 DOES LEARNING SCIENCE MEAN DOING SCIENCE? AN EXPLORATORY STUDY ON THE ROLE OF ICT TOOLS IN SCIENCE CLASSROOM ANCHORED ON LEARNER’S EFFICIENCY MODEL

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Abstract
This paper reports on the authors’ experiences in conducting an in-service training course on ICT tools for secondary science educators in the SEAMEO region. It focuses on some of the ICT tools that could be used effectively to promote learning in secondary science classroom. Pre/post-tests using Likert scales were administered to evaluate the participants’ perceived levels of knowledge and skills before and after the course activities. The perceived attitude of teachers towards the use of ICT tools in the science classroom was also evaluated. Analysis of data was anchored on a learning efficiency framework. The findings showed that learning efficiency through ICT tools could be improved on the five dimensional constructs of content, feedback, user interface, ease of use and satisfaction. The research activities and findings will serve as guidelines for the future planning of in-service teacher education towards improving teaching and learning of science using ICT tools among educators in the SEAMEO region.

Introduction
As we move further into the 21st century, it must be realized that learners in the Southeast Asian countries should be prepared to meet the future needs of a knowledge-based economy (SEAMEO, 2010). Educators who have direct contact with learners should thus be equipped with a plethora of pedagogies and knowledge of cutting edge technology through ‘Continuing Professional Development’ (CPD) activities to understand students better and teach more effectively. The advancements of technology education especially ICT-based learning allow teachers to employ various constructivist strategies such as Project-based Activities (PBA) and Problem-based Learning (PBL) that could actively engage learners’ interest in science. It is with this premise that ICT has been identified as an important component in the training programmes of SEAMEO RECSAM, a regional training institution for science and mathematics education in the SEAMEO region. The objectives of this research are:
• To evaluate the science teachers’ perceived levels of competency and knowledge after their participation in a CPD programme related to the use of ICT tools in science teaching.
• To develop a comprehensive learners’ efficiency framework through structural equation modelling (SEM) to conceptualize the role of ICT tools in promoting constructivist science learning.

Review of Related Literature
The very basic question a teacher may ask is, “How do I use ICT to enhance my teaching process and my students’ learning?” A teacher may use presentation software and may say that he/she is using ICT to enhance her teaching processes and to that effect enhances students’ learning! Education professionals might be asking, is ICT really what we want and what we can do with ICT at hand? What are the varied answers and reasons to this question?

Karasavvidis (2008) said that one of the most significant challenges educators face in the case of technology in education is pedagogical in nature. It is the ability to integrate ICT into the teaching and learning process. ICT integration is interpreted as ICT functioning as an integral or mediated tool to accomplish specific teaching or learning activities to meet certain instructional objectives (Lim & Hang, 2003). It means that ICT is part of the process but not as a mere vehicle of the process. Most governments had been trying their best to integrate ICT into the teaching and learning process in their schools. According to a UNESCO Report (2004), there were different levels of ICT integration in the six countries surveyed and, alongside with it numerous similar experiences of ICT integration were found. An analysis of experiences and best practices with associated problems has generated lessons learned in the following eight components of ICT integration in education: (i) broader environmental context, (ii) policy and regulatory environment, (iii) management and financing, (iv) ICT in schools – policy, vision and strategy, (v) technology infrastructure and connectivity, (vi) curriculum, pedagogy and content development, (vii) professional development, and (viii) monitoring and evaluation (UNESCO, 2004).

Lim and Hang (2003) said that research studies have shown that ICT facilitates the acquisition of higher order thinking skills by providing cognitive scaffolding for students as they make sense of the information gathered; allowing experts, teachers and students to communicate their thoughts and interests in subject matters; and simulating real-life situations and problems for students as they explore the connections between concepts and ideas.

Indeed, ICT has the potential of enhancing teaching and learning processes. But there is a question on how best ICT could be integrated into these processes. Mlitwa and Van Belle (2010) said that integration also requires the understanding of qualitative phenomena of the application of ICT into social-educational settings. Papert (1997) as cited by Lim and Hang (2003) reiterated that as ICT enters the socio-cultural setting of the school, it ‘weaves itself into the learning in many more ways than its original promoters could possibly have anticipated’.

Activity Theory as framework of study
Evaluations of the effectiveness of the integration of ICT into teaching and learning had lead to the development of various frameworks. One of which is Activity Theory that, according
to Karasavvidis (2008), is a promising theoretical framework for the study of tensions in an activity system. Activity Theory according to Engestrom as cited by Karasavvidis (2008) provides an indispensable theoretical tool for understanding conflicts and inconsistencies between and within the components of an activity system. Activity Theory can best be explained in terms of its key terms: internalization, mediation, subject, object, tool, transformation (process), rules, community, division of labour, and outcomes (Mlitwa & Van Belle, 2010). The Activity Theory views a research context as a collective work with a common objective between individual and group actors. In other words, teaching and learning is not an individual isolated exercise but a collective activity that is carried out either by individuals or groups (Mlitwa & Van Belle, 2010).

Various researches had been conducted utilizing Activity Theory to best evaluate the effectiveness of ICT integration in the teaching and learning process. Karasavvidis (2008) reported the following aspects that help in understanding the patterns of using online resources in two ways:

1. There are different approaches to learning that different students take. This means that for some students, the engagement with the materials will be very high and more online resources will be considered by them as useful ‘learning sources’. On the other hand, for other students, this is less likely not to be the case. For such students, more online resources may be interpreted as creating ‘more trouble’ in their learning. What is promising is that blended learning has the flexibility to support both types of students while only the most devoted ones will be benefitted from it.

2. ‘More’ can be ‘too much’ and can be conveniently ignored by the students- especially if it is not very deeply integrated into the course requirements. While students appear to be in favour of more materials in terms of “more options”, some students will simply not view the material. It appears that the majority of students will only view the online resources provided if these are deeply integrated not only into the course structure but - most importantly – into the course assignments. Again, blended learning can offer a very promising solution in this direction.

Kekwaletswe as cited by Mlitwa and Van Belle (2010) found that Activity Theory helps to illustrate an effective analytical tool to interpret the phenomenon of “mobile learning”, the technologies, influencing factors and the context in which mobile learning takes place. Furthermore, Karasavvidis (2008) said that the use of Activity Theory suggests that some important insights can be gained from blended learning.

