Contextual issues in the construction of computer-based learning programs

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Abstract Based on the constructive learning theories, particularly constructivism, four contextual issues are identified and discussed in this paper regarding the construction of effective computer-based learning programs, namely topic selection, authenticity, complexity, and multiple perspectives. These four issues are considered essential for effective learning in terms of learners’ participation, reasoning and knowledge construction. After a thorough review and discussion of these issues, a generic conceptual model is built, which shows both the interrelationships among the four issues and the measurement variables of each issue. It is expected that the four contextual issues and the generic model can provide invaluable insights toward research in computer-based learning, training and many other related fields, and address the needs of practitioners to develop better computer-based learning programs. Recommendation for further research is also suggested in the end.

Keywords: Constructivist; Courseware; Discovery learning; Multimedia; Problem solving; Student-centred

Introduction

As indicated in many learning literatures, learning research focus has been shifting from direct instruction to a more opened and learner-centred learning process, which requires high-order reasoning and knowledge construction. As the main objective of such a shift is to provide shared environments that permit sustained exploration by learners and enable them to understand the kind of problems, opportunities and knowledge that experts in various areas would encounter and apply (CTGV, 1993a), it is essential to create authentic problems within authentic environments for effective learning: environments that correspond to the real world and emphasise the importance of anchoring or situating instructions in meaningful and problem-solving contexts (Choi & Hannafin, 1995). Learners can then explore, interrogate, discover and learn within that environment through a knowledge construction process. Such an approach can provide learners with the conceptual power needed to deal with many situations particularly in complex and ill-structured domains (Ertmer & Newby, 1993).

With the increasing use of computers and computer-based learning (CBL) programs in education, the same learning principles should be considered in
constructing these programs. In fact various CBL programs were developed, such as complex content-focused learning environments (Jonassen, 1993), intentional learning environments (Scardamalia et al., 1989), open-ended learning environments (Land, 2000), and generative learning environments (CTGV, 1991). These environments all allege to be interactive, learner oriented and constructivistic engaging higher order thinking skills. However, in terms of implementation, there is no generally accepted framework or design guidelines for the construction of such programs, though numerous articles can be found on the issue (e.g. CTGV, 1991; Lebow, 1993; Choi & Hannafin, 1995; Hannafin et al., 1997; Jonassen, 1997; Petraglia, 1998; Herrington & Oliver, 2000; Land, 2000).

The lack of generic frameworks or design guidelines could be caused by the complexity involved in knowledge construction processes, since the requirements of constructing a CBL program may vary with topics selected, roles that the proposed program is intended to play, and the way it is integrated into a course curriculum (Jonassen, 1993). Apparently, one set of design principles of a particular domain may not be applied directly to another domain. Nonetheless, it is essential to provide more explicit guidelines on how learning programs can be designed to foster effective learning (Jonassen, 1993). A general guideline in this nature will greatly help operationalise the descriptive theories into actual practices by providing explicit methods on how to design better CBL programs. Thus, it has been set as the main objective of this paper to establish such guidelines toward this endeavour.

In view of the enormous work involved in constructing a complete guideline incorporating all aspects of learning requirements, this paper mainly focuses on the contextual issues in constructing CBL programs. Based on a broad literature review, particularly on constructivism, four contextual issues were identified and discussed in this paper, namely topic selection, authenticity, complexity and multiple perspectives. Instead of attempting to marginalise the differences among various learning approaches, this paper tries to incorporate validated applications from different domains and the generalised utilities of various approaches. Thus, the four issues are not bound to any specific contexts projecting that they can be generalised to other domains withstanding their differences in theoretical foundations and assumptions of learning requirements. It should also be noted that these issues are by no means exhaustive, but they potentially address some of the major concerns of constructing CBL programs.

In this paper, the theoretical background of the related learning research is presented first. Then, the four contextual issues identified and their theoretical justifications toward learning effectiveness are provided. Various implementation alternatives of the four issues and their potential impacts on learning effectiveness are also discussed in detail. In an attempt to establish a generic framework, which would not only be acceptable by researchers and practitioners, but also be applicable to various domains, a conceptual model is built integrating all the four contextual issues, which shows both their interrelationships and measurement variables toward learning effectiveness for better learning outcomes. Implications toward research and learning practices of the model and the four issues are also discussed. Finally, conclusions and recommendations for further research are given in the end.

