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Teaching Model of Integrating Constructivist& Sociocultural Learning Principles and Information & Communication Technology

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Abstract

This paper presents the development and evaluation of a pedagogic model which integrates information communication technology (ICT) and constructivist& sociocultural learning principles in teaching. In the model, ICT is a tool which offers considerable learning flexibilities. It supports internal learning processes (creation and self-organisation of knowledge - cognitive constructivism) and promotes interaction (social processes of learning–sociocultural views).

The model had been developed based on these principles and subsequently evaluated by New Zealand and Vietnamese experts in science education. The pedagogic model, informed by the experts' views, reflected the nature of learning and the role of ICT. The strong points of this model from the experts' perspective were (1) a reasonable pedagogic framework which includes the individual and social aspects of learning, (2) the role of ICT in the model, and (3) the pedagogic value of the model. The experts also advised changes to improve the model. Based on experts' advice, one important adjustment had been made: sociocultural views were employed as a foundation for the social aspect of learning in the model.

The revised pedagogic model has been implemented into an undergraduate physics course. A comparison on test scores of the experimental group and the control group showed that the experimental group test score was statistically significantly higher than the control group test score (effect size was large). It is recommended that this pedagogic model should be trialled in a variety of educational contexts.

Keywords: Information communication technology, constructivism, sociocultural, pedagogic model, teaching, Physics.

1. Introduction

Human beings have never experienced the proliferating development of information communication technology (ICT) as in the last 50 years. The implementation of ICT in education has significantly impacted teaching and learning. Since the 1960s and 1970s,printed material, slides, audiotapes, videotapes and computer-based learning as forms of ICT have been utilized in education (Caladine, 2008; Ipek, Izciler, & Baturay, 2008; Nippers, 1989).These technological teaching aids were used in the provision of learning materials in the classroom and in distance education in this early stage.

In the late 1980s and 1990s, the numbers of personal computers and access to the Internet resulted in significant changes in the implementation of ICT in education: ICT developed from learning resources into tools to facilitate interaction and collaboration (Caladine, 2008; Taylor, 1995). Learning management systems such as Blackboard and WebCT became widespread. The implementation of online interactive multimedia, internet based access to resources, computer mediated communications, automated response systems, and campus portal access provided a highly interactive and flexible learning environment for learners.

Following the trend of applying ICT in education, Vietnam's Ministry of Education and Training set an important goal for educational reform: implementing information communication technologies (ICT) to promote teaching and learning ("Luật Giáo dục [Education law] (Vietnam)," 1998; "Nghị quyết 14/2005/NQ-CP về đổi mới cơ bản và toàn diện giáo dục đại học Việt Nam giai đoạn 2006 - 2020 [The resolution no. 14/2005/NQ-CP on fundermental and comprehensive higher education reform in Vietnam for the period of 2006 – 2020] (Vietnam)," 2005). ICT is becoming integrated into education; this integration is top-down and is being applied on a large scale. Emerging from this reform, an important issue arose in that the applications of ICT have not resulted in the expected pedagogic effectiveness. Teachers seem to focus more on the use of technology itself rather than the pedagogies of implementation (using ICT to promote students' learning) (Farrell & Wachholz, 2003; Peeraer & Van Petegem, 2011). It is argued by Harman and Nguyen (2010) that Vietnamese teachers are now facing the challenges of technology-driven education; the critical need for teachers in this context is to acquire new understanding and skills in using ICT to support teaching in the light of a student-centred approach. However, there is very little literature which could inform Vietnamese teachers on how to use ICT underpinned by a student-centred approach in their teaching context.

1.1 Seeking a Suitable Model

A range of models for using ICT in education has been reviewed, and their utility has been examined. The reviewed models generally can be categorised into two main groups based on their utility. The first group of models focus on the implementation of ICT at an institutional level. Examples of this group are:

- 4-E Model (Collis, Peters, & Pals, 2001)
- ICT implementation models (Mooij, 2009)

The second group focus on the implementation of ICT at individual level. The examples of models that belong to this group include:

- TPCK Model (Mishra & Koehler, 2006)
- The generic model (Wang, 2008)

The first group of models such as the 4-E Models and the ICT implementation models focus on the institutional level. The 4-E Model (Collis et al., 2001) presents four factors (four Es) that are considered to be most influential in the educational use of new technology: effectiveness, ease of use, environment and engagement. The Es can be expressed as four vectors. The higher the vector sum of the four Es, the greater chance that people will apply new ICT in their learning and teaching context (Collis & Moonen, 2001). The ICT implementation models, which is suggested by Mooij (2009), include five models. Each model focuses on intervention conditions (i.e. dissatisfaction with status quo, knowledge, resources, time, rewards, participation, commitment and leadership) and the appropriated actions relating to the condition.

These models appear to be useful for managers and policy makers who want to promote a network implementation of ICT in their institutions or countries. However, they do not seem to meet the needs of Vietnamese teachers who are seeking a theoretical framework to guide the efficient implementation of ICT in their daily teaching. They need to understand the nature of learning and use ICT to support learning effectively. These models do not explain these issues.

The second group of models focuses on individual teacher level. The TPCK Model, for example,(Mishra & Koehler, 2006) describes the inter-relationships between content, pedagogy and technology, and then emphasises the importance of knowledge about the three areas in developing effective teaching. Knowledge of content (C) in the model is an understanding about subject matter; pedagogical knowledge (P) is knowledge about teaching and learning; and technology knowledge (T) involves the awareness of and skills in operating. Technology pedagogical content knowledge is the knowledge of how to teach a subject using technology pedagogically. The TPCK Model is a valuable guideline for pre-service teacher training and teacher professional development. Nevertheless, the model does not provide specific and detailed guides for Vietnamese teachers who need a framework for applying ICT.

Another example from the second group is the generic model which consists of three components (i.e. technology, pedagogy and social interaction). The ideas from the model could be useful for this research include social interaction and constructivism as theory foundations. The genetic model informs teachers with guideline for designing an interactive learning environment:

> *"As a practical guideline, the design of the three components of the model can focus on learner–content, learner–people, and learner–interface interaction, respectively. For instance, the pedagogical design of an interactive learning environment can (1) make content meaningful, authentic, and relevant to learners and (2) allow learners to add further resources to share in addition to those suggested by a teacher. The social design of a learning environment ought to (1) involve more authentic tasks, group work, or project-based learning to promote interaction with peers, teachers and other experts, and (2) involve both synchronous and asynchronous communication, which can be implemented in forms of text, verbal chat or visual exchange."*
>
> (Wang, 2008, p. 414)

The TPCK Model is a standard guideline for teachers' professional development; the 4-E Model and the ICT implementation models of Mooij tend to be effective at institutional level. The models are functional; however, they do not meet the goal of this research.

The ideas from the above guideline of the generic model are valuable for this research. The generic model supports students in socially constructing their own knowledge through social interactions. This model acknowledges individual differences; however, does not explain how technology supports students to individually construct their knowledge.

1.2 Why constructivist learning principles should be employed in the pedagogic model

As mentioned earlier, there is a need for Vietnamese teachers to have a pedagogic model to help them implement ICT in their teaching. Constructivist learning principles are chosen to underpin the use of ICT in the model for two main reasons.