It is very interesting to note the words of Salomon as cited by Lim and Hang (2003): “No tool is good or bad in itself; its effectiveness results from and contributes to the whole configuration of events, activities, contents, and interpersonal processes taking place in the context of which it is been used.” (p.54)

Science teachers are concerned about helping students to become critical thinkers, problem solvers and scientifically literate citizens. One of the methods for encouraging students to develop higher order thinking is Project-based Activities (PBA). PBA involves designing learning experiences around projects (Sherman & Sherman 2004). The core idea of project-based learning is that real-world problems capture students’ interest and provoke serious thinking as the students acquire and apply new knowledge in a problem-solving context. Adopting a PBA approach can invigorate the learning environment, energising the curriculum with real-world relevance and spark students’ desire to explore, investigate, and understand their world.
Hoban (2007) defined Slowmation as ‘Slow motion animation’ which is a new teaching approach that uses a simple animation process to engage learners in creating their own comprehensive animations of science concepts. He added that this approach simplifies the complex process of making animations to enable pre-service teachers to create comprehensive animations about science concepts. The entire concept is based on more hands-on and minds-on classroom activities which makes students to learn pedagogical concepts in the simplest way. He argues that it is much better than learning through simulation because students are researching information, scripting, storyboarding, designing models, capturing digital still images of small manual movements of the models, and using computer programs such as QuickTime Pro to play the images in a sequence to simulate movement.

Chen and Howard (2010) examined the effect of live simulation on students’ science learning and attitude. The study also found that the change in student’s science learning was significantly influenced by the teacher. The classroom preparation for the simulation experience proved vital to students’ attitudes toward science as well as their scientific understanding. Chen, Hong, Sung and Chang (2011) studied the learning performance of students using simulation. The study indicates that the learning performance was higher for learning software utilizing simulative manipulation and visualization yields than for that lacking simulative manipulation, which suggests that learning performance can be enhanced if visualized learning can appropriately integrate simulative manipulation activities.

The constructivist learning theory posits that knowledge is actively constructed by learners rather than transmitted by the teacher; learners are active knowledge constructors rather than passive information receivers (Wang, 2008; Jonassen, 1991). Cognitive constructivists believe learners construct knowledge individually based on their prior experience, supported by new information and communication tools such as WEB 2.0 tools. WEB 2.0 tools are the new wave of innovation in teaching and learning of science. It allows students to do collaborative learning. For instance, blog is used as a learning management system (LMS) where students can share their ideas, prepare digital portfolios, download resources from other websites, give feedback to teacher’s contents and so on. Even one can develop an online questionnaire/test/quiz using third party tools such as Zoomerang. The integration of blogs in the traditional teaching and learning process requires preparation and planning on the part of the teacher so that applicable and timely activities could be given to the students (Arnold Nicholas, 2010). Another study by Alan (2010) highlighted that Middle East countries such as Israel, Saudi Arabia, United Arab Emirates and Qatar have made substantial investments in web-based learning and concluded that students were motivated by WEB 2.0 tools.

Research Questions, Framework and Data Collection
This section will brief on the research questions anchored on the two objectives of the study with the illustration of the conceptual framework and elaboration on the data collection activities.

Research questions and hypotheses
As stated earlier, this paper aims to report on the evaluation of the science teachers’ perceived levels of competency and knowledge after their participation in a CPD programme conducted at RECSAM in April 2011 that was related to the use of ICT tools in science teaching. It also aims to develop a comprehensive learners’ efficiency framework through structural equation
modelling (SEM) to conceptualize the role of ICT tools to promote constructivist science learning. The following are the research questions.

**Research Question 1 (RQ1):**
Are there evidences of enhanced perceived levels of competency and knowledge among participants who attended the Regular Course RC-SS-135-3 at RECSAM that focussed on the use of ICT tools in science teaching?

H₀: There is no evidence of enhanced perceived levels of competency and knowledge among participants who attended the Regular Course RC-SS-135-3 at RECSAM that focussed on the use of ICT tools in science teaching.

H₁: There is an evidence of enhanced perceived levels of competency and knowledge among participants who attended the Regular Course RC-SS-135-3 at RECSAM that focussed on the use of ICT tools in science teaching.

The hypothesis is that the participants would have increased their perceived levels of competency and knowledge after they attended the in-service course at RECSAM on the use of ICT tools in science teaching. The variables that reflect the enhanced perceived levels of competency and knowledge are the difference of scores between pre-test and post-test administered before and after the in-service course. This RQ1 is set for the preliminary or exploratory study which leads to RQ2.

**Research Question 2 (RQ2):**
Do ‘content, feedback, user interface, ease of use and satisfaction on use’ play important roles in ICT tools to promote constructivist science learning and improve learners’ efficiency?

H₁: Appropriate ‘content in ICT tools’ will improve the learner’s efficiency

H₂: Appropriate ‘feedback through ICT tools’ will enhance the efficiency of ICT tools and improve learner’s efficiency

H₃: Appropriate ‘user interface in ICT tools’ will enhance the efficiency of ICT tools and improve learner’s efficiency.

H₄: Appropriate ‘ease of use of ICT tools’ will enhance the efficiency of ICT tools and improve learner’s efficiency

H₅: High ‘satisfaction on use of ICT tools’ will improve the learner’s efficiency

**Conceptual framework of the study and Research model**
The following are the variables identified relevant to the framework of study:
**Dependent variable** — Efficiency of ICT tools and/or Learner’s Efficiency. The dependent variables were derived from existing literatures and adapted for discussion in the analysis of items in the instruments.

Fourteen survey questions or instrument items were used to measure the following 5 independent variables in this study.

**Independent variable (1) — Content (CO).** The content is related to the quality and effectiveness of the knowledge transmission. The materials used to illustrate the features of ICT tools are easy to understand, must also be simple and clear for the learners. In line with the past literature, the aforementioned hypothesis H₁ is developed.

**Independent variable (2) — Feedback (FB).** The students can effectively communicate through online tools for feedback (for instance through Blog, Wufoo, and so on). In line with the past literature, the above hypothesis H₂ is developed.

**Independent variable (3) — User Interface (UI).** The ICT tools with user interface (including Blogger, Wordpress) introduced are well-designed with ‘drag and drop’ option. In line with the past literature, the above hypothesis H₃ is developed.

**Independent variable (4) — Ease of Use (EU).** The software introduced in the course is easy to use because of its features and ‘drag and drop’ facilities in the menu. In line with the past literature, the above hypothesis H₄ is developed.

**Independent variable (5) — Satisfaction (SF).** Satisfaction relates to perception of being able to achieve success and feelings about the achieved outcomes from the course. In line with the past literature, the above hypothesis H₅ is developed.

**Sampling, instrument, variable measurement and data collection activities**
The target population of this study were teachers working in schools in the Philippines. A total of 98 hardcopies of surveys were distributed to these participants of the ICT tools.
workshop in June 2011. Out of the 98 survey forms distributed, 82 were received (83.7% response rate) while 16 were incomplete. Therefore the total usable questionnaire in this study was 82 which included 31 male (37.8%) and 51 female (62.2%), and with 64% teachers with a Masters degree and the rest Bachelors degree (36%). Hair, Black, Babin and Anderson (2006) stated that the appropriate minimum sample size for a research is to have 15 observations for each independent variable. As there are 5 independent variables measuring learning effectiveness of ICT tools in this study, a minimum sample size of 75 is needed. Since there were 82 respondents involved in this study, the sample size for this research was considered adequate.