**Theoretical background of learning research**

Research in learning has shifted from passive human memory to active strategies for
learning: what it means to learn, the content that learners are to acquire, and the context in which they are to acquire it (Glaser & Bassok, 1989). There are increasing concerns about helping learners to learn to think more effectively, and to help them develop effective problem solving, reasoning, and learning skills, which have brought increasing demands for more subtle methods to render overt the human thought processes (Resnick, 1987). Such change can be observed from the shift of focus in learning research from a more instructor-driven behaviourist approach, to more active learner’s cognitivism, and to the learner-centred constructivism, as discussed below.

Learning in behaviourist view is shaped by serially structured sequences that model, establish and reinforce the relevant associations in the mind of the learner through review and practice combined with feedback on his or her performance against explicit criteria (Atkins, 1993). For example, the traditional lecturing method embeds the basic pedagogical assumptions of the behaviourism theory of learning. Thus, no attempt is made to determine the structure of a student’s knowledge nor to assess which mental processes it is necessary for them to use (Winn, 1990). Also, learners are characterised as being reactive to conditions in a learning environment (Ertmer & Newby, 1993). Therefore, the resulting instruction teaches components but not integrated knowledge and skills, and the resulting learning is poorly retained, which does not relate well to previously learned materials (Merrill, 1991). More importantly, learners often have trouble generalising their learned knowledge from one situation to another, remaining poor in divergent reasoning, problem solving, and troubleshooting (Hannafin & Rieber, 1989).

By contrast, cognitivism mainly concerns explication of the process of learning, which is the least developed component of behaviourism (Glaser & Bassok, 1989). It advocates leaning in the context of working on specific problems, and learners are required initially to have certain amount of declarative knowledge of a particular domain before proceeding to the problem-solving. Moreover, it recommends explication and modelling of the appropriate problem-solving structure and of the procedures or strategies entailed. Because of the emphasis on mental structures, cognitive theories are usually considered more appropriate for explaining complex forms of learning than are those of a more behavioural perspective (e.g. Schunk, 1991). However, the actual goal of instruction is often to communicate or transfer knowledge to the learners in the most efficient, effective manner through simplification and standardisation (Jonassen, 1993). The process of reducing the complexity of learning tasks may well be misrepresenting the thinking or mental processing required by the task. Due to these limitations, it is argued that cognitivism has not provided enough of a paradigm shift in terms of learning and problem solving (Jonassen, 1991).

Constructivism can be considered to be an extension of cognitivism characterised by discovery and experiential learning whereby learners learn best what they discover or can be led to discover for themselves. It focuses on creating authentic problems within authentic environments for learning: environments that correspond to the real world (Petraglia, 1998), so that learners build personal interpretations of the world based on individual experiences and interactions with those environments (Ertmer & Newby, 1993). Constructivism has recently attracted most of the attention of educational technologists, partially because of the ways information technology is impacting on life, learning, and work, and partially
because it offers innovative approach to instructional design (Duffy & Jonassen, 1991; Cobb, 1999). It claims that everyday learning always takes place within a social context, instead of as largely independent situational variables (Jonassen & Rohrer-Murphy, 1999). Thus, there are many ways to structure the world and there are many meanings or perspectives for any event or concept (Brown et al., 1989; Herrington & Oliver, 2000). For instance, one critical epistemological dimension of constructivism is to create learning environments with embedded problems, which are authentic to reflect the real world (Land & Hannafin, 1996).

Despite the theoretical appeal of constructivism, there are competing constructivist views (Phillips, 1995) as well as criticism (e.g. Fox, 2001). There is also lack of empirical-based evidence to back up many of the advantage claims (Hay & Barab, 2001). Furthermore, there is research that found no significant contribution of constructivism to the quality of teaching and learning (e.g. Tenenbaum et al., 2001). From a theoretical point of view, constructivism has become a term that encompasses many different types of learning environments, even though they are based on different theoretical assumptions (Duffy & Jonassen, 1991; Barab & Duffy, 2000). While it is not the purpose of this paper to joining in the debate on these issues, we try to incorporate views from various perspectives and generalised utilities of various approaches instead of marginalising the differences among them, as long as they have similar underlying theoretical assumptions.