The first reason is the current research from a range of countries which suggests that the applications of ICT in education, based on constructivist learning principles, can effectively enhance students' learning generally (Al-Fadhli & Khalfan, 2009; Beenakfer et al., 2004; Christina & Dimitrios, 2008; Driver, 1988; Driver & Scott, 1996; Ozkal, Tekkaya, Cakiroglu, & Sungur, 2009; Rovai, 2004; Wang, 2009), and students' physics learning specifically (Driver & Scott, 1996; Fazio, Sperandeo-Mineo, & Tarantino, 2004; Iofciu, Miron, & Antohe, October, 2011; Rodrigues, Pearce, & Livett, 2001; Soong & Mercer, 2011; Tekos & Solomonidou, 2009; Wang, 2009). In addition, the integration between constructivist principles and the use of ICT is able to promote students' thinking skills (Al-Fadhli & Khalfan, 2009; Wegerif, 2002).

The second reason for constructivist learning principles to be employed in the model is that the pedagogy currently underpinning the ICT applications of Vietnamese tertiary teachers appears to be related to constructivism (Nguyen, William, Nguyen, Nguyen, & Chantaranima, 2012). MS PowerPoint, MS Word and some simulation software are very commonly and frequently used in courses in Vietnamese universities while ICT applications such as learning resources and communication to support learning (except e-mail) are not regularly used by teachers (Nguyen, Williams, & Nguyen, 2012; Peeraer & Van Petegem, 2011). The purpose of using MS PowerPoint and other software is to simulate and help students to visualise natural phenomena and experiments.Nguyen, Williams, et al. (2012) indicate that the pedagogical view underpinning the ICT applications in Vietnamese Physics undergraduate courses seems to be associated with a cognitive constructivist perspective which emphasizes students individually constructing their own knowledge.

Constructivist learning principles appear to be appropriate for a pedagogic model of integrating ICT in teaching and learning. Moreover, Vietnamese teachers' pedagogy of using ICT in teaching seems to relate to a cognitive constructivist perspective. One important factor for implementing successfully a pedagogic model into a Vietnamese university context is that the model has elements that are familiar to Vietnamese lecturers. For these two main reasons, constructivist learning principles are utilized in the pedagogic model.

This paper will present the development of a model which integrates constructivist learning principles and ICT in teaching. It begins with the development of a theoretical foundation based on the key concepts: constructivism and ICT, then each element of the model will be described. The feedback from experts is presented and critiqued, and concludes with a revised model. The implementation of the revised model and the evaluation on this implementation will be then explained. Finally, a conclusion and discussion will end the paper.

2. Literature Review on Constructivism and ICT

2.1 Constructivism

Constructivism is a theory about the cognition of human beings. There are two major approaches of constructivism: cognitive constructivism and social constructivism. These approaches each reflect a fundamental aspect of human cognitive processes: internal re-organising of the cognitive system and meaning making through social interaction. The following sections will develop the notions of cognitive constructivism initiated by Piaget and social constructivism originating from Vygotsky.

2.2 Cognitive Constructivism

The original conception of constructivism comes from GiambattistaVico, an Italian philosopher, humanist, and rhetorical theorist who was born in the 1600s. The fundamental idea of Vico's is that human beings only know the knowledge which they have constructed, and from Vico's perspective, to know means to know how to make or how to create. Two centuries after Vico's time, Piaget significantly advanced constructivist theory. According to Piaget, knowing is constructing and reconstructing knowledge. To know also means to produce in thought. The cognition process is the "optimizing equilibration" which brings us from "equilibrium" to new "equilibrium" (Bettencourt, 1993). This process may result in confirming or changing existing knowledge. Piaget stated that *schemes* (concepts, models, or patterns) were created by *assimilation* and *accommodation*. When confronting experience, human beings tend to judge the schemes, ignore the differences, assimilate and bring them under a category. Then the schemes become *assimilations*. When the assimilations are made, they are used many times. Three consequences of the repeated assimilations are the generalization and flexibility of the schemes, the integration of different schemes, and problems. When the problems appear, human beings start to notice the differences and make consequent perturbations in cognitive activities. Based on concepts, models and patterns, they generate new solutions repeatedly until the new schemes encompass expected results. In this way, the schemes have been *accommodated*. Piaget stated that assimilation and accommodation, which were vital for interaction between human beings and their environment in learning processes, led to a new equilibrium of knowledge.

Piaget emphasised the inner process by which a human being constructs his/her own knowledge. Though social interaction sometimes happens, the schemes are constructed mainly by personal experiences (Powell & Kalina, 2009). The constructivist theory which focused on the individual constructing knowledge is called cognitive constructivism. Human beings live in society, and this social environment strongly influences them and their learning, therefore the social factors should also be taken into account during the knowledge construction process.

2.3 Social Constructivism

The concept of social constructivism was developed originally by Vygotsky (Powell & Kalina, 2009). In social constructivism, collaboration and social interaction play a very important role in the process by which

learners actively construct knowledge. This is the social process of creating perturbations based on existing experience (Tobin & Tippins, 1993). The creation of perturbations leads to a new equilibrium state where new knowledge fits with prior knowledge.

In learning processes, social interaction greatly affects learners and their learning. Teachers promote students' learning by providing them with opportunities to collaborate with others, to solve problems and to present their work, knowledge and skills to others. Teachers design learning tasks which direct learners' thinking and activities. Teachers play the roles of supporters, mentors or guides who foster students' learning. Students play the active roles, construct their own knowledge and skills through social interaction, and so are the centres of learning processes. From the social constructivist perspective, students collaborate, share information, negotiate with each other and consequently make meaning.

Cognitive constructivism focuses on how human beings as individuals construct knowledge; social factors are acknowledged but not deeply investigated. In contrast, social collaboration and interaction play a central role in social constructivism; understanding occurs through social activities. Learning is a process involving both the learners' social interaction and their personal critical thinking process. Therefore, social constructivism and cognitive constructivism are two vital aspects of the learning process; they have a mutual relationship and cannot be separated (Powell & Kalina, 2009).

2.4 Information and Communication Technology and Learning

Information and communication technology (ICT) is defined by UNESCO as forms of technology used for creating, displaying, storing, manipulating, and exchanging information (Meleisea, 2007). ICT in general consists of computers, networks, learning management systems, e-mail, internet, telephone, television and radio.

ICT embraces many forms of technology. The focus of ICT in this study is the use of internet, software, multimedia resources, course management systems and computer-based testing systems in education. The applications of ICT are categorised into three groups represented in Table 1: learning resources, instructional organisation of learning and communication.

Table .1 The application of ICT in this Study

Categories	The applications of ICT
Learning resources	• Educational software • Distributed resources via the internet • Video resources
Instructional organisation of learning	• Software and technology tools supporting face-to-face lectures • Course management system • Computer-based testing system
Communication	• E-mail system • Websitesoffering communication options for the direct sending for e-mail and forms of structured communication • Software system for text-based chat

(Collis & Moonen, 2001)

3.Research Questions

The research in this paper aims the development and evaluation of a model that incorporates information and communication technologies into a teaching environment according to constructivist principles. The research questions therefore are:

1. What are the elements of a teaching model which represents the incorporation of ICT into a constructivist framework?
2. How does the application of the teaching model impact students' Physics test results?

4. Methodology

The methodology involved a search of relevant literature to select appropriate ICT applications and to develop a theoretical framework for the model. A trial model was then developed and subjected to critique by a number of experts. This critique was evaluated and as a result changes were made to the original model. The revised model was then implemented into a Vietnamese context; the impact of the revised model on students' physics learning was investigated. This structure is represented in Figure 1.

The research framework included two phases relating to two research questions: Model development and model implementation. The Model Development Phase which addressed the first research question started with a literature review and context analysis. Current literature and research on constructivism, ICT, Physics learning and teaching were reviewed. The context of Vietnam was also considered. Based on the literature review and context analysis, a pedagogical model was developed. Experts in science education were invited to examine the pedagogical model, and revision was made based on the experts' evaluation. The teaching model was applied into an undergraduate Physics course in Vietnam. About ninety students participated in this intervention. The impact of the model was examined by comparing the Physics test result of the experimental group and the result of the control group. The findings from this phase of the research answer the second research question.

