Designing e-learning cognitively: TSOI Hybrid Learning Model

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***Abstract*—Research on learning has proposed various models for learning. However, generally, there has been an inadequate research of the application of these models for learning for example the Kolb's experiential learning cycle or the Jarvis's model of reflection and learning to the development of e-learning materials. This is more so especially due to lack of effective yet practical design model for designing interactive e-learning materials. Having this in mind, the TSOI Hybrid Learning Model can be used as a pedagogic model for the cognitive design of e-learning. This Model represents learning as a cyclical cognitive process. A major feature is to promote active cognitive processing in the learner for meaningful learning proceeding from inductive to deductive. Design specificity in science and chemistry education is illustrated in terms of instructional storyboarding and the research-based e-learning product developed. Learners' cognitive abilities will be addressed as part of the research data collected.**

***Index Terms*—Active learning, cognitive design, e-learning, learning model.**

I. INTRODUCTION

Research on learning has proposed various models of learning. However, there has been an inadequate research of the application of such models for learning for example the Kolb's experiential learning cycle or the Jarvis's model of reflection and learning especially to the development of e-learning materials though the Kolb's experiential learning cycle model has been used quite extensively in designing instructional materials to cater to the different learning styles [1,2]. This is more so especially due to lack of effective yet practical design model which can serve as a framework for not only organizing but also designing e-learning materials.

Having this in mind, TSOI Hybrid Learning Model™ & © 2005 All rights reserved. can be used as a pedagogic model to design e-learning cognitively.

A. *Theoretical Framework of TSOI Hybrid Learning Model*

The theoretical basis of this TSOI Hybrid Learning Model™ & © 2005 All rights reserved. is derived from the Piagetian learning cycle model and the Kolb's experiential learning cycle model. The term hybrid will mean the mixing of two different things to give a better product.

The Piagetian learning cycle model being inquiry-based represents an inductive application of information processing models of teaching and learning. It has three phases in a cycle: exploration, concept invention, and concept application [3, 4, 5]. The exploration phase centers on "What did you do?" During the exploration phase, learners learn through their own actions and reactions in a new situation and have the opportunity to explore new learning materials and new ideas with minimal guidance from the teacher. The new experience is designed to raise questions that the learners may not be able to resolve thus leading to the learners starting to analyze the reasons for their ideas.

The concept invention phase focuses on "What did you find out?" The concept invention phase involves the introduction of a new term or terms and gives the opportunity to the student and/ or teacher to derive the concept from the data through classroom discussions. Ideally, learners are encouraged to discover as much of a new pattern as possible before the new term is revealed to them. The concept application phase is the third phase and is essential as it allows learners to extend the range of applicability of the new concept. The concept application allows the student to explore the relevance and application. In this last phase, the learners apply the new term(s) to additional problems.

These three phases are similar to Piaget's assimilation, accommodation, and organization phases. According to Piaget, assimilation involves a quantitative and qualitative change in existing schemes or mental structures. As such, a conflict between newly assimilated information and previously formed mental structures will give rise to a disequilibrium state which is meant to motivate the learner to seek equilibrium. Regaining equilibrium or cognitive harmony is called accommodation which is actually the development of new mental structures.

Hence, the learner's adaptation to inputs from the environment is represented by both the assimilation and accommodation phases. However, the learner having gone through these two phases still has incomplete learning. The learner has yet to organize the new or modified mental structures with previously learnt or existing mental structures allowing structure placement or interconnectedness so that they are in accord with one another.

The Kolb's experiential learning cycle [6] 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".

At the concrete experience stage, learners rely more on feelings or emotions than on a systematic approach to solving problems and situations thus preferring personal relationships and involvement with people. At the reflective observation stage, learners rely on personal thoughts, patience, objectivity and careful analysis to understand ideas and situations from many perspectives.

At the abstract conceptualization stage, learners prefer to use logic rather than feelings or emotions to understand situations or problems. In other words, there is systematic and logical planning that take into account theories and ideas before solving problems. As for the active experimentation stage, learners tend to take a practical approach and be carrying out the plans or tasks rather than simply observing the situation, are preferred by the learners.