The first part of the study in response to RQ1 involved an in-service training Regular Course entitled RC-SS-135-3 that was held at SEAMEO RECSAM in April 2011. This CPD programme focussed on the use of ICT tools in science teaching. All thirteen participants from the eleven SEAMEO countries participated in this study. Prior to the training programme, a pre-test was administered to the participants to identify their prior knowledge and levels of competence in relation to ICT tools for science teaching. After the conduct of training course, a post-test was administered to the participants to explore their enhanced perceived levels of knowledge and competency on various topics introduced in the course.

The second part of the study in response to RQ2 involved a five days hands-on and minds-on training workshop conducted by one RECSAM participant from Philippines who attended the RC-SS-135-3 course and implemented her multiplier effects activities upon completion of course as one of the requirements of CPD. In addition, the data collected from this activity was also used to develop a comprehensive learners’ efficiency framework using structural equation modelling (SEM) to conceptualize the role of ICT tools to promote doing science. The following topics were included in the workshop: (1) Simulation concepts: Demonstrate the use of simulations in science teaching and learning (for instance using PhET simulation from URL: phet.colorado.edu); (2) Slowmation (i.e. Slow animation): Demonstrate the use of slow animation techniques in science teaching and learning; and (3) Web 2.0 Tools: Demonstrate the use of various Web 2.0 tools in science teaching and learning.

A survey instrument was designed to develop a research model based on the framework identified as shown in Figure 1 with hypothesis testing activities. Following the advice from Toral, Barrero, Martinez-Torres, Gallardo and Duran (2009), the majority of the items were developed for each construct from review of past literatures. The survey consists of 47 questions to measure the constructs relevant to this study. Each question was measured by five-point Likert scale. For instance, ‘1’ denotes ‘strongly disagree’, ‘2’ denotes ‘disagree’, ‘3’ denotes ‘neutral’, ‘4’ denotes ‘agree’ and ‘5’ denotes ‘strongly agree’. In order to ensure that the survey items used to measure the variables are reliable, the reliability analysis using Cronbach’s Alpha (CA) was applied. The analysis of data showed that all the CA values are greater than 0.70, that is, Content (0.871), Feedback (0.789), User Interface (0.891), Ease of Use (0.867), and Satisfaction (0.917). Table 1 shows one of the items for each dimension in the questionnaire.
Table 1  
--- Dimensions and an Item for each Dimension of Instrument with its Reliability and Validity ---

<table>
<thead>
<tr>
<th>Dimensions (No. of items)</th>
<th>Item</th>
<th>Factor Loading</th>
<th>AVE</th>
<th>CR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content (3 items) (0.871)</td>
<td>The materials used to illustrate the features of ICT tools are easy to understand.</td>
<td>0.891</td>
<td>0.815</td>
<td>0.769</td>
</tr>
<tr>
<td>Feedback (3 items) (0.789)</td>
<td>Feedback can easily be given through online comments for ICT tools.</td>
<td>0.762</td>
<td>0.805</td>
<td>0.760</td>
</tr>
<tr>
<td>User Interface (2 items) (0.891)</td>
<td>The ICT tools introduced are well-designed.</td>
<td>0.874</td>
<td>0.893</td>
<td>0.868</td>
</tr>
<tr>
<td>Ease of Use (2 items) (0.867)</td>
<td>The ICT tools introduced help me to design and use teaching and learning activities in my classroom.</td>
<td>0.799</td>
<td>0.806</td>
<td>0.781</td>
</tr>
<tr>
<td>Satisfaction (4 items) (0.917)</td>
<td>I am satisfied with the ICT Tools introduced</td>
<td>0.871</td>
<td>0.844</td>
<td>0.812</td>
</tr>
</tbody>
</table>

Data Analysis and Discussion of Findings

**Research Question 1 (RQ1):**
Are there evidences of enhanced perceived levels of competency and knowledge among participants who attended the Regular Course RC-SS-135-3 focusing on the use of ICT tools in science teaching?

The observed t test between pre- and post-test score is 2.273. Since the value of t is 15.947 at p=0.000 < 0.05, the mean difference (2.273) between the pre-test and post-test is statistically significant. Since the sig. of p=0.039 is less than 0.05, hence the null hypothesis 1 is rejected. Therefore, it can be inferred that the Regular Course RC-SS-135-3 was effective to improve the participant’s perceived levels of knowledge and competency on ICT tools.

**Research Question 2 (RQ2):**
Do ‘content, feedback, user interface, ease of use and satisfaction on use’ play important roles in ICT tools to promote constructivist science learning and improve learners’ efficiency?

To assess the extent and the specific nature of ‘learner efficiency’, the different dimensions of the roles of ICT tools were taken into consideration. A structural and measurement model taking into account all dimensions, must be defined. Up to 5 dimensions were identified, including Content (CO), Feedback (FB), User Interface (UI), Ease of Use (EU), and Satisfaction (SF) as shown in Table 1, were considered in order to assess learner’s efficiency.

The research model as illustrated in Figure 1 was analyzed using ‘Structural Equation Modelling’ (SEM). The data analysis was conducted following the steps: (i) Investigating the assumptions of multivariate analysis, (ii) Examining the measurement models for each factor
using confirmatory factor analysis (CFA), and (iii) Testing the research model using SEM. The above-mentioned steps are discussed in the following subsections.

I. Investigating the assumptions of multivariate analysis
The skewness and kurtosis of the variables fall within the acceptable ranges of (± 1), therefore the data is normally distributed (Garson, 2007). The correlation coefficients for the independent variables were less than 0.90, thus confirming that multicollinearity did not exist.

II. Examining the Measurement Model using Confirmatory Factor Analysis (CFA)
The measurement model included 19 items explaining five dimensions: content (CO), feedback (FB), user interface (UI), ease of use (EU) and satisfaction (SF).

In relation to this study, the CFA indices for all the five dimensions are above 0.9 levels which implied the evidence of unidimensionality (Al-Hawari & Ward, 2006).

As shown in Table 2, the square root of the average variance extracted (AVE) on the diagonal of all latent constructs exceeded the benchmark of 0.7 (Nunnally, 1978), implying that the measurement is acceptable.

| Latent Constructs Correlations using ‘Structural Equation Modelling’ (SEM) |
|-----------------|---|---|---|---|
| CO              | 1.000 | FB | 0.298** | 1.000 |
| FB              | 0.574** | 0.547** | 1.000 |
| UI              | 0.289** | 0.557** | 0.455** | 1.000 |
| EU              | 0.261** | 0.434** | 0.322** | 0.344** | 1.000 |

N = 82; **p < 0.01; Diagonal elements (in bold) are the square root of the AVE.

III. Testing the research model using Structural Equation Model (SEM)
The structural model has a well fit as determined from the Chi-square index (χ² = 1.319; p-value = 0.267 > 0.05) as well as other indices (GFI = 0.991; AGFI = 0.934; CFI = 0.994; NFI = 0.977; RMSEA = 0.052). All the model-fit indices exceeded their respective common acceptable levels, recommending the structural model displayed to represent an acceptable model fit to the data. (Hair et al., 2006)

Hypothesis testing
The statistical significance of all the structural parameter values was examined to determine the validity of the hypothesized paths. The analytical results revealed that content [Critical Ratio (CR) = 3.162; p < 0.01], feedback (CR = 3.659; p < 0.01), user interface (CR = 3.221; p <0.01), ease of use (CR = 2.987; p<0.01) and satisfaction (CR = 3.661; p<0.01) were found to have a significant and positive relationship with learners efficiency.