4.1 Theoretical Framework

Based on current literature, a pedagogic theoretical framework has been created. The framework is built on two constructivist learning principles, one of which originates from cognitive constructivism; the other from social constructivism. The first version of the framework was named the theoretical model which integrates constructivist learning principles and ICT. While 2. Literature Review on Constructivism and ICT section provided basic ideas on constructivism and ICT, this section will focus on explaining relationship among the components of the framework.

Knowledge, from the constructivist perspective, cannot be transferred from teachers to students but is constructed by students as individuals in a social environment. This environment includes books, reading materials, learning tasks, curricula, teachers, peers and learning supporting tools (e.g. computers, experimental equipment, films, software and online course management system) (von Glasersfeld, 2005).

Figure 2 presents the first version of a theoretical model which integrates constructivist learning principles and ICT. In general, the nature of learning can be enlightened by cognitive and social constructivist points of view in the case where learning means creating and self-organising knowledge (cognitive constructivism), and learning is a social process of interaction and making meaning (social constructivism). Moreover, leaning is facilitated by tools, and ICT is one important tool which offers considerable learning flexibilities. By providing several options for students, ICT can be considered an effective means to support internal learning processes (individual aspect of learning) and as a powerful tool to promote collaboration and interaction (social aspect of learning). The following section will explain the model in detail. Some elements of the framework in Figure 2 will be presented again in order to specifically identify the appropriate parts in the model.

Learning, which is in the centre of the diagram, consists of two aspects, individual and social. The nature of learning in the personal aspect is explained by cognitive constructivism; and in the social aspect by social constructivism.

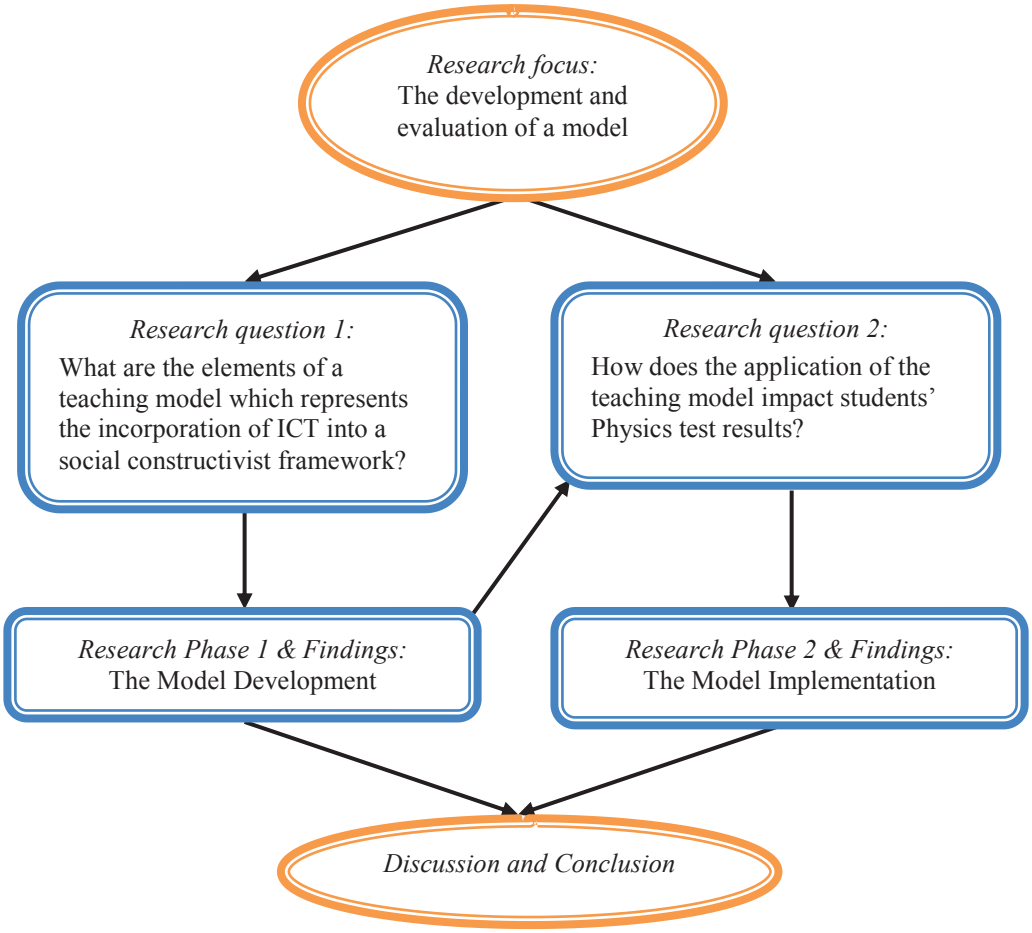
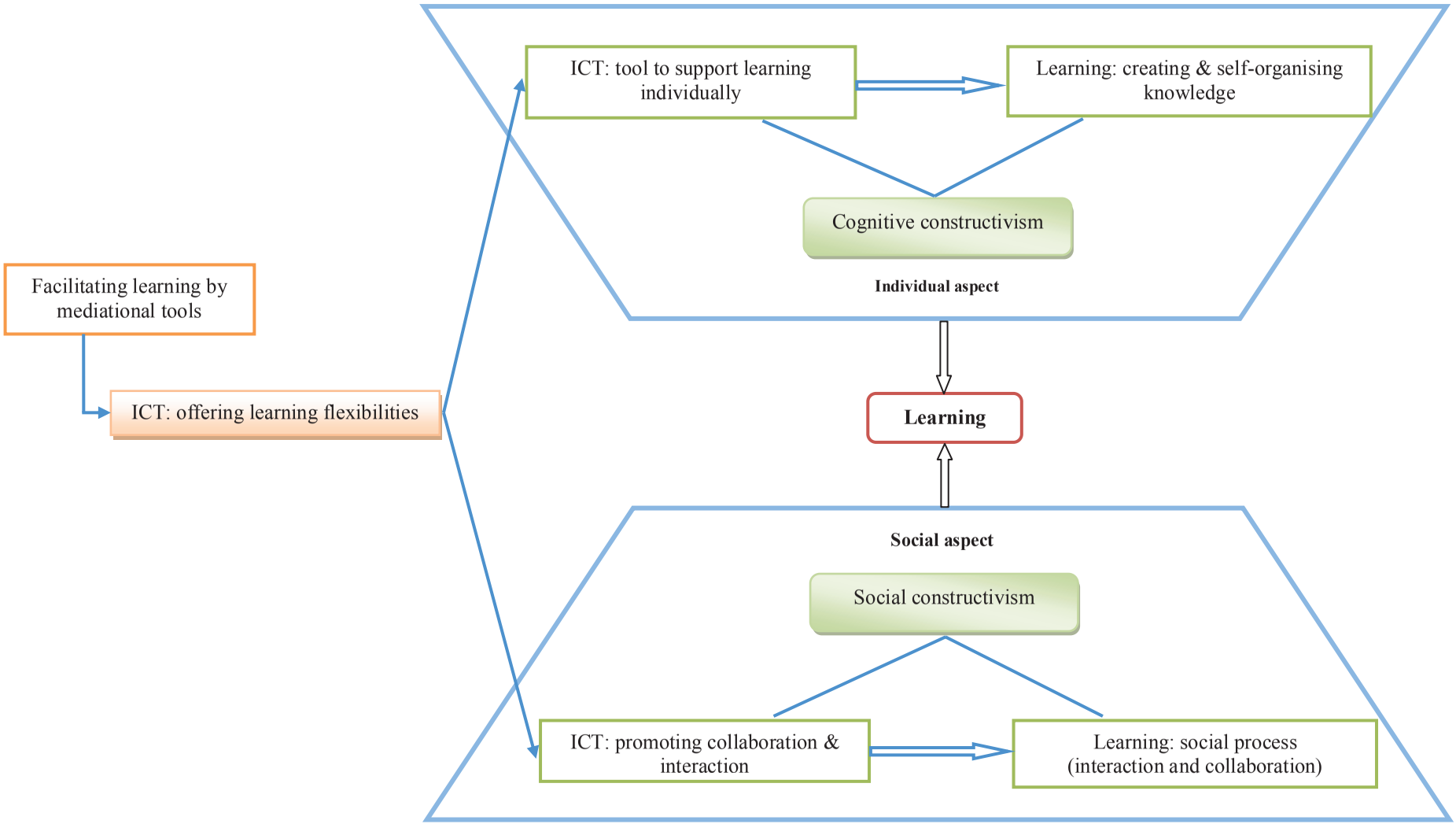


