information generation, the *pre*-dynamic information generation (DIG), and most decision makers were brought up and made decisions based on the old generation, not DIG. Very few systems have been designed for DIG. This means more than just applying DIG techniques to systems built or developed in the *pre*-dynamic information era. Information is of paramount importance for decision making; for example, sensible decisions cannot be made without information or made with old out-of-date information. An invaluable feedback mechanism for each student, for each class, for each year, for each school, for each province, for each state and finally at national level, will enable rapid comparisons between national results and the national syllabi. Currently, this generally takes a long time, at least 12 months. Using dynamic feedback, it might be possible to cut this time back to days. The most up-to-date information (dynamic information), typically provided by an information system, must be used.

Interactivity of learning systems

Designing an effective learning system requires looking at several variables and considerations; including interactivity and interaction design (Graham, McNeil, & Pettiford, 2000). For a learning system to be interactive for different types of learner, it will be necessary to take account of the users (the learners) who are expected to use such systems for learning, and it is not merely enough to give students access to different tools and/or learning environments (Bates & Leary, 2001). It requires a move from a teacher–student *dependence* design to a teacher–student *independence* design that gives students flexibility and control over their learning in line with their changing needs. This essentially requires investigation of factors such as learners' different learning preferences, needs, interests, prior knowledge, experiences, background, culture, talents and abilities. Further, the focus should be on the best available knowledge about learning, how it occurs and the effective ways for achieving it for the learners. Learner-centred pedagogy should be based on learners' needs rather than teachers' or institutions' needs and should be compatible with the use of information

and communication technology especially those that promote the teachers as *facilitators* (Tam, 2000).

Interactivity is at the heart of learning systems design for the influential role it plays in the effectiveness of the learning process (Moore & Kearsley, 1996) and as a *fundamental mechanism for knowledge acquisition* (Barker, 1994). Using an interactive web-based learning program can increase the learning enjoyment level, which in turn may increase students' understanding and the effectiveness of learning in a longer timeframe in terms of information retention (Street & Goodman, 1998). Some authors have argued that the interactivity of computer-mediated learning (CML) can boost the speed and level of students' learning (Horton, 2000; Najjar, 1998) and helps to improve students' confidence and motivation (Klassen, Vogel, & Moody, 2001).

There have been several attempts to define the interactivity of computer/web-based systems (Laurillard, 2002; Graham et al., 2000) that support a learner-centred design. Interactivity of learning systems can be claimed to have certain features or mechanisms that allow students to act to achieve certain tasks, receive relevant intrinsic feedback on their actions and a change occurs as a result of their reactions (Laurillard, 1993). According to Reeves (1999), a learning environment can be described as *interactive* when it allows a person to perform meaningful activities such as navigating through it, selecting information, responding to questions using computer input devices such as a keyboard, mouse, touch screen, or voice command system, solving problems, completing challenging tasks, creating knowledge representations, collaborating with others, or otherwise engaging in meaningful learning activities. Interactivity of learning systems can take different shapes through using different types of learning interaction, which can be categorised into three main types: learner-content where a learner interacts with information, learner-instructor where the learner interacts with experts, and learner-learner where the learner interacts with other learners (Moore, 1989; Moore & Kearsley, 1996). Evans, Baldwin, and Sabry (2002) combined a set of principles (heuristics) for interactive systems, which includes not only appropriate use of multimedia and active engagement of the learner, but also allows for reflection – which can help learners in filling the gaps in their own understanding (Lin et al., 1999).

An interactive learning systems (ILS) must therefore, adopt some basic design principles such as active engagement (Alexander & Boud, 2001), active thinking (Salmon, 2002), the involvement of a learner with a variety of interactions with materials, peers, and experts (Bonk, 1999; Park, 2003), flexibility in expanding interactions beyond the lecture or tutorial in case of campus-based learning (Jung, Lim, Choi, & Leem, 1998), allow for reflection and provide feedback (Laurillard, 2002), provide choices, easy navigation, variety of interaction patterns, and use of multimedia (Evans et al., 2002), including graphics, which may promote discovery and inference (Mayer, 1989; Tessler, Iwasaki, & Law, 1995). *Interactivity* of learning systems also takes into account learners' profiles including for example, their learning styles, their *use* and *perceptions* of usefulness of the different types of CML, individual differences, and learning preferences in relation to traditional methods (Sabry, 2005; Sabry & Al-Shawi, 2008).