In this regard, the four constructive learning approaches namely, cognitive apprenticeship, anchored instruction, problem-based learning and case method can all be categorised under constructivism, since they all emphasise the importance of situating instructions in meaningful contexts in which learners approach tasks with some prior knowledge and expectations based on their knowledge of the context around them. Cognitive apprenticeship has been applied extensively in training as well as in education mostly in the form of apprenticeship and lab experiments (Brown et al., 1989; Lajoie & Lesgold, 1989). Anchored instruction has also been successfully applied at various levels of education when tools such as video tape or video CD are frequently used to present real or simulated situations in classroom settings (CTGV, 1992; Shyu, 1999). When learners are competent enough to understand, analyse, explain, and absorb abstracted materials, case methods and problem-based learning are more often used, especially in the disciplines of business, medicine and law in higher education (Williams, 1992; Savery & Duffy, 1995; Barron et al., 1998). All these approaches demonstrate that the philosophy of constructive learning has already been playing a major part in traditional educational practices.

These learning theories and associated approaches, particularly constructivism, offer promises in the development of effective learning environments. However, to some extent, it is difficult to develop practical applications, particularly computer-based learning (CBL) programs without frameworks or guidelines for such undertakings. On the other hand, rapid advances in computer technologies have facilitated the development of electronic tools and resources that have expanded the opportunities to empower learner-centred alternatives (Jonassen, 1993; Land, 2000). With the available computer technologies such as multimedia, multimedia authoring tools, and Internet technologies, the construction of CBL programs now becomes much easier and less labour intensive than before. For example, multimedia has the capabilities to create learning environments wherein complex concepts can be represented, manipulated and explored (Hill, 1999; Land, 2000). Potentially, these
tools can significantly reduce development cost of interactive learning applications, and make the CBL approach a viable and affordable option to consider. It is therefore essential to develop guidelines on how technologies should be used to build effective CBL applications.

The four contextual issues

The above review indicates that learning environment plays a key role in effective learning. Consequently, the contextual issues of learning programs are crucial for the success of CBL approach, and are also the major focus of this paper. Based on a broad review of the related learning research literatures, four contextual issues are identified namely, topic selection, authenticity, complexity, and multiple perspectives. These issues are considered significantly influential on the design and implementation of CBL programs leading to effective learning. They were identified based on not just one single learning theory, but a wide range of relevant theories, approaches, and practices as shown in the following discussions.

Among these four issues, topic selection is about evaluating and selecting a particular domain such as a discipline, a subject of a discipline or even a specific problem of a subject for CBL program development. Usually, it would be the first challenge faced by an educational developer to identify the topics that the learning theories and the associated technologies could effectively apply (e.g. Edwards, 1995). If inappropriate subject areas are selected, the impact of CBL on learning performance may not be significant even when advanced technologies are used. Therefore, subject matters should be considered well before any actual development (Leung, 1998). Once a topic is selected, appropriate learning approaches should be considered due to the fact that some domains may limit certain dimensions of the applicability of certain learning theories (Petraglia, 1998).

Secondly, authenticity concerns providing authentic contexts and authentic activities around authentic missions in terms of personal, real world and disciplinary authenticity. Within an authentic scenario or situation, learners are believed to learn more and perform better (Shute & Glaser, 1990; Schank, 1993; Nicaise, 1997), and also better motivated with a reason for learning relevant materials and skills (Grabinger, 1996; Nicaise, 1998). It is now widely accepted that a learning program should provide authentic contexts and authentic activities around authentic missions (Brown et al., 1989; Jonassen, 1993; Vosniadou, 1994; Schank et al., 1995; Grabinger, 1996; Nicaise, 1998; Squires, 1999; Herrington & Oliver, 2000; Land, 2000), so the knowledge gained will be readily available in the kinds of situations they will face in their work (Collins, 1994). Authenticity is the cornerstone that many contemporary learning theories and instructional methods are based on, such as constructivism, situated learning model, cognitive apprenticeship, case approach and problem-based learning (e.g. Brown et al., 1989; Williams, 1992; Phillips, 1995), thus it is an essential ingredient for effective learning.

Thirdly, complexity concerns the complexity of a CBL program, i.e. to what extent a learning program should be designed to reflect the real-world complexity. Complexity of a learning program is very important for learning, particularly in ill-structured domains (Gruba & Søndergaard, 2001). Unless learners have had the opportunity to explore complex problems, they often remain poor at assembling subskills for purposes of problems solving, even when they become quite good at those subskills (CTGV, 1991). According to Petraglia (1998), an authentic learning
environment reflecting a real world domain needs to be constructed in full complexity into problem solving by presenting learners with thick problems. The great strength of the learning theories that promote high-level thinking and problem solving is their ability to support such complexity of a learning program in contrast to the traditional objectivistic approaches (Gruba & Søndergaard, 2001). Since learning does not result from a single activity, but from the integration of multiple activities based on multiple sources of information, thus a learning program must take the complexity into account by offering a wide range of learning resources that will accommodate the variety of individual learning styles and needs.