In reference to the analytical results of the data as presented in the preceeding paragraph, the following are revealed:
- Appropriate ‘content in ICT tools’ improved learner’s efficiency;
• Appropriate ‘feedback through ICT tools’ enhanced efficiency of ICT tools and improve learner’s efficiency;
• Appropriate ‘user interface in ICT tools’ enhanced efficiency of ICT tools and improve learner’s efficiency;
• Appropriate ‘ease of use of ICT tools’ enhanced efficiency of ICT tools and improve learner’s efficiency; and
• High ‘satisfaction on use of ICT tools’ improved learner’s efficiency.

Conclusion

Summary and research implications
In this study, learner efficiency has been modelled using Structural Equation Modelling (SEM) Analysis of Moment Structures (AMOS). Learners’ efficiency is positively impacted when the ‘content’ is transmitted through adequate ‘user interface’, when the interaction with instrumentation equipment and tools easy and adequate to the students’ level, and when they feel motivated by the work they are required to do. The model distinguishes five pure independent variables: content, feedback, user interface, ease of use and satisfaction of the workshop course.

The ‘content’ dimension is improved by planning new ICT tools in the classroom. The ‘user interface’ dimension is improved through the application of a learning management system while the ‘ease of use’ dimension is enhanced using multimedia technologies and contents to improve the learning processes. The inclusion of collaborative and cooperative hands-on minds-on activities improves competences like teamwork and collaboration skills. Finally, the ‘feedback’ dimension is promoted by having a forum (http://forum.sp3aceman.net).

Limitations and future directions of the research
There were some potential limitations for this study. First, the research data for the second part of the study has been collected from the workshop in Philippines by ex-RECSAM’s participant. Second, the sample size is relatively small, hence difficult to make generalization. Third, the framework included only 5 dimensions and there may be more constructs that are relevant to use of ICT tools for science teaching that had not been identified.

A similar type of study could also be replicated in other countries and even conduct cross-country analyses to compare if the results are consistent in the SEAMEO region. Perhaps other dimensions such as learner community, previous experience and learner responsibility could also be included. The future model may also incorporate some moderators such as age, gender, culture to see if there is any influence on learner’s efficiency.

References


CONSTRUCTION OF MODUL CELIK MOL TO INCREASE THE EFFECTIVENESS OF THE PROCESSES OF TEACHING AND LEARNING SCIENCE

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Abstract
Effective teaching module is needed in the teaching and learning of science process to enhance students' construction of concepts. This study develops a teaching module, 'Modul Celik Mol' to help overcome an alternative framework problem and enhance math skills for the topic of mole concept among students. This module is built based on analogy methods of teaching. In addition, various additional elements such as consolidation and evaluation activities were applied. To assess the appropriateness and effectiveness of this module, twelve chemistry teachers in the district of Johor Bahru were chosen as respondents. Data were collected using a set of questionnaire and analyzed by using descriptive statistics involving frequency and percentage. The findings showed that all respondents gave positive opinions on the suitability of the module to be applied in the process of science teaching in schools and it also can enrich the references material for students in chemistry subject. This study certainly opens a new chapter in the world of effective teaching of science education.

Introduction
Chemistry is one of the most important subjects taught in schools in Malaysia. In this country, achievement reports of Sijil Pelajaran Malaysia (SPM) in 2003-2004 stated that the topics of 'chemical formulas and equations', 'atomic structure', 'periodic table', and 'chemical bond' are among the basic chemistry subjects needed to be stressed (Kementerian Pendidikan Malaysia, 2004). However, most students have problems in those chemistry topics, which contain the foundations of mathematics such as the topic of 'chemical formulas and equations' (Aziz & Hasnah, 1990; Gilbert & Watts, 1983; Md Nor & Nur Afza, 2010). This topic requires students to have a strong mathematical foundation to enable them to understand the mathematical concepts are used in chemistry subjects. The mole concept is one of the main concepts taught in "chemical formulas and equations." It is important because it is the main thrust used in the next chemistry topic such as rate of reaction, oxidation and reduction and thermo chemistry. Students often have a problem with the mole concept because they do not understand it clearly. If students cannot understand the concept, then they will not understand the next topics connected with the concept. This issue is then associated with building an alternative framework in the construction of this concept in students' minds.

Students Difficulties in Mastering the Mol Concept
Many researchers have stated that chemistry is a subject which contains many difficult to understand and abstract concepts (Gabel, 1999; Yalcinalp, Geban, & Ozhan, 1995). The mole
concept is one and it also is of the most important subtopics in chemistry. The word 'mole' is a uniquely chemistry concept (Uce, 2008). The word comes from Latin that is 'moles', which means heap or pile. In chemistry, the word mole gives meaning of a pile or heap of atoms, molecules, ions, and so on. The learning and teaching processes in chemistry for the mole concept is a major challenge to teachers and students because the it involves many mathematical calculations, new chemistry terms and abstract facts that are difficult to master by the students, especially students who are weak in math skills (Gabel & Sherwood, 1984; Niaz, 1996; Reid & Yang, 2002). The difficulties in mastering the mole concept can be divided into two alternative frameworks the mole concept and the mathematical skills associated with the mole concept.

Alternative Framework for Mole Concept
Studies have shown that there is a variety of alternative framework in mastering the mole concept. Among them are (1) difficulty in mastering moles terms that are various and misleading. The basis of misleading the mole is in the definition of 'standard units for the amount of a substance'. Cervellati, Montuschi, Perugini, Grimellini-Tomasini, and Pecorini Balandi (1982) examined 13 chemistry textbooks used by schools in Italy. Most of the text gave no precise definition and some textbooks even gave a false definition. (2) Failure to build a relationship of moles to mass, volume and number of particles. The study found that students became confused when the concept of moles was associated with volume and mass of different materials. There was a variety of disagreements when it was alleged that the mole is the quantity of material containing a certain number of particles or a unit of the part while others believed that the mole was a unit of calculation. Uce (2008) in his study stated that students could not link molar mass and relative atomic mass, and the relationship between molar mass and relative atomic mass to the mole and atom mass unit.