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 [7, 8, 9].

The TSOI Hybrid Learning Model™ & © 2005 All rights reserved. represents learning as a cognitive process in a cycle of four phases: **T**ranslating, **S**culpting, **O**perationalizing, and **I**ntegrating [10, 11, 12]. A major feature is to promote active cognitive processing in the learner for meaningful learning proceeding from inductive to deductive. Fig. 1 shows the four phases of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved.

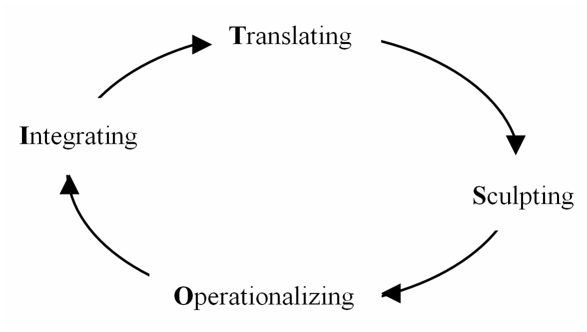

Figure 1. TSOI Hybrid Learning Model™ & © 2005 All rights reserved.

The Translation phase is similar to the exploration phase of learning cycle model and the concrete experience stage of 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 learning cycle model and predominantly the reflective observation stage of the experiential learning cycle including partially the abstract conceptualization stage of the experiential learning cycle. This is where the beginning idea or concept still in its raw form is further molded to s concrete form that is meaningful to the learner.

The Operationalizing phase similar to predominantly the abstract conceptualization stage of the experiential learning cycle involves increasing the understandings of the relationship between thinking and concept acquisition.

The Integrating phase parallels the concept application of learning cycle model as well as the active experimentation stage of experiential learning cycle. This is where the concept is applied to new domains in which the transfer of learning is practiced.

TABLE 1
INSTRUCTIONAL STORYBOARD

S/N	Animation	Narration	Text on Screen
2.1	After narration, display onscreen text & diag A a. Instructions appear. User to drag & drop the suitable no. of flask A, B. Flasks are of equal size. Instructions disappear when user has done so. Diag B as it is. User to input 1 vol for A & 1 vol for B. b. When done, onscreen text display just below Diag B (Diag A &B remain) c. Diag A & B fade! Display diag C. Animate the particles A, B, C. After which, display the question "What have you observed in terms of vol & no. of particles?" 4s before displaying & narrating the next sentence "I have observed that equal volumes of all gases contain the same no. of particles".	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 **1 volume** of A reacts with **1 volume** of B to give **1 volume** of C.
2.1 a	Display onscreen text followed by dig D. animate the particles E, G, D. After which display the question "How are your observations for this reaction like the observations you made previously?" 4 s pause before displaying & narrating the next sentence "Again, I have observed that equal volumes of all gases contain the same no. of particles".		**Molar Volume and Molar Mass** *Investigating gaseous reactions* You are to observe the following general chemical reaction at room temperature and pressure

Throughout the four phases, 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.

II. PEDAGOGICAL DESIGN FOR E-LEARNING COGNITIVELY

For illustration in chemistry education, the mole concept, an abstract and difficult concept is used [13]. One of the subtopics used is molar volume and molar mass. Since the focus is on designing e-learning cognitively, 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 cognitive processes involved in e-learning.

A. 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. This 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 (a) Investigating gaseous reactions, (b) Relationship between mole and volume of gas, (c) Stoichiometry calculations, and (d) Gas stoichiometry problems. As mentioned, the Translating phase will be used as the example.

B. 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 cognitive processes are involved as well. Part of the instructional storyboarding for designing e-learning cognitively is illustrated (see Table 1).

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. Critical 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, $A + B \rightarrow C$ to a complex type, $2E + G \rightarrow D$ 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 contain the same number of particles as Avogadro's hypothesis experience 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.