Components of an interactive learning system

A learning system generally consists of four main components (Sabry, 2005). The *Learner* component is concerned with knowledge about the learner such as individual

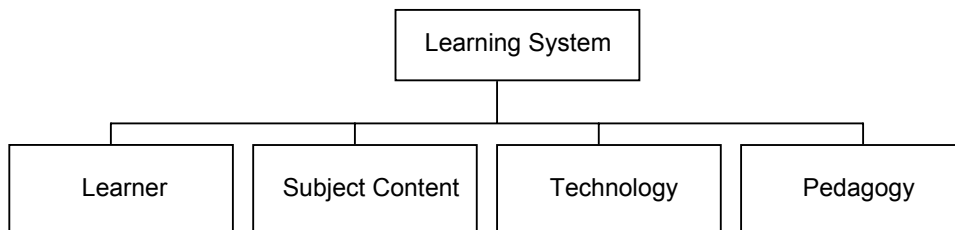


Figure 1. Components of a learning system (adapted from Sabry, 2005).

differences (for example, gender, prior knowledge, age, culture and special needs); learning styles (for example, Sequential/Global, Active/Reflective and Visual/Verbal); performance and attainment level; attitudes and beliefs. The *Subject Content* component, includes information that constitutes relevant subject knowledge required to be learned including internal information or actual contents provided (subject material) and other external information that are relevant or supplementary to subject material, for example, searching the Internet for information such as papers relevant to subject material), items to be taught, course aims and objectives, and skills to be developed (Figure 1).

The *Technology* component is concerned with *how* a course of study may be delivered in terms of different tools to be used, including usability, interactivity, navigation, and human–computer interaction (HCI) aspects of learning systems. It also includes hardware issues, for example whether fixed position (PCs) or mobile (laptops and PDAs). The technology component is an important part of the learning system, but should not be treated as a determiner of the system design or treated in isolation of the other components. It includes knowledge about the media through which information can be delivered, for example, e-mail, Internet search engines, learning environments such as FirstClass, WebCT, and Blackboard, where different types of learning interaction can be accommodated, including different combinations of multimedia representations to accommodate different types of interaction, teaching and learning styles. Learning environments generally include four main components, an enabling context, resources, tools, and scaffolds (Hannafin, Land, & Oliver, 1999) and more specifically, *Personal Learning Environments* (PLE) transfer the management of learning from the institution to the learner (BECTA, 2007). On the other hand, multimedia learning technologies can provide different combinations of picture (static and/or dynamic) and word (written or spoken) (Mayer, 2001; Najjar, 1998).

Whilst this study views technology as a tool and a *black box*, it does not underestimate the importance of the understanding of ICT artifacts, as part of the *Technology* component of an ILS, in order to cope with ongoing changes (Orlikowski & Iacono, 2001) and support the adaptation notion of learning systems. However, this should be in conjunction with, not on the account of, the *Learner* component and/or other components of an ILS. The instructional design should not only be concerned with delivering information to learners, but also with the efficient way information is presented (Mayer, 2001), the way learning interactions can be designed to engage learners, and the way student-assessment can be implemented. Further, the design and development of relevant and appropriate electronic *sharing mechanisms* is essential to achieve flexibility of access and delivery of educational materials in a global manner (Barker, 1997).

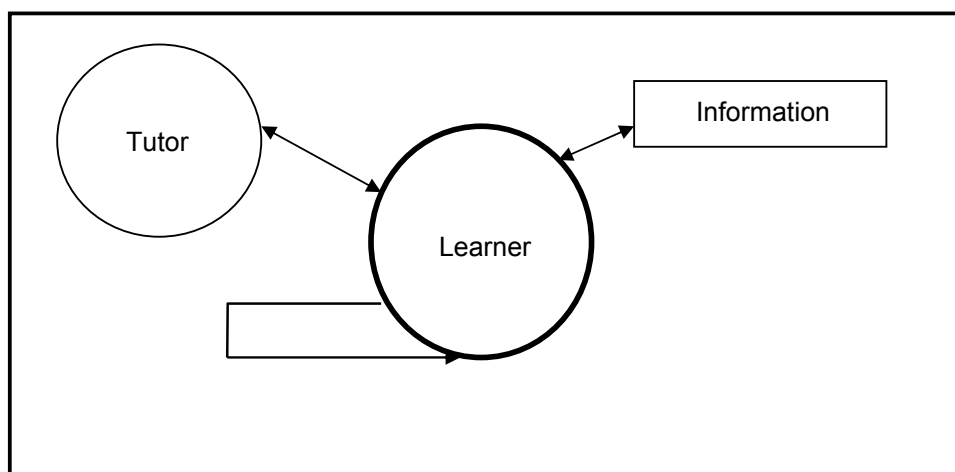


Figure 2. Learning interactions (diagram adapted from Sabry & Baldwin, 2003).