Math Skills Problem for Mole Concept
The second problem faced students learning the mole concept was related to mathematical skills. Mathematical knowledge is knowledge of the calculations in the mole concept. Students who do not master this knowledge have difficulty solving the mole concept problem. The problems related to mathematical skills can be divided into three kinds. First is the algorithm. In the mole concept, the algorithm needs to be applied rigorously to solve the problem according to the rules or procedures, step by step until one gets the answer. According to Frazer and Servant (1987) students faced difficulties since they were unable to bring the problem to its solution because of a lacking in knowledge of the algorithm. Thus, algorithm knowledge can assist and guide students in solving problems with the mole concept in accordance with the step by step procedure until the end (Abdul Rahman, 2005). The second reason is mathematics. BouJaoude and Barakat (2000) found that low mathematical reasoning among students made it difficult to understand the mole. They felt that these difficulties could be reduced by distinguishing between the quantity with the number and replace moles in stoichiometric calculations with a particle number as a unit of computation. The third reason is standard form of numbers. According to Esguerra and Punzalan (1983), difficulties with the moles concept were due to the standard form of numbers. The value of $6.02 \times 10^{23}$ is too large and it is also a difficult figure for students to do mathematical calculation if the rules needed for these operations weak in the students. Mathematical operations such as multiplication and division involving these numbers add to the difficulty because it involves the decimal point and exponent.
Clearly the variety of problems mastering the mole concept is very important and is basic to many more complex chemistry concepts. Consequently, effective teaching strategies are needed to help students overcome their problem in the concept construction process.

**An Effective Teaching Strategy for Understanding of the Mole Concept**

Teaching strategies based on efforts to help students overcome problems in constructing the mole concept should be implemented. Therefore, this research chose an effective teaching strategy, which was the analogy method in devising the ‘Modul Celik Mol’. This method provided an opportunity for students to develop the mole concept by themselves through understanding and knowledge. The analogy method is a teaching technique using 'parable' to represent a concept to be taught (Allan & Richard, 2008). This method helps students to improve their knowledge in scientific concepts. This method is important in describing an object or process, especially on something which cannot be seen such as atoms and molecules. This method gets attention because it is able to explain easily the ideas of abstract learning. The three principles for the use of analogy are focus, action and reflection (Allan & Richard, 2008). Through this strategy, students can be guided to overcome their difficulties in mastering the mole concept. Therefore, this study seeks to build ‘Modul Celik Mol’ based on the topic of the mole concept using these three teaching strategies in an effort to help students to master the concept effectively. Based on the teachers’ opinion, this study also evaluates the effectiveness of the module in the teaching process.

**Construction of ‘Modul Celik Mol’ Based on Effective Teaching Strategies**

‘Modul Celik Mol’ was developed as a guide to teachers in overcoming the existing problems in teaching the mole concept (Figure 1).

![Diagram](https://via.placeholder.com/150)

**Figure 1. Design for the Construction of ‘Modul Celik Mol’**

This module was developed through four stages, namely (1) identify students' problems in mastering the mole concept, (2) select effective strategies to overcome students’ problems, (3) apply strategies to overcome students’ problems, and (4) build ‘Modul Celik Mol’. It was also built based on the syllabus issued by the Curriculum Development Centre (2005). The design contains four main components: module application guide, mole concept and the difficulty to master it, strategies (analogy) to overcome the difficulties and self reflection. It is
presented in the form of text and graphics to facilitate the use of this module. Here is an example of the module content (Figure 2) of the analogy strategy. It gives the analogy of an area consisting of five islands and it is used to show the analogy to the topic of the mole concept.

**KISAH PULAU BESTARI**

Through this module the teacher can explain the similarities between the pictures of the story of Bestari Island with the mole concept. Students can be guided to understand the relationship between moles, mass, volume and number of atoms with how that can be used to convert the units of each concept. It becomes very important to realize the relationship between each concept would explain possible conversion unit. It also explains the concept of the mole as a single entity such as dozen is a standard measurement unit (Gabel & Sherwood, 1984). Recognizing the difficulties students faced in order to understand this relationship, analogy serves to develop students' understanding by giving easier, concrete and meaningful examples (Allan & Richard, 2008). For example, if students want to know the number of particle in 12g of carbon, they have to convert it to mole unit first (12g is equivalent to one mole). Then, students need to convert it to the number of particle by multiplying it with Avogadro constant (6.02x10²³ particle). In order to assist students’ understanding, they can form an analogy by associating the task with someone’s journey from Pintar Island to Cerdik Island and they have to go through Bestari Island first. The teaching stages using the Analogy
method can be summarized as in Appendix A. Overall this module provides guidance to teachers to teach the moles concept overcome students’ learning difficulties.

Suitability of Modul Celik Mol in the Teaching Process
To assess the suitability of the built modules, a set of evaluation forms was developed and validated by two experts. To improve reliability, a pilot study was conducted on three chemistry teachers. Feedback received indicates that the instrument used is easy to understand, consistent with the level of respondents and able to measure the objectives of the study. Then, the instrument was distributed to twelve chemistry teachers in the district of Johor Bahru. The respondents were randomly selected. Data were analyzed using descriptive statistics involving frequency and percentage. Results of the study are discussed based on the three categories content, teaching strategies and general assessment.

Content
Result of the analysis as in Table 1 shows that the respondents were satisfied with a few of the items in the assessment module. This is shown by the 100 % percentage in those items as shown in Table 1. The figure proves that the module achieved its objectives in some aspects especially its suitability with the syllabus, relation with students’ prior knowledge and organization of contents. It is also easy to understand and appropriate to the target group. In general, the respondents agreed that the contents of the modules were organized. This allows a more structured, orderly and efficient learning.

Table 1
Suitability of Module Content

<table>
<thead>
<tr>
<th>Item</th>
<th>Agree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The teaching content is suitable with the syllabus</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>2. No error in content</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>3. Teaching material is easy to understand</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>4. Teaching is relevant with daily application</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>5. Information is related with students’ prior knowledge</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>6. Content is organized</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>7. Delivery language is easy to understand</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>8. No error in spelling</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>9. Difficulty levels of the term, approach and content are</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>appropriate to the target group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Teaching is available and suitable to be used by the target group</td>
<td>12</td>
<td>0</td>
</tr>
</tbody>
</table>

Average Percentage Distribution 83.3 16.7

This finding is supported by Rashidi and Abdul Razak (1995) who stated that the delivery of orderly and smooth learning content would facilitate the process of teaching to be done in three stages, beginning of lesson, development and closing. With an average of 83.3 % the respondents indicated that the content of the modules was very good. This result means that majority of the respondents were with the content of the module. However, there is a weakness such as a few spelling errors in the instruction and examples. Some of the respondents (33.3 percent) mentioned that the content materials are difficult to understand and irrelevant to their daily application. This feedback may be referred to the examples on
Bestari Island which are less meaningful and not related to the students’ daily lives. According to Mohd Ali, Ahmad Nurulazam, and Zurida Ismail (2003) contextual examples of the contextual nature can facilitate interpretation and assist in the process of relating a concept with experience and existing knowledge.

**Teaching strategies**

Results of the analysis show that the respondents were very satisfied with a few of the assessment items of the module. This notion was shown by the 90.36 per cents who agreed that the module had achieved its objectives in introducing an alternative teaching strategies for teachers, these are given in Table 2. All respondents agreed that the learning objectives are clearly written. In addition, the set induction is effective and attractive. It also encourages creativity and concepts construction. They also agreed that the teaching strategies in the module allow students to participate in the teaching and learning process. Overall, the method was able to help them formulate their effective teaching strategies to help students master the mole concept.