Lastly, multiple perspectives concern learners’ problem solving ability across analogous or even different domains, and also the reality of multiple solutions to a single problem in real situations. Complex learning environments require multiple perspectives of representations due to their ill-structured and highly conditional nature (Gagné, 1990; Lewis et al., 1993). Therefore, in a relatively complex learning program, learners should be given the opportunity to experience an event from multiple perspectives in terms of multiple solutions or views of a phenomenon under study (Atkins, 1993; Park & Hannafin, 1993; Cobb, 1997; Chou & Lin, 1998; Laurillard, 1998), as well as to solve comparative problems under different settings or even in different domains (Levin & Waugh, 1988; Bransford & Vye, 1989; Duffy & Jonassen, 1991; Merrill, 1991; Hannafin et al., 1994; Choi & Hannafin, 1995; Dunlap & Grabinger, 1996; Burke et al., 1998; Berge, 1999).

These issues are discussed individually in details in the following sections in terms of implementation methods and respective theoretical justifications. Critical reviews of various implementation alternatives are also conducted. It is expected that these discussions could lead to a design guideline or a framework for CBL research and development from a contextual point of view. A conceptual model is also built at the end of these discussions, which integrates all the four issues and also shows their intervening relationships.

**Topic selection**

The constructive learning theories have been applied to domains such as sciences (e.g. CTGV, 1992; Edwards, 1995; Salomon, 1996), engineering (e.g. Gruba & Søndergaard, 2001), language acquisition (e.g. Cobb, 1999), and technical training (e.g. Silber, 1998). However, up to date, there is no significant research on topic categorisation for constructive learning applications. One potential category suggested in (CTGV, 1993b) is developing vocabulary and reading comprehension, because visual information can provide learners with a conceptual link between the text and an understanding of what is presented in the text. Furthermore, many studies on anchored instruction conducted by the Cognition and Technology Group at Vanderbilt (e.g. CTGV, 1990; 1991; 1992; 1993a) implied that any domains that can be represented in interesting and realistic multimedia contents to make learning more motivating, meaningful and useful for subsequent problem solving, are appropriate. For example, in an anchored instruction program for learning mathematics (CTGV, 1992), the pupils in primary schools were required to carry out journey planning and actual plan execution based on information on available routes, travel distance, amount of cash to buy gas and food, and gas stations on various routes, etc.

Leung (1998) suggested a simple way to select subject areas for CBL development, which is to choose those topics that teachers feel difficult to explain in
a classroom setting without exposure to an authentic real world situation. Similar criteria were proposed in (Cobb, 1999) for selecting suitable domains for constructivist applications, which is when traditional instructional models are used but have not produced the desired learning results. A model of expert knowledge construction was also made available to serve as a basis for instructional design; and so was an empirical methodology to measure quantities and qualities of learning.

A complete categorisation on applicable topics for CBL development is difficult if not impossible. Hence, a more feasible option could be to produce a general guideline on the principles of selecting topics. In view of the past research and practices, three criteria of topic selection are proposed here, i.e. problem environment, context representation, and manipulation space. A targeted problem environment should be presented to learners with interesting, relevant, rich and engaging problems preferably from real world contexts to be solved (e.g. Rieber, 1992; Edwards, 1995; Jonassen & Rohrer-Murphy, 1999). Accordingly, contexts such as engineering design, language, mathematics, medicine, and business management can be considered viable topics for CBL development. Secondly, context representation concerns whether the targeted context and the embedded challenges for learners can be easily and naturally represented in a computer-based environment (e.g. Salomon, 1996; Hannafin et al., 1997; Leung, 1998). Context representation plays a critical role in the learning process, because it presents all the important details of a context including the physical context, the actors and stakeholders, and the organisational and culture climate, in which the embedded problems need to be solved by learners.