The *Pedagogy* component is concerned with *how* a course of study will be delivered in instructional terms. This may include, for example, information about different learning theories (instructivism, cognitivism, and constructivism), instructional approaches (for example learner-centred), methods and styles of teaching relevant to the subject matter (such as problem solving, deep, surface, etc.) and to different learning styles and strategies, learning interactions, contexts and models of learning. Interactivity of learning systems can take different shapes through using different types of a learning interaction, which can be categorised into three main types: *Student–Content*, where a learner interacts with information; *Student–Lecturer*, where a learner interacts with experts; and *Student–Student*, where a learner interacts with other learners (Moore, 1989; Moore & Kearsley, 1996). These three categories of interaction (Figure 2) can play an important role in making the learning process an interactive one, by helping to adapt instruction to better suit learners' requirements (Jonassen, 1988), expanding interaction beyond the lecture or tutorial (Jung et al., 1998), encouraging learners to actively process information (Bower & Winzenz 1970), providing access to learning resources (Jung & Leem, 1999), adding flexibility to learning (Naidu, 1997; Reeves & Reeves, 1997), and allowing learners to interact synchronously and asynchronously in collaborative and distributed environments (Harasim, Hiltz, Teles, & Turoff, 1995).

ICT is at the heart of CML. Education that is supported by ICT can promote the acquisition of knowledge and skills that will empower students for lifelong learning, if designed and implemented properly (World Bank, 1998). According to research, appropriate use of ICT can catalyse the paradigmatic shift in both content and pedagogy that is at the heart of educational reform (Bransford, 1999). However, the availability of learning-interaction tools in learning environments is not solely considered sufficient, the incorporation of such interactions into the learning design is essential for the effectiveness of both the flow of interaction and learning (Nelson, 1999).

Model for an interactive learning system

The extent of a system's interactivity will depend on how the learning system's components are coordinated and managed. The *Interaction* component (Figure 3) will help

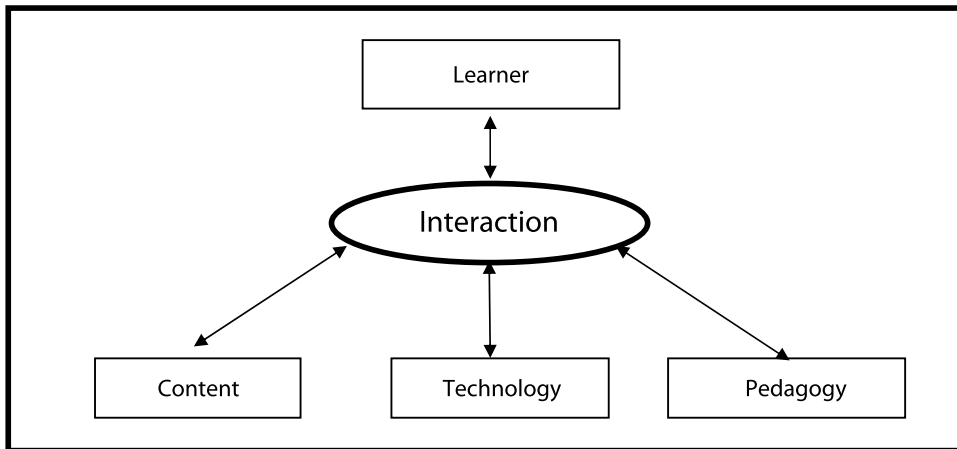


Figure 3. ILS model.
Source: Baldwin & Sabry (2003).

in coordinating and balancing the other four elements, for example, how learners interact with the computer system, the design of the interface between these, presentation of multimedia, considerations and decisions about interactivity level, interaction, and consideration of the teaching styles to be used according to the skills to be developed as well as each individual learner's needs.