**Table 2**

<table>
<thead>
<tr>
<th>Teaching strategies</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>N</td>
</tr>
<tr>
<td>1. Learning objective is clearly written</td>
<td>12</td>
</tr>
<tr>
<td>2. Learning objective can be achieved</td>
<td>8</td>
</tr>
<tr>
<td>3. Effective set induction</td>
<td>12</td>
</tr>
<tr>
<td>4. Organized delivery</td>
<td>12</td>
</tr>
<tr>
<td>5. Teaching method attracts attention</td>
<td>12</td>
</tr>
<tr>
<td>6. Teaching method encourages active learning</td>
<td>11</td>
</tr>
<tr>
<td>7. The user was encouraged to be creative</td>
<td>12</td>
</tr>
<tr>
<td>8. Module encourages concept construction</td>
<td>12</td>
</tr>
<tr>
<td>9. Subtopics were linked nicely</td>
<td>11</td>
</tr>
<tr>
<td>10. Students were involved in teaching and learning</td>
<td>12</td>
</tr>
<tr>
<td>11. Analogy method was suitable in teaching mol concept</td>
<td>11</td>
</tr>
<tr>
<td>12. Contextual method was appropriate to teach the mole concept</td>
<td>10</td>
</tr>
<tr>
<td>13. Problem-solving method was suitable for teaching the mole concept</td>
<td>12</td>
</tr>
<tr>
<td>14. Diversity of methods could assist in the teaching process</td>
<td>12</td>
</tr>
</tbody>
</table>

**The average percentage distribution**

This result is supported by the effectiveness of the teaching method (analogy) in science teaching. For example, using the analogy method, Black and Solomon (1987) examined how students used an analogy to understand electrical current. This notion also supports the constructivist theory of analogy allowing students to build knowledge by themselves by forcing them to see new knowledge within the analogy framework. It is also supported through the use of the contextual method. The contextual approach states that learning occurs only when students (learners) process information or relevant knowledge new to them in their reference frame (Centre for Occupational Research and Development, 1999). Learners will develop their own knowledge through the learning progress. Similarly, the use of the problem-solving method was also tested in other research. Ausubel, Novick, and Hanesian (1978) focused on problem solving as a form of composite learning and high cognitive activity helping in the process of obtaining meaningful learning. In contrast to memorized learning, meaningful learning can help students to understand concepts. Through memorized learning, students can only remember but lack of understanding of the concepts.
General assessment
Table 3 shows the general responses of teachers for the purpose of the improvement of this module. All respondents thought the analogy method used in this module is very effective and some teachers assumed that the Bestari Island story and strategy implementation (analogy) presented in this module is the most favoured aspects. However, a few respondents suggested that there should be more examples of analogous (66.7 percent) and the examples should be contextual in order to assist students in developing effective meaning (66.7 percent).

Table 3
General Assessment

<table>
<thead>
<tr>
<th>ITEM</th>
<th>RESPONSES</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The most preferred aspects</td>
<td>Teaching method</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>How to implement</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>Bestari Island story</td>
<td>33.3</td>
</tr>
<tr>
<td>2. The aspect mostly in need of</td>
<td>Less of contextual examples</td>
<td>66.7</td>
</tr>
<tr>
<td>improvement</td>
<td>Need more analogy example</td>
<td>33.3</td>
</tr>
<tr>
<td>3. Suggestion to improve</td>
<td>Present more contextual examples</td>
<td>66.7</td>
</tr>
<tr>
<td></td>
<td>Present more analogy examples</td>
<td>33.3</td>
</tr>
<tr>
<td>4. The effective method to teach the mole</td>
<td>Analogy method</td>
<td>100</td>
</tr>
<tr>
<td>concept</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Will you suggest this module to other</td>
<td>Yes</td>
<td>100</td>
</tr>
<tr>
<td>people?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Suggestion and overall comment</td>
<td>Creative Module</td>
<td>66.7</td>
</tr>
</tbody>
</table>

With the percentage of 100%, all respondents strongly agreed that the analogy method was an effective method to teach the mole concept. As stated earlier, the analogy method is a teaching technique that uses a 'parable' which is used to represent a concept to be taught. The story of Bestari Island was used to attract the interest of students to understand the mole concept, and gain meaningful knowledge in the mole concept. The effectiveness of the use of the analogy method in the mole concept is proven through previous research. Furio, Azcona, and Guisasola (2002) stated that the problems and difficulties to understand the concept of mole can be overcome by the use of the right analogy. In the present study, all of the respondents also agreed to suggest the module other teachers, because the method helps facilitate the process of teaching and learning. Furthermore, respondents also said that the module is very interesting and creative.

This study shows that the method used in the module is attractive and affordable to help students understand the lessons. In contrast to conventional learning, where students rely on teachers and memorization systems, students can easily bore and do not acquire proper knowledge. This is supported by Tengku Sarina and Yusmini (2006) when she mentioned that the effective teaching methods could increase students’ motivation in learning by stimulating interest and enthusiasm. Students will not be bored if they are interested in the learning process.

Conclusion
One of the efforts to obtain effective teaching is through the use of a module based on analogy teaching methods. It can also organize and systematize the teaching and learning
processes. In addition, students can be motivated to be interested in learning and thinking critically.

Acknowledgement
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References


Center for Occupational Research and Development. (1999). Teaching Science Contextually. Texas: CORD.


APPENDIX A: Example of lesson

Subject: Chemistry  
Form: 4 Arif  
Time: 1 hour  
Topic: Numbers of mole  
Objective: At the end of this lesson, students will be able to develop ideas about mole.

Prior knowledge: Students already know the definition of mole.

Teaching and Learning Activities:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activities</th>
<th>Learning Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus Phase</td>
<td>Teacher tells Bestari Island story to the students with Diagram and makes an analogy with mole concept.</td>
<td>Students make a relationship between journeys in Bestari Island story with change a unit in mole concept.</td>
</tr>
</tbody>
</table>
|             | Teacher gives an example to the students to make a relationship between Bestari Island and Mole concept using Bestari Island story:  
*If I am at Pulau Bestari and I want to go to Pintar Island, which pathway that I need to choose?*  
Answer: C→E  
Then, teacher gives another example:  
*If I am at Cerdik Island and I want to go to Pintar Island, which pathway that I need to choose?*  
Answer: B→C→D  
Teacher explains the relationship between Bestari Island story with mole concept using a diagram. | |
| Action Phase| Teacher gives a question about the concept of mole to the students and instructs students to answer.  
Question:  
*Find the mass of 3 moles of oxygen atoms*  
Students are required to use the figure earlier taught as a reference.  
Teacher checks students’ answers and the process of discussion. Teacher gives students tips on how to answer the questions given. | Students can evaluate their understanding of the mole concept and story analogy Bestari Island |
| Reflection Phase| Teacher assesses students understanding by providing a new and more difficult question.  
Question:  
*Find the number of molecules in 6 dm³ of nitrogen gas.*  
Teacher will see if students are able to answer the question and discussions with students will be conducted.  
Teacher identifies strengths and weaknesses of the method of analogy in the process of teaching and learning. | Students strengthen their understanding of the concept of moles in the title. |
INVESTIGATING HERBAL MEDICINE IN THE COMMUNITY: WEBQUEST ACTIVITY

