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Students' Characteristics: Implications to the Design of Interactive Multimedia Module with Pedagogical Agent (IMMPA) in the Learning of Electrochemistry

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Abstract: Kemp Model and Gerlach and Ely Model are combined as an Instructional Design Model for the design of IMMPA named EC Lab for the learning of Electrochemistry. A preliminary survey was carried out to study the learners' characteristics including general characteristics, specific entry competencies and learning styles. There were 126 students involved in this survey which was carried out by means of questionnaire. All of the samples involved are 15 years old and the majority of them are female. Specific entry characteristics involve items related to skills in using EC Lab. Results showed that the students have high computer proficiency and excellent reading and listening skills. They are able to study alone and have positive perception toward new learning methods. Results from VAK Learning Style Self test showed that the majority of the samples have auditory and kinaesthetic learning styles.

Key words: Learners' characteristics, interactive multimedia module, pedagogical agent, electrochemistry, listening skills

INTRODUCTION

Designing instructions using multimedia has become a trend in this Information and Communications Technology (ICT) era. Application of multimedia in education through World Wide Web, CD-ROMs, DVDs and virtual reality can help students visualize the abstract concepts, especially in the learning of chemistry. To design an effective instruction, the subject matter expert should cooperate with the instructional designer to ensure that the instruction is valid in terms of content and instructional design principles. Instructional design refers to the systematic and reflective process of translating principles of learning and instruction into plans for instructional materials, activities, information resources and evaluation (Smith and Ragan, 2005). Some commonly accepted instructional design models are ADDIE Model in 1995, ASSURE in 1996, Dick and Carey Model in 1996, Rapid Prototyping in 1990, Kemp, Morrison and Ross Model in 1994, etc. (Kemp *et al*., 1994; Dick and Carey, 1996). Each model has its own strengths, weaknesses and focus: classroom-oriented, product-oriented and system-oriented. The selection of appropriate Instructional Design Model depends on the purpose of the instructional design. In this study, the researcher is interested to develop an Interactive Multimedia Module with Pedagogical Agent (IMMPA) named EC Lab in the learning of electrochemistry by combining two instructional design models: Kemp Model and Gerlach and Ely Model. The two models are combined as they are both classroom-oriented (Gustafson and Branch, 1997) with their own strengths. The conceptual framework of the KemGerly Model used in this study is shown in the Fig. 1.

Kemp Model: Morrison, Ross and Kemp Model is commonly known as Kemp Model. It is an oval-shaped model consisting of nine major elements in the core and some elements at the two ovals surrounding the core (Fig. 2). Kemp Model describes the elements not step, stage, level or sequential item in an instructional design (Kemp *et al*., 2004). The oval shape of the model indicates the independency of the elements in the model. It is a Non-Linear Model with no starting and ending point. All the processes of designing, developing, implementing and evaluating can be done concurrently and continuously. The nine major elements in the core of the oval are:

- Instructional problems
- Learners' characteristics
- Task analysis

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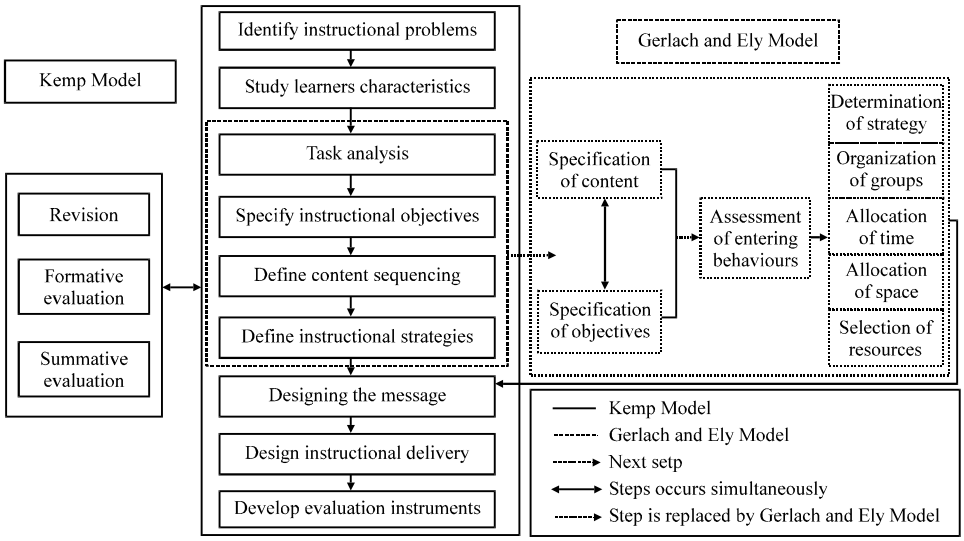