Adding the dynamicity dimension to the ILS model

Dynamic information can be defined as information that is updated instantly as soon as changes occur and is available to those who need it at the time and in the form and relevance in which it is needed (Barker, 2007; Barker & Finnie, 2004). Many learning systems have been designed without giving much attention to the next generation of information, Dynamic Information Generation (DIG). There are two perspectives for the relationship between the DIG and education: educate *for* the DIG and educate *in* DIG. Educating *for* DIG will be required at all levels of education, from primary to university. This will include developing skills and literacy in digital age literacy (informational, technological, cultural, global, functional, and scientific literacy), inventive thinking (adaptability, curiosity, creativity, and risk taking), higher order thinking (creative problem solving and logical thinking), and effective communication (collaboration, interpersonal skills, team work, personal and social responsibility, interactive communication and high productivity) (METIRI Group, 2003).

On the other hand, for education *in* DIG, ICT greatly facilitates the acquisition and absorption of knowledge, offering unprecedented opportunities to enhance educational systems all over the world, reducing any sense of isolation, and opening access to knowledge in different ways (Blurton, 1999). Education *in* DIG is therefore for all (classical or modern, formal and non-formal, urban and non-urban, ethnic minorities, special needs, male or female, young or elderly) at any location anytime with a more flexible pedagogy. It seeks more variations of different activities, collaboration, creativity (Figure 4), integration (between theory and practice and between different subjects and disciplines) and evaluative learning (towards a more diagnostic approach rather than

Aspect	Less (‘traditional pedagogy’)	More (‘emerging pedagogy’ for the information society)
Active	<ul style="list-style-type: none"> • Activities prescribed by teacher • Whole class instruction • Little variation in activities • Pace determined by the programme 	<ul style="list-style-type: none"> • Activities determined by learners • Small groups • Many different activities • Pace determined by learners
Collaborative	<ul style="list-style-type: none"> • Individual • Homogenous groups • Everyone for him/herself 	<ul style="list-style-type: none"> • Working in teams • Heterogeneous groups • Supporting each other
Creative	<ul style="list-style-type: none"> • Reproductive learning • Apply known solutions to problems 	<ul style="list-style-type: none"> • Productive learning • Find new solutions to problems
Integrative	<ul style="list-style-type: none"> • No link between theory and practice • Separate subjects • Discipline-based • Individual teachers 	<ul style="list-style-type: none"> • Integrating theory and practice • Relations between subjects • Thematic • Teams of teachers
Evaluative	<ul style="list-style-type: none"> • Teacher-directed • Summative 	<ul style="list-style-type: none"> • Student-directed • Diagnostic

Figure 4. New Pedagogy.
Source: Thijs et al. (2001).

summative and student directed rather than teacher-directed) from teacher-focused to learner focused (Thijs et al., 2001). Moving education to DIG requires changes to: the role of teachers, education process and progress (non-median), customisation of text books from static to dynamic, redefining the conduct of class teaching, and distance education.

This paper proposes adding the Dynamicity Component to the ILS design (Figure 3) to develop a Dynamic Interactive Learning System (DILS), which can be defined as an ILS that implements DIG principles (Figure 5). DILS will not only have interactive components, but dynamic components rather than static, components that are constantly updated and modified based on latest research and updated knowledge gained in the field concerned. It is based on open systems that are flexible, adaptable, adaptive, interactive, relevant, anytime and anywhere similar to the *Living System* paradigm and the *Gardening analogy* described by Ray Paul (1993). The DILS advocates the inclusion of a *dynamic feedback and adjustment mechanism* which is largely ignored by most learning systems. Based on the proposed DILS model, students are assessed on a regular basis, with the marking being done electronically for appropriate subjects and the individual dynamic text books, workbooks and exercises being constructed according to the assessment, focusing on students’ knowledge. The dynamic texts will typically be only about one to two weeks ahead of the student. They will NOT be created for a year or even a term. They will be consistently built on the individual student’s knowledge of the topics at that time. The DILS also stresses and highlights the importance of the *balancing* concept through the interaction and coordination between the different components of the model based on up-to-date and dynamic information including course material, relevant technology, pedagogy and learners’ actual profile in order to both accommodate students’ differences and develop skills required in a relevant and balanced manner.