Thirdly, manipulation space concerns the amount of freedom, flexibility and choices that a learner can have to explore within a given context (e.g. Tessmer & Richay, 1997; Jonassen & Rohrer-Murphy, 1999). With more manipulation space, learners presumably can carry out more activities and have more interactions with the learning program for better learning. In fact, it is closely related to problem environment, in which complexity and multiple perspectives of ill-structured domains can determine the amount of manipulation space. Overall, the proposed criteria can serve as a guideline for selecting potential topics for CBL development.

**Authenticity**

Authentic tasks must be realistic in terms of the cognitive, physical, social requirements and alignment with the essential practices of a discipline (Grabinger, 1996; Shaffer & Resnick, 1999). A realistic learning program and associated learning activities should include as much fidelity as possible to what learners will encounter outside school in terms of tools, complexity and interaction with people (Shaffer & Resnick, 1999). For example, authentic activities might ask learners to investigate a ‘real’ problem such as thorium waste in nuclear power or Legionnaires disease (Stepien & Gallagher, 1993). In other words, authentic activities should include anything that works ‘toward production of discourse, products and performances that have value or meaning beyond success in school’ (p.8) (Newmann & Wehlage, 1993). In traditional teaching, real-world case-based approach is often used to fulfil these authenticity requirements especially in ill-structured domains such as business and law (Williams, 1992). It is also suggested in (Jonassen, 1994) that purposeful knowledge construction can be facilitated by providing real-world case-based learning environments.

Personal authenticity also play a critical role in determining whether an activity is worthwhile or authentic (Myers, 1993; Petraglia, 1998), so that the educational significance of an activity must be judged — at least in part — by its significance to the learner (Schank & Jona, 1991; Shaffer & Resnick, 1999). Furthermore, in terms of disciplinary authenticity, learners should not only learn to solve problems in a way as domain experts do, but they should also be doing so in ways that build on the prior knowledge and intellectual tradition of particular disciplines (Shaffer & Resnick, 1999).

Shaffer & Resnick (1999) summarised four kinds of authentic learning based on the literature on authentic education: (a) learning that is personally meaningful for the learner (b) learning that relates to the real-world outside of school (c) learning that provides an opportunity to think in the modes of a particular discipline, and (d) learning where the means of assessment reflect the learning process. They argued that instead of achieving one without the other, all four kinds of authentic learning should be considered in a ‘thick’ view of authenticity. Indeed, these four kinds of authenticity generally represent all the essential authentic requirements in constructive learning.

To achieve the kind of authenticity without being physically exposed to a real world situation, multimedia learning programs are supposed to have the potential of creating authentic learning experiences and of offering learners opportunities to process large amount of information independently (Smeets & Mooij, 1999). The link between multimedia and authenticity is intimate, as real life is fundamentally multimediated by the senses (Petraglia, 1998). Furthermore, computational media have the potential to create thickly authentic learning environments, and these media are particularly well suited to restructure learning in terms of personal, real-world and disciplinary authenticity (e.g. Shaffer & Resnick, 1999). Therefore, with the available multimedia technologies, it is essential to implement these authenticity requirements whenever appropriate in CBL applications.

**Complexity**

The complex content is characterised by high cognitive demands due to contextually induced variability, multiple knowledge representation, and multiple interconnections of knowledge components (Spiro *et al*., 1991). Thus, effective learning is achieved in the process of schematisation and abstraction of the complexity of reality by the learners (Mendelsohn, 1996). Hannafin & Land (1997) regarded integration and comprehensiveness as two of the most critical features of a learning program, in which comprehensiveness refers to the importance of linking learning in a broad and realistic context rather than decontextualising and compartmentalising knowledge. Thus, as suggested in (Savery & Duffy, 1995), complexity can be achieved by integrating all learning activities into a larger complex task or problem.

However, if a program is too complex, there is a concern that learners with weak background may not begin learning effectively (Dick, 1991; Mendelsohn, 1996). A novice may easily be overwhelmed by the complexity, become distracted by surface features of a problem (Chi *et al*., 1981), and fail to see the important underlying principles (Levin & Waugh, 1988). This is because knowledge is stored as chunks in memory, with each chunk containing the amount of information based on a learner’s existing knowledge (Miller, 1956). There is also evidence that learners pass through
a series of stages or phases during which the learning process and the variables influencing it change systematically (Shuell, 1990). Therefore, it is important to determine how a complex environment should be presented to learners.