Fig. 1: The conceptual framework of the KemGerly Model

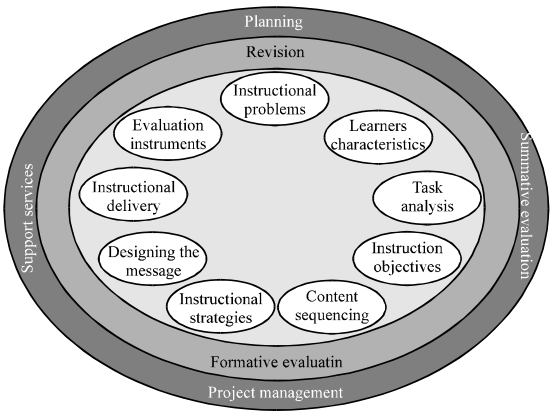
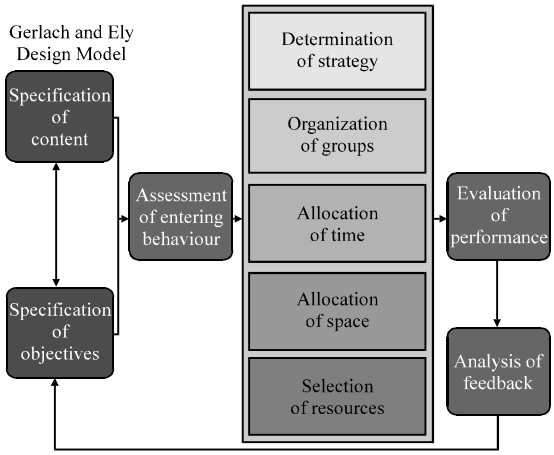


Fig. 2: Kemp Model



A conceptual framework for comparing Instructional Design Model

Fig. 3: Gerlach and Ely Model

- Instructional objectives
- Content sequencing
- Instructional strategies
- Designing the message
- Instructional delivery
- Evaluation instruments

There are two ovals surrounding the core. The inner oval consists of four elements: revision, formative evaluation, summative evaluation and confirmative evaluation.

The outer oval also consists of four elements: planning, implementation, project management and support services. These eight elements are ongoing processes with the nine major elements during the instructional design process.

Gerlach and Ely Model: Gerlach and Ely Model (Fig. 3) is suitable for novice instructional designers who have knowledge and expertise in a specific context. This model is classroom-oriented and is suitable for teachers in secondary schools and higher education institutions.

To design an instruction, a teacher needs to specify the objectives that the students need to achieve after the instruction and select the appropriate contents to help them achieve those objectives. Next, the teacher has to consider the students' existing knowledge before they start with the instruction. To assess the students' entering behaviour, the teacher can refer to available records showing their achievement in previous tests. The teacher can also design a Specific Pre test to measure the

students' ability in the subject area. Then, the teacher should determine the strategies to conduct the instruction, organize the students into groups, estimate the time needed for each session, consider the learning space provided and select appropriate instructional materials. During the teaching and learning session, the teacher needs to evaluate the performance of the students and give feedback.

Performance is the act of teaching, the act of learning (Gerlach and Ely, 1980) which indicates whether the instruction is able to meet the objectives stated. The concept of feedback thus implies a confirmation or correction. Once the students give their response, the teacher should confirm it if it is correct and correct it if it is wrong.