Figure 1 The Research Framework


ICT: tool to support learning individually
Learning: creating & self-organising knowledge
Cognitive constructivism
Individual aspect
Facilitating learning by mediational tools
ICT: offering learning flexibilities
Learning
Social aspect
Social constructivism
ICT: promoting collaboration & interaction
Learning: social process (interaction and collaboration)

4.2 Constructivist Learning Principles in the Model

The first constructivist principle is that learning is development which requires learners to create and to self-organise their knowledge(Fosnot & Perry, 2005). The first principle, illustrated in Figure 3 concerns human internal processes of constructing knowledge (cognitive constructivism). Learning normally starts by observing or experiencing, continues with making meaning and relating current experiences to cognitive systems which learners have already developed. Learners then integrate or differentiate the new knowledge; a new balance (accommodation) in their cognitive system is formed. Based on this nature of learning, educators can facilitate students' learning by offering them as many opportunities to observe and to experience as possible in a learning context. The teaching content should be based on learners' prior knowledge. Teachers need to provide the appropriate help so that learners can relate new cognition to prior cognitive systems, then make the accommodation change and so enrich their understanding.

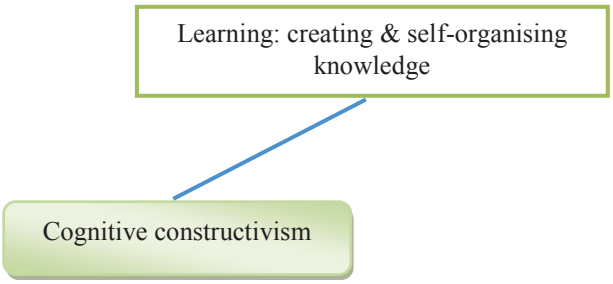


Figure 2 Constructivist Principle One

The second constructivist learning principle is that learning is a social process (Tobin & Tippins, 1993). Individuals construct their understandings in social settings. While the first principle focuses on the personal cognition component of the learning process, the second principle is directed at the social component of learning (social constructivism). Social interaction between learner-learner and between learner-teacher plays an important role in the learning process (Figure 4). Students should be provided with a supportive, open and interactive environment which helps them discover knowledge. This learning environment facilitates learners to generate as many of their own hypotheses, models and ideas as possible, including both affirmative and contradictory possibilities. Moreover, the learning environment encourages students to present, discuss, negotiate their points of view with the community, test their hypotheses, models or their possibilities, and find out the viability of their ideas (viable knowledge).

Learning, from a cognitive constructivist point of view, is a process of creating a new balance of cognitive system and re-organising knowledge; and, from a social constructivist perspective, a social process of interaction and meaning making. Learning is the process involving both learners' social interaction and their personal thinking process; as a result, the two elements in the diagram have a mutual relationship, exist together and cannot be separated from each other.

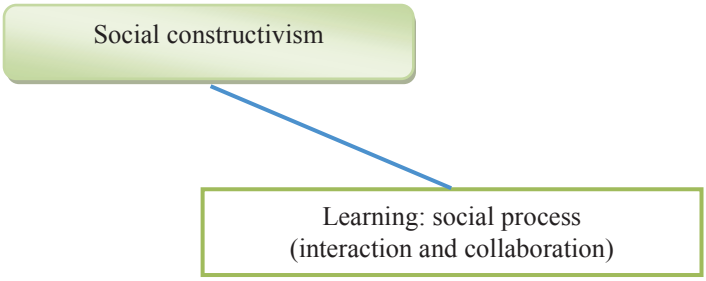


Figure 3 Constructivist Principle Two

4.3 ICT Facilitating Learning

Learning is facilitated by mediational tools (Figure 5), such as signs, diagrams, language, experimental equipment, technical tools and technology (Daniels, 2008). The tools are powerful means to enhance learning processes by directing thinking and shaping actions. The mediational tools can stimulate learners to construct their own knowledge in a social context if teachers use them effectively. For the purpose of the study, the tool "information communication technology" will be a focus.

A flexible learning environment usually means distance learning in common ways of thinking, yet flexible learning relates to the provision of choice for students related to time, topics and learning materials. Places where learners contact teachers and other learners are just one dimension of flexibility.

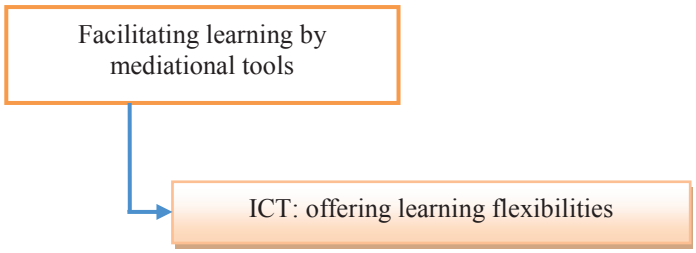


Figure 4 Mediational Tools

Collis and Moonen(2001) state that flexibility in learning concerns a variety of options for learners in the learning environment. In the current research, ICT is used to diversify options for students in terms of learning resources, instructional organisation of learning and communication. In addition, ICT is applied to support learners' choices in social organisations of learning and languages.

First, learners are provided with a wide range of learning resources, including traditional resources (e.g. textbook, library resources) and ICT resources (e.g. educational software, rich internet based resources and video resources). The flexibility in learning resources connects with three dimensions: topics, key learning materials and learning resources.

Second, the instructional organisation of learning becomes more flexible since face-to-face lectures, a course management system and a computer-based testing system are integrated. Software and technology tools are implemented in face-to-face lectures. The integration of face-to-face lectures, a course management system and a computer-based testing system provides learners with many alternatives for submitting assignments and interacting within a course. This integration permits them to decide on the pace of study, to choose the instructional organisation of learning (i.e. face-to-face and online), and the time and place to contact teachers and other learners (i.e. in classes at fix time or off campus during weekdays). Moreover, the application of ICT gives students choices of methods and technology for obtaining support and making contact.

Third, the implementation of ICT offers different methods of communication such as face-to-face, e-mail, chat, forum and social networking websites. It enhances flexibility of social organisation of learning and time, location and methods of interacting.

Last, students explore various alternatives of social organisations of learning and languages. ICT actively promotes communication; therefore, it effectively fosters different kinds of social organisations of learning (e.g. working in groups, working individually and in combination). Rich learning resources, including ICT, are also in different languages so students can choose languages which are appropriate for them.

By providing several options of learning resources, instructional organisation, communication, social organisation of learning and language, ICT has the potential to effectively facilitate learning. It can be a tool for individuals to create and self-organise knowledge and also a tool for learning by promoting collaboration and interaction.