One way is to let a novice start out with a simplified representation of a task domain, and gradually move on to more and more complex representations, until the learner is able to deal with the full complexity of the content domain (Levin & Waugh, 1988). The same is proposed in Park & Hannafin (1993) where information should be layered to accommodate multiple levels of complexity and accommodate differences in related prior knowledge. However, when simplification is necessary, the essence of the authenticity must be maintained (Bednar \textit{et al.}, 1991). The instructors and developers can then determine the entry level of complexity based on their experience and the expectation of the learners, as well as the amount of knowledge involved and the number of actions required for the solution (e.g. Dijkstra, 1997). However, it is important to understand how fluent those required skills are arrived at and how this process might be enhanced within a learning program (CTGV, 1992).

When it is not required for learners to reach the full complexity of the real world, it is still essential to show them the nature of the problems that they might confront in daily life, because the experience of dealing with simple problems can lead to misconceptions about the nature of environment and the problem solving skills (Schoenfeld, 1989; Spiro \textit{et al.}, 1991). Additionally, it is also useful for learners to build an understanding of the reason and need for further learning (Brown, 1985; CTGV, 1993a), which is similar to cognitive apprenticeships that learners get to see the finished products, even though they may be unable to create them on their own.

\textit{Multiple perspectives}

Unlike solutions to well-structured problems that can simply be right or wrong, in complex domains such as business, law and medicine, it is often unrealistic to have one single answer to a problem. Rather, solutions to ill-structured problems can be in different categories such as better, good, bad and worse (CTGV, 1991). For instance, Dick (1991), proposes the integration of multiple objectives in terms of the more comprehensive range of activities in which a learner is engaged. Thus, in a learning program, there should be multiple routes or options for learners to choose from, which are categorised according to their respective levels of appropriateness toward a solution. Learners should also be informed of the outcome at the end of each exploration.

Furthermore, to help learners react in response to varying situational demands, they must understand problems in their full complexity and must ‘criss-cross’ the problem space in multiple passes in order to observe how shifts in variables and goals alter the space (Lewis \textit{et al.}, 1993). Sometimes, a route can be made a dead end. As stated in (Minstrell, 1989), ‘Making software failure-driven means creating situations that allow learners to make mistakes. The right time to present information to learners is after they fail.’ (p. 634). Thus, when a learner fails, s/he should be guided to the point where s/he made the wrong move, and be allowed to restart from there again (Resnick, 1981; Merrill, 1991; Lewis \textit{et al.}, 1993; Laffey \textit{et al.}, 1998). Such practices may help learners understand the circumstance under which one solution is the best and may not be the best under other circumstances (Minstrell, 1989), so that the objective of multiple perspectives is achieved.
Observing the reasoning processes and strategies that experts usually employ when applying knowledge and performing complex and real-life tasks is another way to achieve multiple perspectives, as learners can acquire the ability to discriminate among subtle features by virtue of experience across a range of situations that provide relevant contrasts (Honebein et al., 1993). Again, multimedia can be used in such situations to show how experts would approach a problem under certain circumstances, and also comments on the learners’ approach as compared with the expert. Moreover, learners can be challenged at various stages of the learning process to solve similar problem under different settings or even in different domains if necessary. Thus, multiple perspectives can enhance learners’ understandings of the various approaches to the problem under different circumstances.

The conceptual model

The four issues discussed above, namely topic selection, authenticity, complexity, and multiple perspectives, are the major contextual issues considered influential on the effectiveness of CBL programs in this paper. As already mentioned before, these issues are by no means exhaustive, and they are not restricted to any specific learning theories and domains. Rather, they are identified and discussed based on a spectrum of constructive learning theories, associated approaches and practices, so presumably they can be applied to any domains or disciplines. Yet, no discussion is conducted so far on their interrelationships, especially the intervening effects among the four issues. Understanding in this respect would certainly contribute toward the success of the proposed approach through reducing conflicts and maximising overall performance, as learning requires an integrated effort from all available sources. Therefore, a conceptual model needs to be built for such purposes.

There is less research in modelling the influences of various factors on learning effectiveness. However, from a contextual point of view, it is possible to build such a model based on what has already been discussed. First of all, topic selection can be affected by authenticity, complexity and multiple perspectives, because a topic can be selected based on problem environment, context representation and manipulation space. Obviously the selection criteria are closely related to all contextual issues. On the other hand, once a particular topic is selected, it will affect the design and implementation of CBL programs in terms of authenticity, complexity and multiple perspectives, as different topics would have different requirements in these aspects.