Learners' characteristics: Four fundamental components of instructional design as proposed by Morrison *et al.* (2007) are:

- Learner: for whom is the program developed?
- Objectives: what do you want the learners or trainees to learn or demonstrate?
- Instructional strategies: how is the subject content or skills best learned?
- Evaluation procedures: how do you determine the extent to which learning is achieved?

The four components are inter-correlated as shown in Fig. 4. Once the instructional problem is identified, an instructional designer should study the learners' characteristics. There are three categories of learner characteristics: general characteristics, specific entry competencies and learning styles (Henich *et al.*, 2002). General characteristics are demographic information such as gender, age, ethnicity, work experience and education.

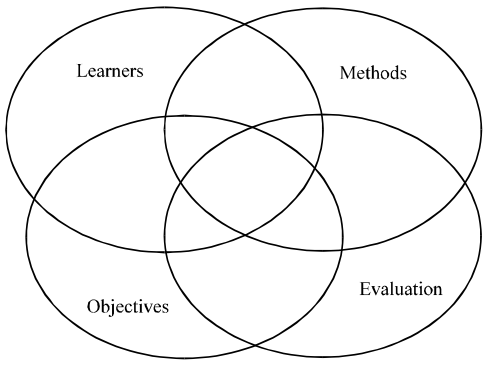


Fig. 4: Inter-correlation of four components in instructional design (Morrison *et al.*, 2007)

Specific entry characteristics are prerequisite knowledge or skills that serve as preliminary conditions to follow the instruction designed. Learning styles are the way students interact with the learning task during the learning process.

Students in a class possess diverse general characteristics. Generally, boys and girls have different strengths and weaknesses in the learning process. Girls score better in sustained tasks that require memorizing unambiguous facts and rules while boys are more responsive to open-ended tasks which are related to practical and realistic situations (Ofsted, 2003). On the other hand, girls show more positive attitudes in computer-supported learning but boys possess better skills and experience in handling computers (Leong and Al-Hawamdeh, 1999; Ariffin, 2005). In a study by Zalizan, both boys and girls are comfortable with male teachers but boys face problems with female teachers. But studies have shown that the vast majority of boys and girls prioritise a teacher's individual ability as a teacher and his or her level of care for his or her students, rather than the teacher's gender (Department for Children Schools and Families, 2009). In the context of Malaysia, the majority of students in Form four chemistry classes are 15 years old youths. They are either boys or girls from three major ethnics: Malay, Chinese and Indian.

By conducting the analysis of specific entry competencies, teachers will learn about students' prerequisite knowledge and skills. This can help them select appropriate methods and resources to be used during the instruction. Pre-test is always the best way to evaluate students' existing knowledge in the content area. Studies (Alkazemi, 2003) showed that students have low understanding of electrochemistry concepts before the instructions. Students' prior knowledge is important to construct and organize new concepts as described in Ausubel's theory (West and Fensham, 1976). Misconception occurs in the students' mind if their prior knowledge is different from the formal instructions given by the teachers. Hence, students' prior knowledge is important to both teachers and students in the learning process.

Learning styles are preferences and habits of learning (Mc Keachie, 1995). There are various types of learning styles which can be identified through different instruments such as Kolb's Learning Styles Inventory in 1984, Honey and Mumford Learning Styles Questionnaire in 2006, Dunn and Dunn Learning Style Inventory in 1978 and VAK Learning Style Self test in 2005 (Kolb, 1984; Honey and Mumford, 2006; Dunn and Dunn, 1978). Each student has different learning styles and the learning

styles are related to their academic achievement and motivation (Gee, 1990; Yahaya *et al*., 2002; Hamdan *et al*., 2008; Aripin *et al*., 2008; Deryakulu *et al*., 2010).

MATERIALS AND METHODS

Samples: In order to study students' characteristics before designing the EC Lab, the researcher had carried out a survey involving 126 students from two secondary schools in Malaysia. The samples were form three students who have the potential to obtain good results in the Lower Secondary Examination (Peperiksaan Menengah Rendah, PMR) and be selected into the science stream classes when they proceed to form four. These samples will be using the EC Lab in the learning of Electrochemistry when they proceed to form four. Profile of the samples is shown in Table 1.