ICT, from a cognitive constructivist point of view, is a tool for learners to construct knowledge individually (see Figure 6). As discussed above, learning from a cognitive constructivist perspective is the process of self-organising knowledge. Learners experience, make assimilation and accommodation, and then gain a new equilibrium of cognition. ICT is a means for internalising knowledge. For example, ICT offers rich learning material and resources including texts, photos, audio, video and software; hence, learners can observe new phenomena and experience in a supportive environment. Furthermore, software that is used to draw mind maps (e.g. MINDMAP, SmartDraw and FreeMind) can be an effective tool for students to organise ideas and refine their system of cognition.

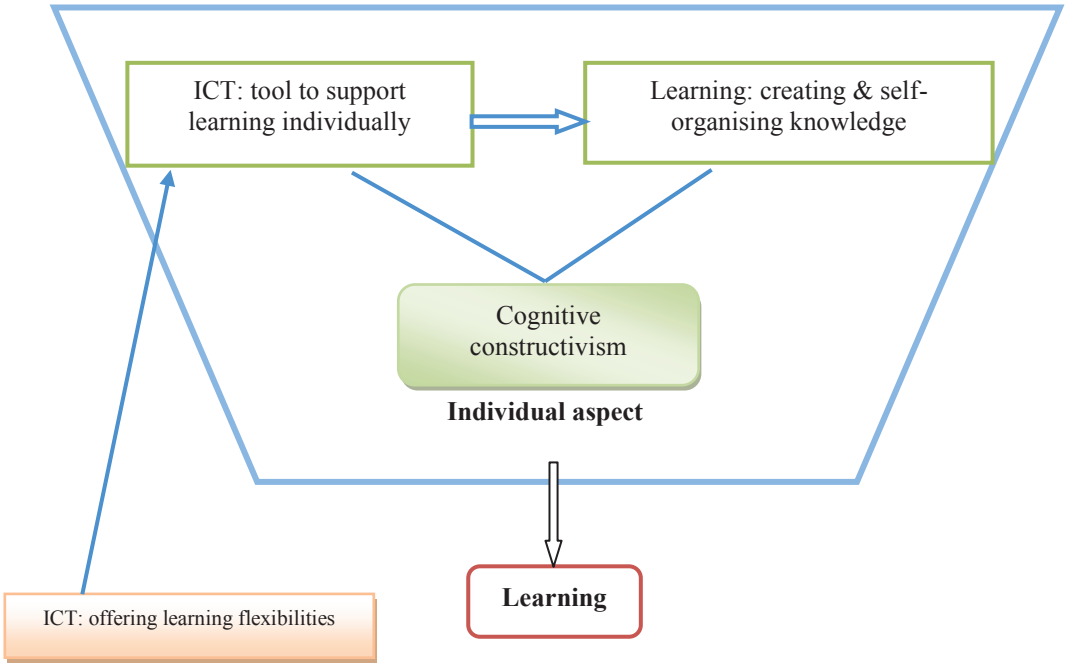


Figure 5. ICT Supporting the Individual Aspect of Learning

4.4 ICT and Collaboration and Interaction

ICT stimulates interaction by providing a supportive and encouraging communication environment (see Figure 7). That ICT offers different and convenient ways of interaction has been mentioned above. Two types of interaction will be examined: students-teacher interaction and interaction between students.

Interaction between the teacher and the learner plays a crucial role in learning processes. That teachers design curricula, content knowledge, lesson plans, learning materials and learning activities creates a learning environment for students to interact with and make meaning. ICT is a powerful tool for teachers to design the interactive learning environment, to facilitate learning by answering questions, mentoring, scaffolding, giving

feedback and so on. Learners can interact and get support from educators in different ways, such as face-to-face, email, chat and forums.

ICT provides flexibility in methods of communication and so collaboration among learners is also enhanced. More flexible communication can foster more collaboration. The application of ICT may provide an interactive learning environment in which students explain and share ideas or hypotheses, justify them, argue or negotiate, and consequently build new knowledge.

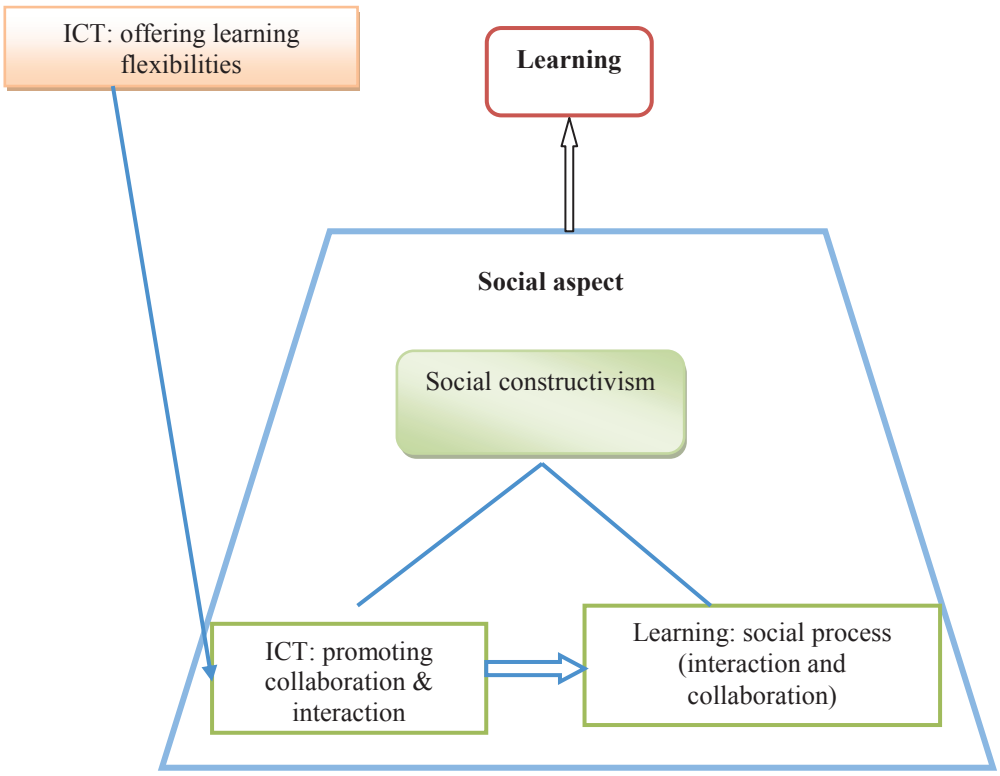


Figure 6. ICT Supporting the Social Aspect of Learning

In general, the internal re-organising of knowledge and construction of understanding in a social context is assisted by mediational tools (e.g. equipment of experiments and ICT). ICT that is considered as a type of mediational tool provides learning flexibilities on learning resources, instructional organisation of learning, communication, social organisation of learning and language. By offering flexibility, ICT promotes interaction and individuals' learning activities. That ICT is used as a tool to support individuals' learning connects to notions of cognitive constructivism, while ICT which fosters interaction and collaboration relates to social constructivism.

5. Research Phase 1: The Model Development

Experts in science education were invited to examine the pedagogic model and its underlying principles. The objectives of the expert-evaluation were: (1) to determine to what extent the model is suitable for teaching, and (2) to ensure it is valid in its representation of the theoretical framework. Two New Zealand experts and a Vietnamese expert evaluated and gave feedback on the model. The New Zealand experts were renowned in science education and have significant expertise in teaching and learning science, and integrating ICT in teaching. The Vietnamese expert, who understand the study context, was an experienced Physics senior lecturer and also a vice-head of the School of Education at a university in Vietnam. The aim of inviting the experts from different backgrounds to evaluate the model was to help ensure the validity of the model through a form of investigator

triangulation. The experts noted the strengths of the model and suggested some changes in order to improve the pedagogic model. This section will analyse the experts' feedback on advantages of the model and their suggestion for the revision.