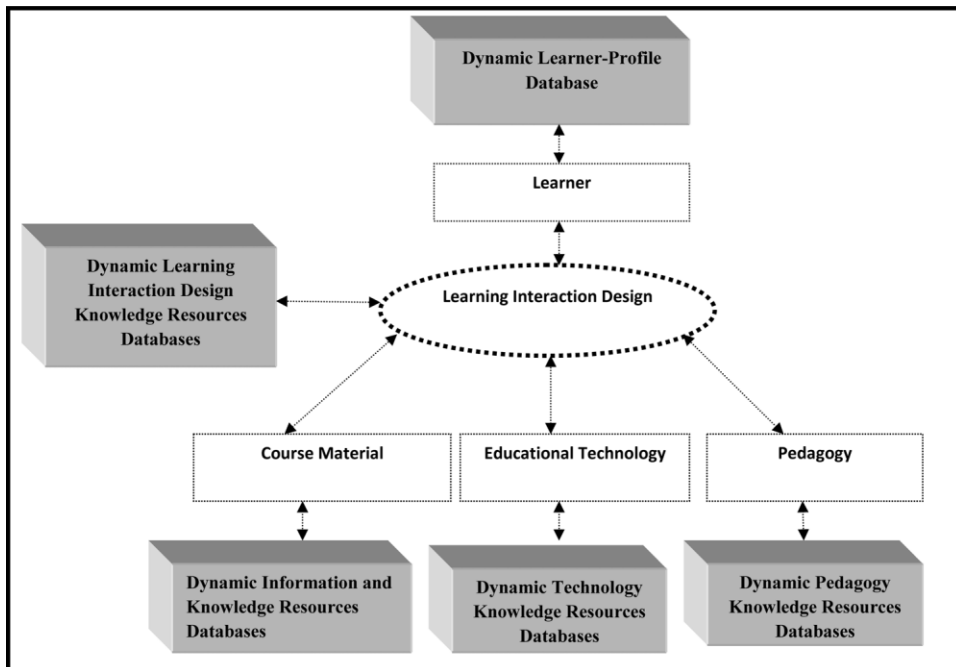


Figure 5. Dynamic Interactive Learning System Model (DILS).

Course material (content)

This component should contain up-to-date links to up-to-date information and knowledge resources related to subject area in digital form (e.g. e-book, virtual lecture, e-libraries, web, simulations, labs, etc). It should not be tied to a hard copy of a text book or static means of information or knowledge, but dynamic digital information and knowledge that are constantly updated and modified based on the amount of knowledge absorbed by the learner. Such information is not tied to a particular place or time. E-books are no longer static, but interactive and updated by their authors where and when applicable. It contains tasks to be taught in relation to course aims and objectives, learner profile and skills to be developed. This should also contain links to recent research in the subject area as well as dictionaries to support students from different parts of the world. As an example, each student in a class will have his/her own dynamic text book, the content of which is based on the constantly updated (dynamic) evaluation of the student's knowledge and understanding of the material.

Learner

This component contains actual and dynamic information including up-to-date information about level of attainment, courses evaluation results (as it occurs), efforts, progress, and considerations about the student, including individual differences (e.g. gender, culture, prior knowledge, language, age, etc.) and preferred learning styles (e.g. sequential, global, active, etc.).

Educational technology

Educational technology contains up-to-date knowledge and considerations about the media through which course contents can be delivered and multimedia representation to accommodate different types of interaction, teaching and learning styles. This also includes different technologies whether asynchronous and/or synchronous. This component is a dynamic component that seeks up-to-date technologies and use of a variety of innovative technologies to accomplish the system's goals and objectives, for example, the use of latest technologies that assist the flexibility, adaptivity, adaptability, and learning interactivity available anytime, anywhere without geographical, special or temporal limitations, such as:

- GIS (Geographical Information Systems) and mapping technologies for capturing, storing, analysing and managing spatial and associated data;
- Radio Frequency Identification (RFID) for data capture and education exploration;
- Global Positioning Systems;
- Smart phones, PDA, Wi-Fi, Nano, etc.

It may include software agents that exhibit some form of artificial intelligence or some sort of embedded intrinsic and seamless actions that assist the users and act on their behalf, in performing repetitive computer-related tasks, for example:

- learn and improve through interaction with the environment (embodiment);
- adapt online and in real time;
- learn quickly from large amounts of data;
- accommodate new problem solving rules incrementally;
- memory-based exemplar storage and retrieval capacities;
- parameters to represent short and long term memory, age, forgetting, etc.;
- ability to analyse itself in terms of behaviour, error, and success;
- perform diagnostic evaluation of student progress to assist learning improvement and provide feedback for student evaluation.