Instruments: The instrument used to study the characteristics of the samples was a questionnaire. The questionnaire consisted of three sections: demographic information, specific entry characteristics and learning style. The main information needed in the demographic section was the students' gender and age. Specific entry characteristics only involved items related to skills in using EC Lab because some of the prerequisite knowledge to study electrochemistry would only be taught in form four Chemistry syllabus.

The skills involved were computer literacy, reading and listening skills, the ability to study alone and the students' perception toward new learning methods. The students had to give their responses using the 5-points Likert scale for each item. The items in the learning style section in the questionnaire were 30 items from VAK Learning Style Self test in 2005. Each item described a situation and was followed by three options. Option A was the response for those who have preference for seen or observed things, Option B was the response for those who have preference for the transfer of information through listening and Option C was the response for those who have preference for physical experience. At the end of the items, the samples were required to add up the number of As, Bs and Cs selected. If a student had chosen mostly A, he has a visual learning style if he had chosen mostly B, he has an auditory learning style if he had chosen mostly C, he has a kinaesthetic learning style. All the information obtained from the study will be used as guidelines in designing the EC Lab to ensure the suitability of the product with the learners' characteristics.

Table 1: Profile of samples

	Gender (n)		Ethnic (n)			
School	Male	Female	M	C	I	Total (n)
SMKTM	23	47	43	19	8	70
SMKL	16	40	40	16	0	56
Total	39	87	83	35	8	126

SMKTM = Sekolah Menengah Kebangsaan Tun Mamat (Tun Mamat National Secondary School), SMKL = Sekolah Menengah Kebangsaan Ledang (Ledang National Secondary School), M = Malay, C = Chinese, I = Indian

RESULTS AND DISCUSSION

Samples of the study consisted of 126 (39 male and 87 female) form three students aged 15 from three different races with the Malay:Chinese:Indian ratio being 10.375:4.375:1. Among the samples, the majority of them (82.54%) will choose science stream when they proceed to form four but twelve of them will not choose the subject Chemistry. Biology and Physics are always more favoured by students. Learning Chemistry involves three representation levels which are macroscopic, microscopic and symbolic (Johnstone, 1993). The abstract concepts in Chemistry may be the reason why the students abandoned this subject when they made their selection of science subjects during form four. Students can go to the school of their choice to continue their upper secondary education based on their PMR results.

Options provided are their current school, boarding schools and technical schools. Current school refers to their existing school either SMKTM or SMKL which are normal daily schools. Almost all of the Chinese and Indian students will remain in their existing school. Boarding schools will provide hostel for the students and have very strict rules and learning schedules. Almost all of the students who wish to transfer to boarding schools are Malay students. Technical schools will teach students on specific technique and vocational subjects besides normal subjects. Students graduating from technical schools are skilled and have high employment rate when they step into the society. Table 2 shows some general characteristics of the samples.

More than half of the samples have high computer proficiency (61.9%) and excellent reading and listening skills (65.1%). They are able to study alone (50.8%) and have positive perception toward new learning methods (53.2%). In terms of computer literacy, samples find it easy to control the mouse (item 2, mean = 4.33) but they are not

Table 2: General characteristics of samples

Characteristics	Options	N (%)
Willingness to choose	Yes	104 (82.54)
science stream	No	22 (17.46)
Willingness to choose	Yes	92 (73.02)
Chemistry subject	No	34 (26.98)
School options for upper	Same school	82 (65.08)
secondary education	Boarding school	31 (24.60)
	Technical school	13 (10.32)

confident in using the keyboard (item 3, mean = 3.93). A possible reason is that students are not familiar with the location of the alphabets on the keyboard causing slow pace in typing. Hence, they feel that they are not good in using the keyboard. The students have better reading skills compared to listening skills with a mean of 4.12 and 3.95, respectively. Samples still depend highly on the teacher's explanation when learning (item 7, mean = 4.26). This is due to the traditional teaching method applied in the schools. A teacher-centred classroom is controlled by the teachers while the students act passively in the classroom, receiving information delivered by the teachers. Hence, students fully depend on the teachers during the teaching and learning sessions. Some of them like to study with friends (item 8, mean = 3.31) while some are able to study alone (item 6, mean = 3.78). The majority of the samples are comfortable with their current learning style (74.6%) but half of them are still willing to accept new learning methods (Table 3 and 4).