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Abstract
The researcher designed a WebQuest Activity in teaching Herbal Medicine. Students investigated the practices of local herbalists by gathering Indigenous Technical Knowledge (ITK) about herbal plants. Working in groups, students conducted interviews, analyzed data and laid out relevant outcomes. Scaffolding materials were provided to students as they brainstorm ideas, collect data, process information and create products. The students developed information drive materials to educate the community about herbal plants and their pharmacological properties. During the conduct of the said activity, the teacher and the students used rubrics to reflect on their output. A significant increase was found in the pretest and posttest scores of the students. Students expressed that in the process of creating the product, they developed 21st century skills such as collaboration, self direction, technology literacy and creativity. The researcher then recommends that teachers should design lessons that will connect course content and community issues. In doing so, students will become responsible for their learning.

Keywords: Herbal Medicine, WebQuests, Collaboration

Introduction
Most students nowadays have easy access to the Internet, email and all types of social networking sites. They are also familiar with productivity tools such as word processing, multimedia presentation, database and other tools that foster creativity. The same technological advances have changed today’s classrooms. As such, developing activities in the classroom that utilize the said tools is empirical.

A WebQuest is wrapped around doable and interesting tasks that require higher level of thinking. The way and process involved in designing the activity discourage students from simply copying information from the Internet. Students need to evaluate the information that they gather from various resources.

The designed WebQuest activity consists of key elements including introduction which gives an overview of the investigation, task which specifies the expected output, process that briefly describes the procedure; resources that includes the online and community resources; evaluation which includes rubrics, self and peer assessment and conclusion that summarizes the activity. The said elements ensure that students gain knowledge from the activity conducted.

For this reason, the WebQuest activity combined with an authentic task could be an indispensable means to motivate students to perform and participate in the lesson. The
designed activity develops higher order thinking skills of the students as well as collaborative skills.

Objectives of the Study
In this study, the researcher aimed to develop and implement a WebQuest activity for Herbal Medicine class.

Review of Related Literature

Technology in Teaching
Using technology in the classroom provides students with the skills they need to become lifelong learners in an information age. With the emergence of computers and the Internet as integral parts of life today, the process of using and communicating knowledge now requires the use of technology. As such, teachers must use technology in their own class and model appropriate technology use in their teaching. They should be trained and must be provided with the materials they need in teaching with the integration of technology (Sherman & Sherman, 2004).

WebQuest
A WebQuest is a lesson originally designed by Bernie Dodge of San Diego State University. It is a teacher-created lesson plan in the form of a simple World Wide Web page with active, pre-selected Internet links and a specific purpose for students. It is designed to provide students with an independent or small group activity that incorporates research, problem-solving, and application of basic skills (Kelly, 2000).

WebQuests are constructivist models of organizing instruction that focuses on organizing the learning process based on the Inquiry-based Learning Framework. One of the basic ideas around the WebQuest model is that students work in teams when they go out in the society to address complex social issues (Dodge, 1997). WebQuests are real, rich and relevant. Real in the sense that a student is looking at an issue or topic that concerns everyone. The task that is assigned for students to complete is something that people really do in their jobs or careers. In seeking the richness within the context of a topic, identifying what students should learn is not only the focus; instead it provides a broader avenue that allows students to connect what they recognize. Aside from these, students need to find themselves, their concerns, or their interests in the scenarios that they are going to work.

WebQuests come in two forms: short term and long term. Each uses the same principle and methods but they are used for different purposes. Short term WebQuests are designed to be completed over one to three lessons, aim to introduce the learner to a significant amount of new information and come up with some understanding. Long term WebQuests usually take between one week and a month of school time which can be extended over long periods of
time if desired. It aims to introduce the learner to new information and analyze them thoroughly. From this analysis, learners extend the subject and in some way demonstrate their understanding through a response.

**Authentic Assessment**

Authentic assessment is a form of assessment in which students are asked to perform real-world tasks that demonstrate meaningful application of essential knowledge and skills. It usually includes a task for students to perform and a rubric by which their performance on the task will be evaluated. In traditional assessment, the body of knowledge is first identified. The knowledge then becomes the curriculum that is delivered. After then, assessments are developed and administered. With authentic assessment, teachers first determine the tasks that students will perform to demonstrate their mastery. Then a curriculum is developed that will enable students to perform those tasks well, which would include the acquisition of essential knowledge and skills (Mueller, 2010).

**Ongoing Assessment**

When understanding is the purpose of instruction, the process of assessment is more than just evaluation. It is a substantive ingredient to learning. Assessment that fosters understanding rather than simply evaluating has to be more than an end-of-the-unit test. It needs to inform students and teachers about what students currently understand and how to proceed with subsequent teaching and learning. The integration of performance and feedback is exactly what students need as they work to develop their understanding of a particular topic or concept. In the teaching for understanding framework, it is called ongoing assessment. Ongoing assessment is the process of providing students with clear responses to their performances of understanding in a way that will help to improve next performances (Blythe & Associates, 1998).

Journals, student feedback forms, portfolios and conferences, classroom observations, group discussions and weekly tests are examples of activities that are used in an ongoing assessment (Carbery, 1999).

**Studies about WebQuest**

WebQuests were designed with the purpose of instilling in students the capacity to navigate the Internet with a clear task on mind, retrieve data from multiple resources and increase critical thinking skills. They provide students with the opportunity to engage in cooperative learning encouraging the development of intrinsic motivation for learning and promoting a constructivist learning environment (Dodge, 1998).

WebQuests increase students’ motivation by providing an essential question, real life resources with which to work, and opportunities to work in cooperative groups. By their very nature, WebQuests encourage the development of thinking skills. The assigned task requires students to “transform information into something else; a cluster that maps out the major issues, a comparison, a hypothesis, a solution, and others” (March, 2000).

Research studies document a variety of ways that WebQuests may be used to promote learning in the classroom. Beane (1997) as cited by Watson (1999) revealed that WebQuests are reflective, fluid, and dynamic. They provide teachers with the opportunity to integrate Internet technology into the course curriculum by allowing students to experience learning as they construct their perceptions, beliefs, and values out of their experiences. It allows
students to develop inquiry skills, learn content and build technology skills (Strickland, 2005).

Castronova (2002) and Milson (2001) showed that students progressed from easy fact-finding to more conceptual learning during the course of the WebQuests. Mohn (2010) further expressed that a WebQuest is particularly effective because it is outside the mold of multiple-choice answers where students were required to gather information and to transform it into new understandings.

Conceptual Framework
The paradigm of this research is illustrated in Figure 1. It shows that the researcher determined the prior knowledge of students using a teacher-made test. The WebQuest activity was tried out to the students. Performance was then measured in the posttest and outputs were rated using rubrics. A set of criteria was used in order to evaluate the outputs. The researcher assessed the content acquisition, application and collaboration. The perception questionnaire contained three questions which were used to determine the perceptions of the students towards the activity. Data gathered were then consolidated and content analyzed.