5.1 Findings on Expert Evaluation of the Model

The pedagogic model, from the experts' views, reflects the nature of learning and the role of ICT. A synthesis of the experts' feedback suggests that the model has main strengths.

First, the model provides a reasonable pedagogic framework which includes the individual and social aspects of learning. It was commented that "*it [the model] does provide a reasonable framework in which to proceed*," and "*strong points are around the attempt to include the cognitive as well as the social*". This evaluation is also supported by other research (Bell, 2005; Cobb, 1994; Powell & Kalina, 2009).

> The role of ICT in the model was considered a second strong point by the experts, who stated:
> *A remarkable point in this model is that the research has exploited the role and effectiveness of ICT. ICT has actively supported learning processes of students; and the value of the model has been proven by the use of ICT in learning and teaching in the current context.... [The model] has efficiently exploited the strong points of ICT in teaching and learning. The strong points are around the attempt to include ... the role that ICT might play.*

> Third, the pedagogic value of the model seems to be appreciated; for example:
> *[The pedagogic model] promotes the role of learning, regarding the student-centred approach, and is very appropriate for the current educational context where information is proliferating.*
> *[The model encourages] the acquisition of self-learning, problem-solving and cooperation skills for learners.*

The idea, reflected in the pedagogic model, that learning involves both the social and personal construction of knowledge, was appreciated by the New Zealand experts. Whilst the Vietnamese expert was more inclined to value its appropriateness to the education context: proliferation of information and a student-centred approach. The role of ICT in the model was considered worthwhile by experts from both cultures. Apart from the strengths of the model, the experts also pointed out its limitations. It was commented that the use of the phrase" learning is a social process" might imply that thinking and language were the same thing from a discursive view. It was presented in the model that language as a meditational tool differs from thinking itself. It was recommended that this phrase should be changed to make its meaning clearer. According to the experts, the rationale for the social aspect of learning could be improved. It was advised that the social aspect of the model should regard students' agency and identity:

> *The section on the social aspects could be strengthened to include the background of the students in terms of identity and agency.*
> *The model can be applied if the following condition is satisfied: learners' attitude; learners deem learning as their own responsibility, and they learn actively and spontaneously under the guide of teachers.*

Moreover, on the social aspect, the model seemed to focus on collaboration, rather than cognition processes. "The weaknesses are that the social aspects of learning are underplayed and tend to be related to collaboration rather than ways of knowing and coming to know", stated one of the experts.

On the individual aspect, it was explained that "learning normally starts by observing or experiencing" and "educators can facilitate student learning by offering them as many opportunities to observe and to experience in a learning context". One expert argued that the explanation concentrated on physical stimuli and disregarded social stimuli. It was suggested that the model could be improved by including sociocultural views.

The Vietnamese expert commented that the model seemed to ignore the teachers' role. Although the role of students was the centre of learning processes, the important role of teachers should be taken into account. The researcher also considered that the role of the teacher was essential, and that this view was not seen to be adequately emphasized.

One expert mentioned that, besides students' attitudes, two other conditions for applying the model were the development of ICT and teachers' competencies. Teachers' competencies included subject matter knowledge, pedagogic knowledge, and abilities to organise and control students' learning activities. The expert claimed that competencies could be developed by teachers' training programmes which were designed in the light of learner-centred approach. The programmes should focus on encouraging active learning, fostering self-learning and problem solving skills. To improve the competencies of the current teachers, workshops and conferences on constructivism could be organised.

In summary, from the experts' views, the pedagogic model could be improved in five aspects. The phrase "learning is a social process" should be revised. The social aspect should be strengthened. In addition, the rationale on the individual aspect appeared to emphasise on physical stimuli. Teachers' role seemed to be neglected; and the conditions for implementing ICT in teaching such as infrastructure and teachers' competencies needed to be mentioned. The following sections will share a critique on the comments and will present the revision of the pedagogic model based on experts' comments.

5.2 Critique of Model Evaluation by Experts

On the individual aspects of the model, it was explained that "learning normally starts by observing or experiencing" and "educators can facilitate students by offering them as many opportunities as possible to observe and to experience in a learning context". One expert argued that the explanation concentrated on physical stimuli and disregarded social stimuli. Nevertheless, the model had included the role of "meditational tools" (e.g. signs, diagrams, language, experimental equipment, technical tools and technology) in the process of the social construction of knowledge. Language and other tools were important for promoting cognition and socially constructing knowledge as well as individually constructing knowledge, which normally began with experiencing and observing. However, the foci of the model were not the use of language and other tools to facilitate learning, but the use of ICT.

One expert suggested focussing on teachers' competencies as a condition for implementing the pedagogic model. Teachers' subject matter and pedagogical competencies were significant in the use and application of ICT. The importance and inter-relationships of subject content knowledge, pedagogy knowledge and technology knowledge, which were mentioned in the expert comments, had been interpreted in the Technological Pedagogical Content Knowledge (TPCK)research(Mishra & Koehler, 2006). The conditions stated in the comment also related to the infrastructure or the development of ICT. ICT infrastructure was certainly important for the use of ICT in teaching. The factors influencing the application of ICT at an institutional level were carefully outlined by Collis and Moonen (2001)

This comment might be useful at the institutional level for leaders, managers, heads of institutions, and deans of faculties who wanted to set up a systematic implementation of ICT in their institutions. However, the goal of the pedagogic model was to propose a theoretical pedagogic framework for teachers to implement ICT efficiently and effectively. The model was in the form of pedagogic booklet which recommended educational strategies for teachers. It did not aim at the implementation of ICT at an institutional level but at the teachers' level. When the infrastructure, policy, support and other factors had been available in some extent, teachers would need a pedagogic model for their integration of ICT in teaching. The current model would provide insights about the nature of learning and the way of using ICT to support learning effectively.

5.3 The Model Revision

After the evaluation and comments from experts were analysed, it was concluded that the model's enhancements will focus on three issues: (1) the use of terms, (2) the social aspect of learning and (3) the discussion on the teachers' role.

First, the phrase "learning is a social process" was imprecise. It was recommended to change it into "learning occurs in social context". This implied that language and thinking were not the same. As a result of the

revision, the two learning principles would be: (1) learning requires learners to create and to self-organise their knowledge, and (2) learning occurs in social context. Furthermore, the model described "ICT: promoting collaboration & interaction"; and the term "collaboration" was not obviously mentioned in the description of the model. For the clarification and simplicity of the pedagogic model, the term "interaction" replaced the term "collaboration & interaction" (see Figure 8). Interaction in this context contained interaction between students – learning materials and learning tasks, between students - teachers and between students - students. "Collaboration" was implied in "interaction" between students.