The majority of the samples have auditory learning style (34.1%) and kinaesthetic learning style (33.3%) followed by visual learning style (22.2%). Students with a combination of two or three learning styles are the minority with a low percentage of 10.4. Students with auditory learning style will be able to perform a new task after listening to the instructions from an expert. They learn fast when information is given verbally. Kinaesthetic learners are students that learn by doing. They like to try out new things involving physical experience. Hence, hands-on activities like experiments, field trips, role play, dancing and drama presentations are their favourite activities. Visual learners learn from seen or observed things. They benefit from diagrams, pictures, demonstrations, handouts and written instructions.

Table 3: Specific entry characteristics

Constructs	M	SD	Level	N (%)
Computer literacy	4.00	0.66	Low	1 (0.8)
			Moderate	47 (37.3)
			High	78 (61.9)
Reading and listening skills	4.04	0.82	Low	3 (2.4)
			Moderate	41 (32.5)
			High	82 (65.1)
Ability to study alone	3.78	0.51	Moderate	62 (49.2)
			High	64 (50.8)
Willingness to accept new learning methods	3.76	0.75	Low	3 (2.4)
			Moderate	56 (44.4)
			High	67 (53.2)

Table 4: Students' learning styles

Learning styles	Frequency (%)
Audio	43 (34.1)
Kinaesthetic	42 (33.3)
Visual	28 (22.2)
Audio + Kinaesthetic	5 (4.0)
Visual + Audio	4 (3.2)
Visual + Audio+Kinaesthetic	3 (2.4)
Visual + Kinaesthetic	1 (0.8)
Total	126 (100.0)

This survey serves as a preliminary step to study learners' characteristics before designing EC Lab for electrochemistry. The questionnaire consists of items involving demographic information, specific entry characteristics and learning styles. Results from the survey and review from literature will be used as guidelines and considering factors when designing the IMMPA for electrochemistry. This is to ensure that the learning material (EC Lab) suits the learners' characteristics so that they can fully benefit from it.

The samples consist of both male and female students with the female students as the majority. In the design of Pedagogical Agent (PA) in multimedia module, female students are more likely to choose cartoon-like agents (as opposed to realistic agents) than their male counterparts (Baylor *et al*., 2003; Baylor, 2004, 2005). Hence, the design of the pedagogical agents in EC Lab will be using cartoon characters. Normally, the roles of the PA in the multimedia module are expert, motivator or learning companion. The expert's role is to give accurate information and explain new concepts to the learner during the learning sessions. On the other hand, the motivator or the learning companion accompanies the students in the learning process. They will give their opinions and encourage the students to be involved in the activities. A study (Baylor, 2005) showed that male experts are more competent than female experts. Although, female agents are perceived as less intelligent, they are more aggressive in enhancing self-efficacy of the students (Baylor and Kim, 2004; Baylor, 2005). With the factors gender and role in consideration, the researcher will design the expert in the form of a male professor of about 60 years old. The professor will speak slowly in a formal manner with little body gestures and facial expressions. On the other hand, the learning companion will be a female youth, about 15 years of age, speaking with an energetic voice. She will show a variety of facial expressions and body gestures. She will learn together with the students and give motivation and encouragement to them to complete the tasks and exercises in the module.

