Addressing cognitive processes in e-learning: TSOI Hybrid Learning Model

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Abstract: The development of e-learning materials for teaching and learning often needs to be guided by appropriate educational theories or models. As such, this paper provides alternative e-learning design pedagogy, the TSOI Hybrid Learning Model as a pedagogic model for the design of e-learning cognitively in science and chemistry education. This model is hybridized from the Piagetian science learning cycle model and the Kolb's experiential learning cycle. The TSOI Hybrid Learning Model represents learning as a cyclical cognitive process of four phases: translating, sculpting, operationalizing and integrating. A major feature is to promote cognitive processing in the learner for active learning proceeding from inductive to deductive. Design specificity in science and chemistry education is illustrated in terms of instructional storyboarding for the developed research-based e-learning product. Learners' cognitive ability for example positive concept achievement will be addressed as part of the research data collected.

Key words: multimedia learning; e-learning design; learning model; thinking skills

1. Introduction

Research on the nature of learning has proposed various models of learning. Though the Kolb's experiential learning cycle model has been used quite extensively in designing instructional materials to cater to the different learning styles. However, in general, there seems to be an inadequate research of the application of the Kolb's experiential learning cycle model as well as the other models for learning, for example, the Jarvis's model of reflection and learning to the development of e-learning materials (Lisewski & Joyce, 2003; Oliver, 2002). This is more so especially due to lack of practical yet effective design model which can serve as a useful framework for not only organizing but also designing e-learning materials cognitively.

As such, having this in mind, the TSOI Hybrid Learning Model™ & © 2005 All rights reserved can be used as a pedagogic model to address this issue.

2. TSOI Hybrid Learning Model framework

The Piagetian science learning cycle model and the Kolb's experiential learning cycle model are used to shape the conceptual framework of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved. The term hybrid will mean the mixing of two different things to give a better product. The Piagetian science learning cycle

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model being inquiry-based represents an inductive application of information processing models of teaching and learning (Karplus, 1977; Lawson, 1995; Renner & Marek, 1990). It has three phases in a cycle: exploration, concept invention and concept application. The exploration phase focuses on “What did you do”, while the concept invention phase places emphasis on “What did you find out”. The concept application phase entails the application of the concept.

The Kolb’s experiential learning cycle (Kolb, 1984) represents learning as a process in a cycle of four stages, namely, concrete experience, reflective observation, abstract conceptualization and active experimentation. The concrete experience stage is about “doing”, while the reflective observation stage concerns the “understanding the doing”. The abstract conceptualization stage focuses on the “understanding” part and the active experimentation stage is about “doing the understanding”. The core idea in the Kolb’s experiential learning cycle is that learning requires both a grasp or figurative representation of experiences and some transformation of that representation. This experiential learning cycle model has also been used as a framework for organizing interactive multimedia learning activities (His & Agogino, 1994; Tsoi & Goh, 1999; Van Aalst, et al., 1995).

The TSOI Hybrid Learning Model™ & © 2005 All rights reserved represents learning as a cognitive process in a cycle of four phases: translating, sculpting, operationalizing and integrating (Tsoi, 2007; Tsoi, et al., 2004; 2005; 2006). A major feature is to promote active cognitive processing in the learner for meaningful and engaged learning proceeding from inductive to deductive and in so doing also address the learner’s individual learning style. As such, the TSOI Hybrid Learning Model™ & © 2005 All rights reserved, is pedagogically more innovative and comprehensive than each of the original model, namely, the science learning cycle model and the Kolb’s experiential learning cycle model as well as more inclusive as it also encompasses the characteristics of each original model. Figure 1 shows the four phases of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved.