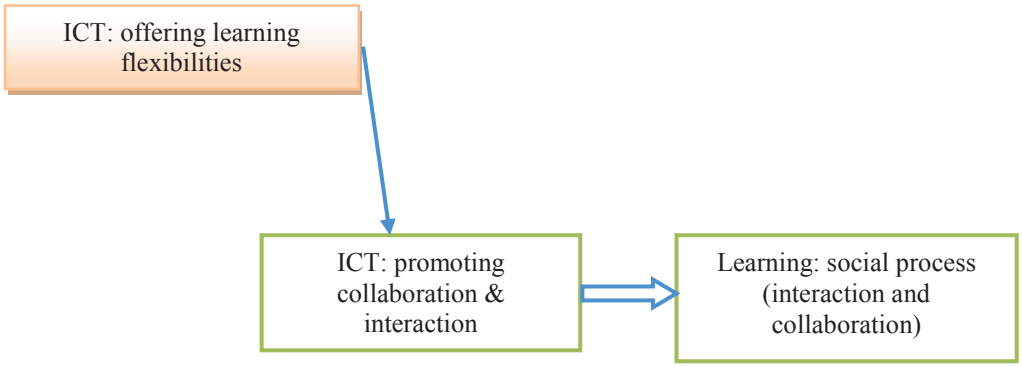


Figure 7 Social Aspect of Learning

The second adjustment was related to the social aspect of learning. Students were considered as agency in a social and cultural context. "They are partially determining and partially determined" (Bell, 2005, p. 42). In addition, the model did not explain explicitly how interaction and collaboration support the social construction of knowledge. It was because of not only the researcher's rationale about how social constructivism can be employed in explaining learning, but also social constructivism itself. Social constructivism emphasised the role of social factors in learning; yet not on how the meditational tools facilitated learning socially.

In contrast, sociocultural views presented in detail how ICT as tools or artefacts and how interaction can enhance learning on social aspect. Bell (2005) discussed three sociocultural views: learning as situated activity, learning as distributed cognition and learning as mediated action. The usefulness of these views for the model was that learning occurs in a social and cultural context(Lave & Wenger, 1991); and knowledge or cognition distributes over the social context, both inside and outside individuals(Pea, 1997; Salomon & Perkins, 1996; Salomon & Perkins, 1998). By employing the artefacts (e.g. signs, diagrams, language, experimental equipment, technical tools and ICT), students interacted with the social settings and co-construct their knowledge. The sociocultural theories were more appropriate for the pedagogic model, especially in terms of the use of ICT as artefacts, so they should be used as a foundation for the social aspect of learning in the model. As a result, the name of the model should be modified as "The Pedagogic Model of Integrating Constructivist & Sociocultural Learning Principles and ICT" (the CSI Model in abbreviation).

The third enrichment of the pedagogic model as a result of the critique was describing more about the teachers' role. Teachers had quite an important position in many Asian cultures, and if it was intended to implement the model in an Asian country, the role of teacher should be taken into consideration.

In conclusion, the feedback of experts was valuable and resulted in clarifications and improvements. The most significant improvement was that sociocultural theories were emphasized in the model. The revised model is presented in Figure 9. Another improvement is the clarifications of teachers' role. Teachers played an essential role in students' learning processes. Teachers designed curriculum, courses and learning tasks. They decided the body of

knowledge and skills, organised learning activities and guided students to learn. Teachers' encouragement and support were important not only for students' learning but also for motivating students in the process of meaning-making. The pedagogic model described the role of ICT in learning, but did not imply that teachers were not important in the model. The role of teachers was vital and cannot be displaced by ICT or any pedagogic models. Teachers were the persons who used the pedagogic model and ICT; and the effectiveness of the model strongly depended on teachers' professional competency.

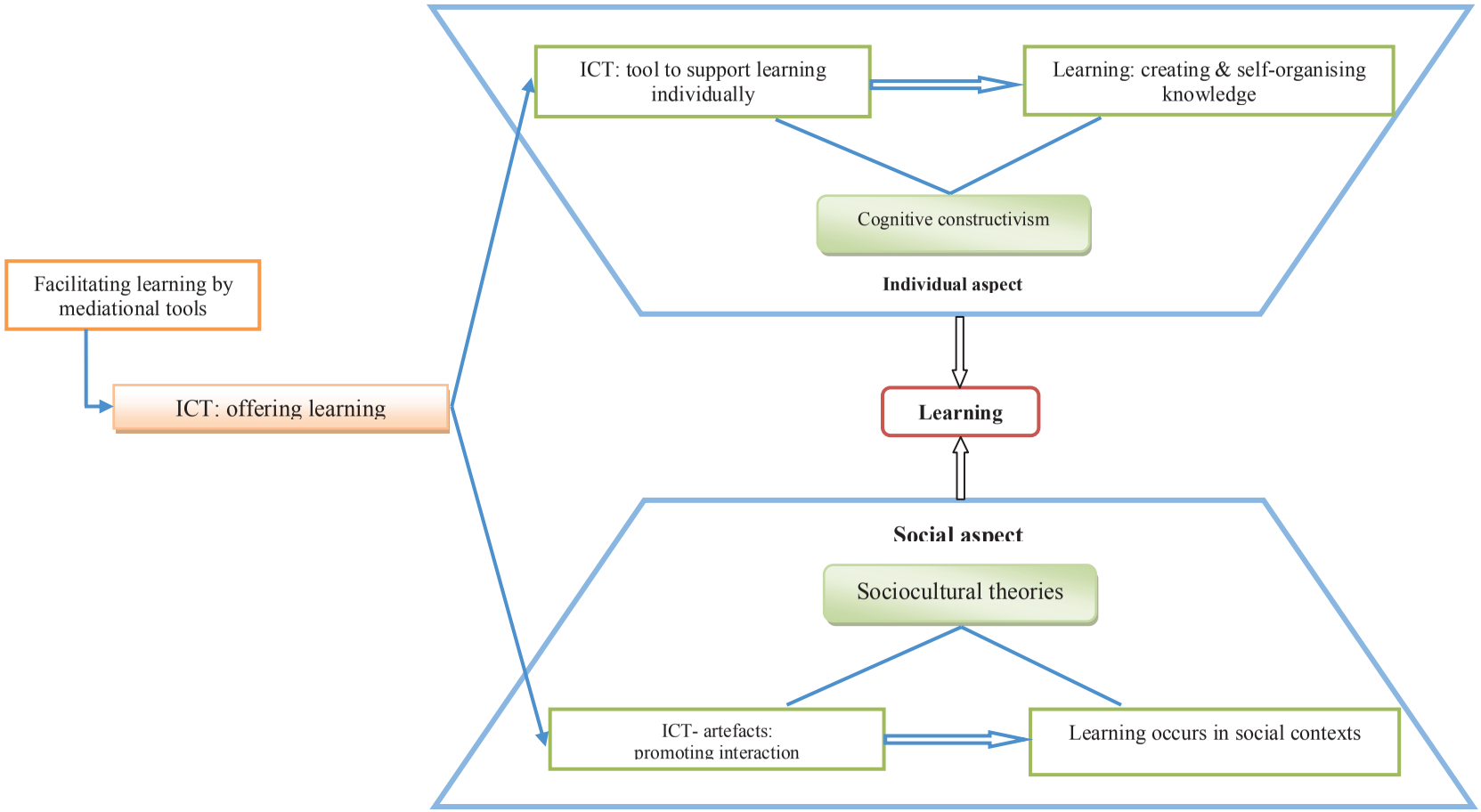


Figure 8The Pedagogic Theoretical Model of Integrating Constructivist, Sociocultural Learning Principles with ICT (the CSI Model)

Although the role of teachers was very important, teachers cannot learn for students or cannot upload knowledge to their brains like to computers. Students had to construct knowledge themselves. This paper will not discuss teachers' role in general but only focus on the role of teachers as facilitators or mediators who help learners construct knowledge. Educational knowledge generally and Physics knowledge particularly have been developed over a long period of time, and its volume is huge. Teachers need to guide students to discover the knowledge and make it meaningful and useful at personal levels.