There should also be interrelationships between authenticity, complexity and multiple perspectives. To make a learning program authentic, it is essential to present the real-world complexity as much as possible to fulfil the authentic requirements. In this regard, authenticity is very much dependent on complexity. Presumably, in an ill-structured domain, more authenticity of a learning program would require more complex representation of the real world. Furthermore, complexity is represented by induced variability, multiple knowledge representation, and multiple inter-connections of knowledge components (Spiro et al., 1991), thus the various level of complexity can be positively determined by the degree of multiple perspectives.

Therefore, based on the above analysis, a conceptual model is built as shown Fig. 1. Not only it shows the interrelationships among the four issues discussed above, the measurement variables of each issue are also included based on the previous discussions. Topic selection is determined by problem environment, context representation, and manipulation space. Authenticity is represented by
personal authenticity, task authenticity, domain authenticity, and assessment authenticity. Complexity is measured by induced variability, multiple representations, and multiple interconnections. Lastly, multiple perspectives is characterised by multiple learning paths, solutions, and domains. One direct derivation from the model is that none of the components are independent; rather, they are affecting each other in various ways. It is projected here that the right combination and balance of these contextual issues will greatly contribute to effective learning.

The model has implications to both research and practical development. From a practical point of view, when selecting topics for CBL development, one should also consider the appropriateness and applicability of the potential topic in terms of the authenticity, complexity, and multiple perspectives. Once a particular topic or domain is chosen, the various level of complexity in a learning program can be influenced by the depth of multiple perspectives embedded, which will in turn determine the degree of authenticity of the program. From the research point of view, the model provides valuable insights on how the intervening effects among the four issues would influence learning effectiveness. It also paves the way for in-depth empirical research to determine the strength of these relationships and their respective as well as integrative influences on learning effectiveness. To make the model acceptable by researchers and practitioners, and applicable to various domains, more research is needed to thoroughly test, validate and refine the model using CBL programs developed under different learning theories and for different domains. The measurement variables and their constructs should also be further refined and developed.

**Conclusions**

The four contextual issues discussed, namely topic selection, authenticity, complexity and multiple perspectives address some of the major concerns of CBL to encourage learners’ participation, reasoning, problem solving and knowledge construction. Constructivism, which promotes creating authentic problems within authentic environments for learner centred exploration and effective learning, was the main theoretical foundation of the discussions around the four issues. The review of the learning literatures also shows that the four issues can contribute greatly toward learning effectiveness. Specifically, the three criteria of topic selection would be very beneficial for choosing appropriate topics for CBL development. In terms of authenticity, a thick view of authenticity is essential in a learning environment. Thus, a CBL program should provide authentic contexts and authentic activities around authentic missions to improve learner’s understanding and ensure the relevancy of the learned knowledge to real world situations.

Several methods are introduced in the paper to resolve the complexity issue in a
learning environment. Though complexity is essential, it is also necessary to accommodate different levels of learners fulfilling their specific learning needs. One method is to build multiple levels of complexity in a learning program. Additionally, strategically embedded challenges in a learning program can be used to elicit high levels of association with prior knowledge to ensure the designated level of complexity for the learners. In regards of the multiple perspective issue, it is necessary to represent the complex nature of real world situations in a learning program by providing multiple solutions under different circumstances as well as in various degrees of optimal level.

The conceptual model built, which integrates all the four contextual issues, shows both their interrelationships and measurement variables toward learning effectiveness for better learning outcomes. The model is an attempt to establish a generic framework, which would not only be acceptable by researchers and practitioners, but also be applicable to various domains. Though the model is yet to be tested, validated, and refined, it provides valuable insight toward CBL in the contextual aspect, and also paves the way for future research in CBL. Particularly, it describes the intervening effects among the four issues during the selection of a topic for CBL development as well as during the development period. For further research, besides the validation and refinement of the model, learner issues such as learner control, online learning support and navigation also need to be thoroughly investigated and be incorporated into the model to build a complete generic CBL framework.

References


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Theme: Crafting Learning Within Context

For many years now, researchers and practitioners have advocated views of learning as happening within various forms of contexts such as those embodying problem-based, scenario-based, cognitive, meta-cognitive, social, linguistic, cultural, artefact, and authentic task elements. The conference theme focuses on the crafting of such learning experiences enabled or mediated by technology that enacts authentic contexts for the learning and doing to take place. We especially welcome papers that study the contextualization and the concretization of learning.