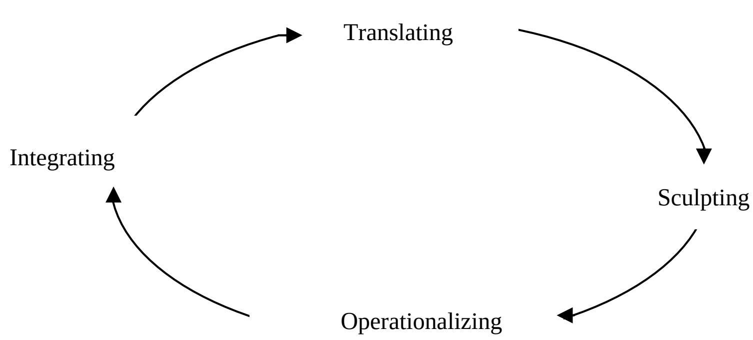

Figure 1 TSOI Hybrid Learning Model™ & © 2005 All rights reserved

The translating phase is similar to the exploration phase of science learning cycle model and the concrete experience stage of Kolb’s experiential learning cycle model. This is where interactive experiences are translated to beginning ideas or concepts to be further engaged in the sculpting phase. The sculpting phase parallels the concept invention phase of science learning cycle model and predominantly the reflective observation stage of the Kolb’s experiential learning cycle including partially the abstract conceptualization stage of the Kolb’s experiential learning cycle. This is where the beginning idea or concept still in its raw form is further moulded to a concrete form that is meaningful to the learner.

The operationalizing phase is similar to predominantly the abstract conceptualization stage of the Kolb’s experiential learning cycle that involves increasing the understandings of the relationship between thinking and concept acquisition. The integrating phase parallels the concept application of science learning cycle model as well as the active experimentation stage of Kolb's experiential learning cycle. This is where the concept is applied to new domains in which the transfer of learning is practiced.

During the first phase, the translating phase, a beginning conceptual understanding is attained from one or more instructional learning activity depending on the nature of the concept. Relevant materials that are not only motivating but also familiar to the learner are incorporated into the design of the instructional learning activity. Such materials include animations and analogies which are used to where appropriate. The translating phase focuses on concept initial awareness.

During the second phase, the sculpting phase, knowledge of the concept is beginning to be constructed based on the learner's facilitated multimedia experiences from the first phase, the translating phase as well as the learner's guided multimedia experiences from the second phase, the sculpting phase. The concept still in its beginning or raw form as taken from the translating phase is logically sculpted or shaped to a more concrete form by a series of appropriate and relevant instructional learning activities that are designed meaningfully to assist the learner to identify the critical attributes of the concept. The sculpting phase emphasizes concept construction for its critical attributes.

During the third phase, the operationalizing phase, the concept formed is internalized for meaningful functionality to allow operability of the concept with existing ideas and concepts. Cognitive processes involved in this phase include using logic, and manipulating abstract symbols. This important phase serves as the vital bridge connecting the sculpting phase and the integrating phase for not only concept formation but also concept internalization in which all the critical attributes of the concept are linked together so as to prepare the learner to be operationally ready for further applications in the integrating phase. The operationalizing phase emphasizes concept internalization for its meaningful functionality.

During the fourth phase, the integrating phase, the concept just learned is applied to new situations as well as is integrated in different contexts in order for meaningful learning to occur. The integrating phase emphasizes concept application for meaningful transfer of knowledge.

Throughout the four phases of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved, the learner is allowed the multiple and varied opportunities to become involved in one's learning and to actively make decisions. In this process of learning, the learner will build on the concrete experience and will learn how to create knowledge and integrate the knowledge with existing ideas and concepts in other context and more importantly, to be an active learner engaged in the various learning processes cognitively.

3. Pedagogical design for e-learning cognitively

For illustration in chemistry education, the mole concept, an abstract and difficult concept is used (Tsoi, et al., 1998). One of the subtopics used is molar volume and molar mass. Since the focus is on designing engaged e-learning, this paper will provide insights on the application of one of the phases namely, the first phase, the translating phase of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved, as an example to demonstrate the active cognitive processes involved in e-learning.

3.1 Overview of the molar volume and molar mass e-learning module

The molar volume and molar mass e-learning module encompasses the following concepts namely, Avogadro's law, molar volume and molar mass, which will lead to forming a quantitative relationship between the mole and the volume of gas at room temperature and pressure. The module consists of four instructional learning episodes in accordance to the four phases of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved. These four instructional learning episodes are: (1) investigating gaseous reactions, (2) relationship between mole and volume of gas, (3) stoichiometry calculations, and (4) gas stoichiometry problems. As mentioned, the translating phase will be used as the example to show the cognitive processes that the learner is involved in the e-learning.