Pedagogy

This component contains pedagogical knowledge that is dynamic and constantly updated with methods and styles of teaching relevant to each subject matter, aims and objectives, relevant to DIG and learners' differences. The wider the range of different strategies, the more effective and efficient the teaching and learning will be. This component should include assessment strategies that are compatible with DIG, i.e. student evaluation methods should not be tied to temporal or spatial constraints, but should use evaluation methods that are more diagnostic, based on dynamic information relating to a student's progress, achievements, and pace.

Learning interaction design

This is the component that coordinates and balances the other four components, based on up-to-date and dynamic course material, technology, pedagogy, and learners' profile. It also helps to produce learning systems taking into account HCI design principles,

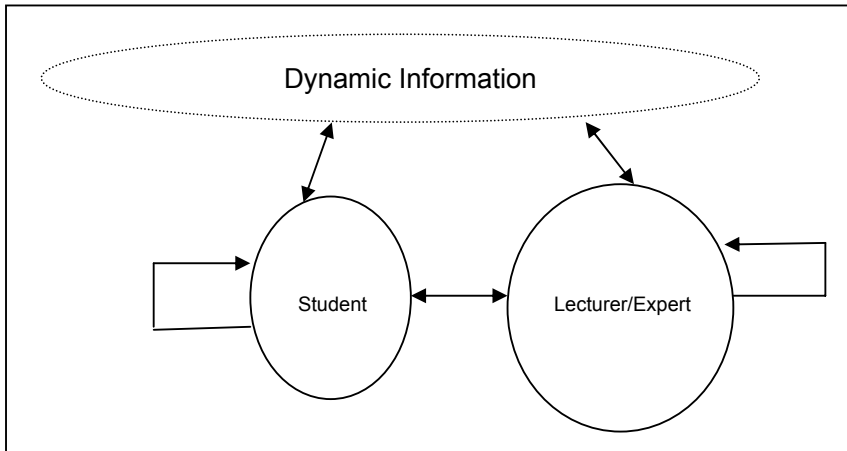


Figure 6. DILS 5 types of interaction.

multimedia presentation considerations and decisions about interactivity level, type of interaction, and teaching styles to be used in accordance to different contents, different learners, and technologies used. It is constantly updated with knowledge of best interaction practices. DILS engages the learner with a variety of interactions with materials, peers, and experts and allows not only for the three types of learning interaction of ILS, but also for Lecturer–Information interaction (where lecturers have access to latest and up-to-date information available) and Lecturer–Lecturer Interactions (where knowledge can be shared between lecturers and/or experts). These interactions are incorporated through the ‘Interaction’ component of the DILS. Figure 6 shows the five types of interaction incorporated in DILS.

Conclusions and future work

Education programmes and learning systems must be designed for the increasingly different mix and combination of learners with considerable age differences, backgrounds, abilities, culture, gender, past experience, different needs, full and part-time, as well as learning styles and communication preferences. Equally important, they need to adequately prepare students for this new volatile, continuously changing and dynamic era the world is now moving into. The current systems and programmes were designed in and for the pre-dynamic information era. The world has moved into an era of Dynamic Information Generation (DIG); education must also move into DIG to be more effective, relevant and compatible with continuous changes in industry and advances in information technologies. An effective DILS design, takes into account different learners and their changing needs, technological advances to accommodate different needs, different and suitable methods of teaching/learning to accommodate students’ different needs and develop required skills. The *Interactivity* and *Dynamicity* dimensions are vital to provide a dynamic feedback and adjustment mechanism to cope with continuous changes in information, communication, technology, business, and learner’s needs.

The review outlined in this paper as well as the proposed DILS model are only attempts towards creating a greater understanding of the new era of ICT and is hoped to lead to improvements in the design of learning systems in relation to developing

more dynamic and interactive participation by a higher percentage of students. This, in turn, should lead to important gains in the acceptability and usefulness of such systems as the awareness of the pedagogical implications related to the use of dynamicity and interactivity dimensions can lead to more effective and usable learning systems. Further, research is needed to examine different applications of the DILS model and different learning interactions that best support students globally.

Notes on contributors

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