III. 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.

A. Research Question

The research question formulated is "Is there a significant difference between pretest and posttest achievement 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 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.

B. 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) (Postgraduate Diploma in Education, Secondary) 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.

C. 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 2.

TABLE 2
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*

* significant at .05 level

The data reveal significant difference at the .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 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 as 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. Not having a control group has a limitation to the research study to some extent however one also needs to recognize the difficulties in obtaining a similar multimedia learning package for the research study. Nevertheless, the e-learning modules in this multimedia learning package have helped the learners cognitively.

IV. CONCLUSIONS AND IMPLICATIONS

In the Translating phase of the TSOI Hybrid Learning Model™ & © 2005 All rights reserved. cognitive processes for example abstracting and comparing are involved during the process of learning. As such, it is essential to first identify the critical features 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 cognitive 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. It is also envisaged strongly that so long as a concept or idea possesses certain critical features, this learning model will be able to be applied innovatively to design to induce various cognitive processes. In essence, the TSOI Hybrid Learning Model™ & © 2005 All rights reserved. has the functional potential to empower the instructional designer with a pedagogic structure for designing the e-learning cognitively.

REFERENCES

[1] B. Lisewski and P. Joyce, Examining the five-stage e-moderating model: designed and emergent practice in the learning technology profession, *ALT-J*, vol.11, no.1, pp. 55-66, 2003.

[2] M. Oliver, What do learning technologists do?, *Innovations in Education and Training International*, vol.39, no. 4, pp. 245-52, 2002.

[3] R. Karplus, *Teaching and the Development of Reasoning*. Berkeley: Unversity of California Press, 1977.

[4] A. E. Lawson, *Science teaching and the development of thinking*. Belmont, CA: Wadsworth, 1995.

[5] J. W. Renner and E. A. Marek, An educational theory base for science teaching. *Journal of Research in Science Teaching*, vol. 27, no. 3, pp. 241-246, 1990.

[6] D. Kolb, *Experiential Learning: Experience as the source of Learning and Development.* Englewood Cliffs, N. J.: Prentice Hall, 1984.

[7] S. His and A. M. Agogino, The impact and instructional benefit of using multimedia case studies to teach engineering design. *Journal of Educational Multimedia and Hypermedia,* vol. 3, pp. 351-376, 1994.

[8] J. W. Van Aalst, T. T. Carey and D. L. McKerlie, *Design space analysis as training wheels in a framework for learning user interface design*. Proceedings CHI. New York: ACM, pp. 154-162, 1995.

[9] M. F. Tsoi and N. K. Goh, *Practical multimedia design for chemical education*. In J. Breaker et al. (Series Eds.) & G. Cumming et al. (Vol Eds.), Advanced Research in Computers and Communications in Education: Vol.1. New human abilities for the networked society. The Netherlands: IOS Press, 1999, pp. 946-949.

[10] M. F. Tsoi, N. K. Goh and L. S. Chia, *Multimedia Design: A Hybrid Approach*. [CD-ROM]. Paper from: SEAMEO-UNESCO

Education Congress & Expo in Education Item: DDR 4705178. Bangkok, Thailand, 2004.

[11] M. F. Tsoi, N. K. Goh and L. S. Chia, Multimedia learning design pedagogy: A hybrid learning model. *Journal of US-China Education Review*, USA, vol. 2, no. 9, pp. 59-62, September 2005.

[12] M. F. Tsoi, Designing for Engaging: Hybrid Learning Model. *Special Issue of the International Journal of the Computer, the Internet and Management*, vol. 15, no.3, pp. 29.1-29.4, 2007.

[13] M. F. Tsoi, N. K. Goh and L. S. Chia, *Some suggestions for the teaching of the Mole Concept*. In Wass, Margit (Ed.), Enhancing Learning: Challenge of integrating thinking and information technology into the curriculum. Educational Research Association, Singapore, 1998, Vol. 2, pp. 778-785.

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