3.2 Translating phase in the molar volume and molar mass e-learning module

Three activities in the translating phase "investigating gaseous reactions" are designed to explore the relationship between equal volumes of all gases and the number of particles. The multimedia experiences are translated into a beginning idea or concept of equal volumes of all gases containing the same number of particles, which is considered necessary to understand molar volume in the second phase, the sculpting phase. This takes place as a chain of logical events of content sequencing, learner guiding and reflecting in which active learning processes are involved as well. Part of the instructional storyboarding for designing e-learning cognitively is illustrated (see Table 1 and Table 2).

Table 1 Instructional storyboard for translating phase

S/N	Animation	Narration	Text on screen
1.1	After narration, display onscreen text and diagram A. (1) Instructions appear. User to drag and drop the appropriate number of flask A, B. Flasks are of equal size. Instructions disappear when user has done so. Diagram B as it is. User to input vol. for A and for B. (2) When done, onscreen text display just below Diagram B (Diagram A & B remain). (3) Diagram A and B fade! Display diagram C. Animate the particles A, B, C. After which, display the Question "What have you observed …?" 4s pause before displaying the next sentence "I have observed …".	Let us investigate some general chemical reactions involving gases only.	Molar volume and molar mass; *Investigating gaseous reactions;* Given the following information, how can you produce one volume of C? Place the correct number of flask for the general chemical reaction. One volume of A reacts with 1 volume of B to give 1 volume of C.

Table 2 Instructional storyboard for translating phase

S/N	Animation	Narration	Text on screen
1.1a	Display onscreen text followed by Diagram D. Animate the particles E, G, D. After which display the Question "How are your …?" As pause before displaying the next sentence "Again, I have observed …".		Molar volume and molar mass; *Investigating gaseous reactions;* You are to observe the following general chemical reaction at room temperature and pressure.

During the first activity, the learner is given a general chemical equation for placing the correct number of flasks of equal size for the general chemical reaction of the ratio 1:1:1 in terms of one reactant reacting with another one reactant to give one product.

This is then progressed to a second activity involving another general chemical reaction also of the ratio 1:1:1 in terms of one reactant reacting with another one reactant to give one product. However, this general chemical reaction is represented at the particle level. The question "What have you observed in terms of volume and number of particles" is posed. The rationale is getting the learner to use one's observation skills and process the information cognitively with the aim of looking for a pattern relating the volume of the flasks of equal sizes and the number of particles in the flasks.

This is further engaged into the third activity that involves another general chemical reaction of the ratio 2:1:1 in terms of two reactants reacting with one reactant to produce one product. Essential question, for example, "How are your observations for this reaction like the observations you made previously" is posed. The purpose is to elicit cognitive observational responses as a result of using thinking skills of abstracting and comparing by the learner. The response will be "I have observed that equal volumes of all gases contain the same number of particles". The learner needs to grasp and master this essential relationship for understanding molar volume.

In essence, the instructional learning activity on these two general chemical reactions involving gases only is provided progressing from a simple type, A + B → C to a complex type, 2E + G → D for the learner to experience the multimedia learning activities and formulate cognitively that equal volumes of all gases contain the same number of particles and that the stoichiometry of a chemical reaction is not addictive in nature.

This beginning idea or concept of equal volumes of all gases containing the same number of particles as Avogadro's hypothesis experienced in the translating phase will be built upon in the second phase, Sculpting phase of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved to expand to a relationship between the mole and the volume of gas.

4. Research data

This section gives an overview of the research findings that are related to cognitive abilities in terms of mastery of the mole concept and the relevant data are extracted from the larger research study. As such, it will focus on the data analysis of the pretests and posttests of Mole Concept Achievement (MCA) Test for Chemistry administered to the four groups that have received the same treatment of using a multimedia learning package consisting of three e-learning stoichiometry modules on simple stoichiometry; molar volume and molar mass; and limiting reactant. This multimedia learning package for the learning of mole concept has as its pedagogic model the TSOI Hybrid Learning Model™ & © 2005 All rights reserved.

4.1 Research question

The research question formulated is "Is there a significant difference between pretest and posttest achievement" that means as they pertain to a learner's level of conceptual understanding of mole concept for each of the four groups using a multimedia learning package for learning of the mole concept, which has as its pedagogic model the TSOI Hybrid Learning Model™ & © 2005 All rights reserved.