From the samples' responses on specific entry characteristics, the results showed that more than half of the samples are able to use the computer and have good reading and listening skills. They are able to learn alone and are willing to accept new learning methods. Thus, the researcher has no worries regarding the usability of EC Lab. The activities in EC Lab will involve students' participation. For instance, students need to select the

sub unit they wish to explore, drag and drop the answers in the space given, click on the button to move forward or backward and type their answers in the space provided. All these actions should not be causing any problem for the samples as they all have experience working with computers. Moreover, PAs in the module speak in standard accent using human voice as proposed by voice principle (Mayer *et al*., 2003) and are easy to understand. Students treat the messages given by the PAs (using human voice with standard accent) as a social conversation (Reeves and Nass, 1996) rather than information delivery. Hence, they will put more effort into building meaningful learning outcomes because cognitive load is reduced and they have more cognitive capacity to build connection between schemas compared to foreign-accented or machine-voiced PAs (Atkinson, 2002; Baylor *et al*., 2003; Mayer *et al*., 2003; Shamir *et al*., 2008).

The design of the module will consider students' learning style to ensure that every student enjoys learning electrochemistry using EC Lab. To benefit the audio learners, most of the instructions and narration of animations are given verbally. PAs will deliver the information verbally and some of the important notes are shown on the screen. To those who are advanced learners, this may become redundant (Chandler and Sweller, 1994; Craig *et al*., 2002) for them because the written notes are similar to the narration given by the PAs. The language used in EC Lab is English following the Teaching and Learning of Science and Mathematics using English Project (Pengajaran dan Pembelajaran Sains dan Matematik dalam Bahasa Inggeris, PPSMI) implemented by the government since, 2003. Comprehension of the decoded message is affected by the ability of the receiver to comprehend the message (Henich *et al*., 2002). Since, English is not the mother tongue, it would create problems in delivering information from PAs to the students if only audio communication is involved. Hence, in some of the screens, information is given in both audio and visual forms.

Types of visual used in EC Lab are pictures, charts, animations and videos. These visuals can provide a concrete referent for ideas, motivate learners by attracting and holding their attention, simplify information that is difficult to understand, serve an organizing function by illustrating the relationships among elements and provide a redundant channel (Henich *et al*., 2002). The use of these visuals is beneficial to the visual learners as well as audio learners because they can comprehend visually what they might miss verbally. Colourful pictures which involve students' daily experience are used in EC Lab to attract students' attention during the learning activities. The charts used as the advanced organizer organize the important concepts in every sub unit so that students have an idea about concepts to be learned before exploring the sub unit. Animations about movement of ions and electrons in microscopic representation level are used to simplify abstract processes during electrolysis. The animations also serve as a concrete idea for the students to visualize the electrolysis process.

Kinaesthetic learners like hands-on activities. To fulfil the needs of the group, EC Lab features several experiments that require students to carry out investigations in the chemistry laboratory. Students need to set up electrolytic cell, observe the changes occurring during the experiment, record the observations, discuss the results obtained and produce conclusions based on the investigations. Science process skills and manipulative skills are involved during the investigations. Kinaesthetic students can learn easily by doing these hands-on experiments. In addition, EC Lab's interactive features require the involvement of students in the learning process. Students need to click on certain buttons to proceed, type answers to the questions and make decisions based on the alternatives given. These make students aware and become involved actively in the activities.

CONCLUSION

Assessing learners' characteristics is one of the elements in Kemp Model while Gerlach and Ely Model focuses on students' entering behaviour. Hence, the survey was carried out to study the characteristics of learners as a preliminary step before designing the EC Lab. The results obtained are set as guidelines and factors in designing EC Lab as well as the roles and characteristics of PAs. Besides that the design of the layout also follows the principles and effects suggested in Cognitive Theory of Multimedia Learning (CTML) and Cognitive Load Theory (CLT).

This is to ensure that students can learn electrochemistry in a low cognitive load environment so that they can have enough cognitive capacity to process the information delivered by the PAs. Researches found that electrochemistry is abstract and difficult to learn, (Bojczuk, 1982; Lin *et al*., 2002) and students face misconceptions (Sanger and Greenbowe, 1997; Lin *et al*., 2002) in learning it. Hence, it is hoped that students can overcome the problems and difficulties in learning Electrochemistry by using this EC Lab.

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