6.Research Phase 2: The Model Implementation

The CSI Model was implemented by a lecturer in an optics course of a Physics department within a School of Education of a university in Vietnam. The process of finding and inviting a lecturer to be involved in this research included: (1) administering questionnaires to lecturers of the physics department, interview 9 students and 4 lecturers (who were most likely to use ICT in their teaching), (2) identifying lecturers who usually use ICT in teaching and their willingness to implement a new pedagogical framework into teaching practice. As a result of this process, a lecturer was invited to implement the CSI Model.

The lecturer participating in this research had applied some ICT in his teaching. He had required students to use ICT to make PowerPoint presentations for optics topics. The objective of the research is to investigate impacts of the CSI Model on learning. Thus, it was appropriate to invite a lecturer who had utilised ICT in education so that the lecturer can fully concentrate on implementing the model rather than becoming familiar with applying ICT in teaching practice.

The course was delivered over 16 weeks, Semester II of the 2011-2012school year, including one week for orientation and one week for the examination. A quantitative data collection method (Optics tests) has been employed in this research.

To identify if the implementation of the CSI Model had any influence on the students' Optics performance, comparison of test scores of two groups of students were conducted. One group of students, *Group I*, did not experience the intervention of the CSI Model implementation. This group studied the Optics Course in Semester I of school year 2011-2012. The other group, *Group II*, who attended the course in Semester II of the same school year, experienced the implementation of the model. Group I was not disadvantaged in comparison with Group II because this group studied the optics course which was normally provided by the university.

The Optics tests were used to evaluate students' performance at the end of each semester. The Optics test papers included 40 items and were designed by the lecturer. The content of the tests were aimed at the goal of measuring students' understanding on Optics knowledge at the end of semester. The test results of the two groups will be presented in the next section; and suitable statistical test will be then performed to compare the test scores of the students in Group I and Group II.

6.1 Findings on Model Implementation

6.1.1 Optics Test Results of Group I and Group II

Table 2 describes the test results of Group I students and Group II students. There were 58 students in Group I who sat the optics test. The minimum score was 5 (out of 40), maximum score 17. The average of Group I was 11.02 (Standard Deviation (SD) = 2.626).

The number of Group II students, who had experienced the CSI Model implementation and sat the test, was 88. Their scores ranged from 8 to 38 (out of 40). The average score was 23.98 (SD = 7.867).

Table 1 Optics Test Results of Group I and Group II

Group	N	Minimum	Maximum	Mean	SD
Group I	58	5	17	11.02	2.626
Group II*	88	8	38	23.98	7.867

** Group II experienced the CSI Model implementation*

The optics test result indicated clearly that the mean of *Group II* (the experimental group) – 23.98 was higher than the mean of *Group I* – 11.02. However, it was not sure that this difference is statistically significant. To identify if the difference between the means of the groups test scores was statistically significant, a further statistic test was been employed.

There were two types of statistical tests that could be used for comparing the test scores of the two groups: (1) independent samples t-test for normal distribution data or (2) Mann Whitney U test for data did not meet normality assumption(Heiman, 2000). A normality test was performed to examine the distribution of the test scores. If students' test scores meet the assumption of normality, a t-test will be used; if the data from their scores violated this assumption, we will use Mann Whitney U Test alternatively.

6.1.2 Normality Test

The normality of the distribution of the students' optics scores was assessed by using the Kolmogorov-Smirnov Test (K-S Test). Table 3 presents the result of the Kolmogorov-Smirnov statistic. If the significance value (Sig.) is above 0.05 in the K-S test it will indicate normality (Pallant, 2001). It is shown in the table that significance values of the test scores of both groups are less than 0.05; the assumption of normality has been violated. Therefore, Mann Whitney U test should be used to compare the test scores of the two groups.

Table 2 Tests of Normality (Kolmogorov-Smirnov Test)

Group	**Statistic**	**df**	**Sig.**
Group I	.116	58	.049*
Group II	.105	88	.019*

** Significance value (Sig.) above 0.05 indicates normality*

6.1.3 Comparison on Test Scores of Group I Students and Group II Students

Table 4 displays the Mann Whitney U Test. The *significance value* in the Mann Whitney U test presented if the test score difference between the two groups was significant while the calculation of the *effect size* helped to identify how large the difference was. A popular measure of effect size was the Glass rank biserial correlation which was computed as (Gray & Kinnear, 2000):

$$r_g = \frac{2(m_1 - m_2)}{n_1 + n_2}$$

Table 3 Mann Whitney U Test Result

Group	N	Mean Rank	Sum of Ranks
Group I	58	36.09	2093.50
Group II*	88	98.15	8637.50

** Group II experienced the CSI Model implementation*

Mann-Whitney U	382.500
Total N	146
Sig. (2-tailed)	0.000

Where m_1 was the mean rank of Group I, m_2 was the mean rank of Group II. n_1 *and* n_2 were the number of students in Group I and Group II respectively who sat the test.

$$r_g = \frac{2(36.09 - 98.15)}{58 + 88} = -0.850$$

According to Cohen (1988), the size of effect could be interpreted from r_g as below:

$|r_g| < 0.1$: Trivial effect

$0.1 \leq |r_g| < 0.30$: Small effect

$0.30 \leq |r_g| < 0.50$: Medium effect

$0.50 \leq |r_g|$: Large effect

In this case, $|r_g| = 0.850$ was larger than 0.50, which constituted a 'large' effect.

In summary, the mean of Group II Optics test scores (Mean = 23.98, SD = 7.867) was higher than the mean of Group I Optics test scores (Mean = 11.02, SD = 2.626). The Mann-Whitney U test result indicated that this difference was statistically significant (U = 382.500, Sig. = 0.000); and the effect size was 'large' ($|r_g| = 0.850$).

7. Conclusion

As mentioned above, this paper focused on the development and evaluation of the CSI Model. The development process began with reviewing literature on the research area and designing a pedagogic model with consideration of Vietnamese educational context. New Zealand and Vietnamese experts, who had established reputations in the field, evaluated the model and suggested some revision. The revised model was then implemented into an Optics course of a Vietnamese undergraduate program; and the impact of the model was accessed.

In the context of this study, the implementation of the CSI Model has positive effect on students' Physics performance. The findings above show that the test scores of the experimental group (Mean = 23.98, SD = 7.867) were significantly higher than the test scores of the control groups (Mean = 11.02, SD = 2.626); and the effect size was large ($|r_g| = 0.850$). This result is consistent with current literature. The incorporation of ICT into constructivist and sociocultural framework has a positive effect on enhancing students' Physics learning (Al-Fadhli & Khalfan, 2009; Bell, 2005; Christina & Dimitrios, 2008; Wang, 2009).

The application of the model was in a social science context where not all the independent variables can be controlled for, and so it cannot be stated with certainly that that all the variance between the two groups is solely due to the application of the model. However, the effect size is large enough for it to be acceptably concluded that that the application of the model did have a positive effect.

In the Introduction section, this paper addressed the need of a pedagogic model of integrating ICT into Vietnamese teaching practices. The CSI Model seems to be a suitable teaching model for the Vietnamese context.

In fact, the CSI Model has cognitive constructivist components which are familiar to Vietnamese teachers (Nguyen, William, et al., 2012; Peeraer & Van Petegem, 2011). To encourage change, ones commonly begin with the familiar. Change in education is similar. When teachers want to adopt a new teaching model into existing practice, a model with some familiar components will help them apply it into daily teaching more comfortably and it will more likely be their choice.

The CSI Model is a pedagogic model integrating constructivist & sociocultural learning principles and ICT. The result of this research reveals that the CSI model is an effective pedagogic model in this study circumstance. Besides the positive result, a limitation of the current research is that, the research was conducted in just one course in a university. It is recommended to apply this model into variety of educational context such as other subjects, other cultures, different age groups and different countries.

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