The Mole Concept Achievement (MCA) Test for Chemistry with test-retest reliability, r_{12} of 0.70 comprises nine multiple-choice questions and seven problem questions.

4.2 The sample

The study involved four groups (CS1, CS2, SC4 and JC1) in year 2006. Group CS1 consisted of forty seven trainee teachers with mean age of 24.6 from the PGDE (S) (Postgraduate Diploma in Education, Secondary) January 2006 intake taking chemistry as the first curriculum study subject (major), CS1. Group CS2 consisted of twenty nine trainee teachers with mean age of 23.7 from the PGDE (S) January 2006 intake taking chemistry as the second curriculum study subject (major), CS2.

Group SC4 consisted of forty secondary four express pure chemistry girl students with a mean age of 15.7 from an independent girl's school. Group JC1 consisted of twenty first year students with a mean age of 16.5 taking chemistry at advance level from a junior college of average ranking.

4.3 Data analysis

Pretest and posttest descriptive data of the Mole Concept Achievement (MCA) Test for Chemistry for each of the four groups (CS1, CS2, SC4 and JC1) are shown in Table 3.

Table 3 T-test for dependent means for pretest and posttest achievement means (mole concept achievement test)

Group	N	Mean diff.	S.D.	df.	T-value
CS1	47	3.81	0.47	46	8.06*
CS2	29	3.38	0.48	28	6.97*
SC4	40	4.45	0.50	39	8.95*
JC1	20	5.65	0.82	19	6.88*

Note: * significant at 0.05 level.

The data reveal significant difference at the 0.05 level between pretest and posttest achievement means (MCA Test) for each of the four groups (CS1, CS2, SC4 and JC1). As such, the null hypothesis, "there is no statistically significant difference between pretest and posttest achievement" that means as they pertain to a leaner's level of conceptual understanding of mole concept for each of the four groups using a multimedia learning package for learning of the mole concept, which has its pedagogic model the TSOI Hybrid Learning Model™ & © 2005 All rights reserved, can be rejected.

The results may be explained according to the groups' background chemistry knowledge. For the two groups CS1 and CS2, the results when compared to the other two groups JC1 and SC4 show a lower mean difference. This may be expected as these university graduates have stronger chemistry background knowledge. Nevertheless, they have also benefited from using the multimedia learning package.

A higher mean difference for the group JC1 as compared to the other three groups has been observed. These first year junior college students are waiting for the release of their ordinary level examination results and have not revised or been taught the mole concept during this period of study. As such, it is likely that these students having used the multimedia learning package have higher achievement gains.

For the group SC4, a similar outcome has also been obtained when compared to the other two groups CS1 and CS2. These students are preparing for their ordinary level examinations and have not yet revised the mole concept during this period of study. Thus, it is probable that these students having used the multimedia learning package have better achievement gains.

5. Conclusions

In the translating phase of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved, active learning processes for example abstracting and comparing engage the learner during the process of e-learning. As such, it is essential to first identify the critical attributes of the concept to be learnt so that varied activities can be designed to assist the leaner to identify these critical attributes and eventually leading to acquisition of concept mastery.

The translating phase of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved is an important phase as it through appropriate active learning processes presents the learner an initial exposure or awareness of the concept to be learned for preliminary experience. Multimedia experiences facilitated are translated to a beginning concept by the learner. This first phase sets the stage for triggering the learner's preexisting mental models.

The results of the study seem to indicate that a significant contribution of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved, as the design framework for designing multimedia learning materials, for example, for e-learning of the mole concept in terms of achievement is highly probable in addition to other important contributing factors such as the type of multimedia learning design principles applied, the examples and the exercises used.

It seems that each phase of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved, has an important task in helping the learner to acquire the concept. This implies that the sum of parts that is the phases to form the whole entity (TSOI Hybrid Learning Model™ & © 2005 All rights reserved is essential and that no one phase should be left out during the process of learning. In essence, the TSOI Hybrid Learning Model™ & © 2005 All rights reserved, has the functional potential to give the instructional designer a viable pedagogic structure for designing the e-learning cognitively.

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