Methodology

Subject of the Study
Thirty (30) students from College of Education in Mindanao State University-Iligan Institute of Technology enrolled in Herbal Medicine Class were the subjects of the study.

Research Design
The study utilized one group pretest-posttest design supported by qualitative data. Pretest and posttest were made by the researcher and validated by experts. After doing the WebQuests activity, students were also asked to share their perceptions towards the activity using the perception questionnaire which consists of questions regarding the activity.

Development of the WebQuest
The following steps were considered for the development of the WebQuest on Herbal Medicine:
Nature of the WebQuest Activity
An iterative process of development of project-based WebQuest activity was employed. The WebQuest was validated by experts and implemented in Herbal Medicine class. This activity was designed for herbal medicine students to gather Indigenous Technical Knowledge (ITK) about herbal plants and understand the scientific concepts behind the ITK.

The following are the phases of WebQuest activity:
- a. Identification of herbal plants with healing potentials
  *Students interviewed the herbalists about the different herbal plants found in the barangay which have healing potentials.*
- b. Identification of illness that can be treated with herbal medicine
  *After identification, the students asked about the illness that can be treated by each plant.*
- c. Preparation of herbal plants
  *‘How herbal plants are prepared’ is another question the students had to ask from the herbalists.*
- d. Identification of phytochemical contents of herbal plants
  *With all the necessary information about herbal plants known, students researched about the scientific name and phytochemical components of the herbal plants using the preselected websites.*

Data Gathering Procedure
A 30-item multiple choice pretest was given to the students to determine their prior knowledge about herbal medicine.

Prior to the actual field activity, students were randomly grouped with five members in each group. Six groups were formed. Each group was assigned to one hinterland barangay in Iligan City. The researcher made sure that herbalists were available in the said barangays.
The students were given two (2) class meetings equivalent to three (3) hours to discuss the activity and assign task to each member with two (2) days to gather information from the community and interview herbalists. For one (1) week, the students conducted research. Another week was allotted for the preparation of their multimedia presentation and brochure outputs. Peer assessment was done during the presentation. Posttest was then given after the presentation of their outputs. A total of four weeks was allotted for the activity. The perception of the students towards the activity was also analyzed using the perception questionnaire.

Results and Discussions

Quality of Outputs
The students developed information drive materials such as multimedia presentation and brochure to educate the community about herbal plants and their pharmacological properties. The teacher and the students used rubrics to evaluate the outputs.

Table 1 shows that three group outputs were rated “Very Good” and the other three groups were rated “Fair”, “Good” and “Needs Improvement”, respectively. Ratings were based on the criteria set for the output. This implies that most students have very satisfactory performance in multimedia presentation.

Table 1
Quality of Students’ Multimedia Presentation

<table>
<thead>
<tr>
<th>Group</th>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>140</td>
<td>Very Good</td>
</tr>
<tr>
<td>2</td>
<td>125</td>
<td>Fair</td>
</tr>
<tr>
<td>3</td>
<td>140</td>
<td>Very Good</td>
</tr>
<tr>
<td>4</td>
<td>130</td>
<td>Good</td>
</tr>
<tr>
<td>5</td>
<td>110</td>
<td>Needs Improvement</td>
</tr>
<tr>
<td>6</td>
<td>145</td>
<td>Very Good</td>
</tr>
</tbody>
</table>

Students together with the teacher also rated the designed brochure. Table 2 shows the summary of the ratings of the groups in the brochure. Two groups were rated “Excellent” and four groups were rated “Very Good”. This implies that the students performed well in their brochure.

Table 2
Quality of Students’ Brochure

<table>
<thead>
<tr>
<th>Group</th>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>85</td>
<td>Very Good</td>
</tr>
<tr>
<td>2</td>
<td>81</td>
<td>Very Good</td>
</tr>
<tr>
<td>3</td>
<td>90</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>89</td>
<td>Very Good</td>
</tr>
<tr>
<td>5</td>
<td>82</td>
<td>Very Good</td>
</tr>
<tr>
<td>6</td>
<td>92</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
Sample Outputs

Figure 3. Sample presentation slide.

Figure 4. Sample brochure.

Performance of the Students
As shown in Table 3, the average score of posttest is greater than the pretest scores. To further compare the performance of the students, paired t-test was used to determine the significant difference between their pretest and posttest scores.

Table 3
Comparison between Pretest and Posttest Scores

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Critical t-value</th>
<th>Probability (p)</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>12.9</td>
<td>3.24 Ho</td>
<td>6.23</td>
<td>0.0001</td>
<td>Reject</td>
</tr>
<tr>
<td>Post-test</td>
<td>17.28</td>
<td>3.26</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ho: There is no significant difference between the pretest and posttest scores of students. (α=0.05)
Since the probability is less than 0.05, then the null hypothesis “There is no significant difference between pre-test and post-tests scores of students” is rejected. The result implies that there was a significant increase in the posttest scores of the students.

**21st Century Skills**

In addition to the quantitative results, the perception questionnaire also determined the 21st century skills developed by students in performing the WebQuest activity.

Collaboration skill was ranked 1st among the 21st century skills mostly developed by students as shown in Table 4. For them, teamwork is essential in achieving desired output. They also recognized the importance of cooperation, helping one other and sharing of ideas.

Table 4

*Developed 21st Century Skills*

<table>
<thead>
<tr>
<th>Skills</th>
<th>Frequency</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>Self-Direction</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>Computer Literacy</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Creativity</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Open-Mindedness</td>
<td>2</td>
<td>5.5</td>
</tr>
<tr>
<td>Flexibility and Adaptability</td>
<td>2</td>
<td>5.5</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

The researcher further investigated the perception of the students towards the activity. Students were asked to answer the following questions:

1. What do you like about the activity?
2. What are the challenges encountered during fieldwork?
3. What have you learned after doing the activity?

Responses of the students were summarized in Table 5, 6 and 7 respectively:

Table 5

*Students’ Comments of What They Liked about the Activity*

<table>
<thead>
<tr>
<th>Perception of the Students</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyment in collecting and identifying herbal plants</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td>Adventure in visiting different places</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>Accommodating and approachable herbalists and local people</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Learning and getting information from the herbalists</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Doing the fieldwork</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Working as a group</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The students enjoyed the gathering and identifying of herbal plants in the area because the herbalists and the people in the barangay were very helpful and accommodating. They also liked visiting the different places which were really different from what they usually saw in the city, and even the chance of working with their groupmates.
The challenges encountered by the students included the following, i.e. means of transportation, doing the presentation, doing research which takes time, translating information gathered from the field, preparing materials and scheduling the interview for the herbalists.

Table 6

Challenges Encountered by the Students

<table>
<thead>
<tr>
<th>Perception of the Students</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means of transportation</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td>Adventure in visiting different places</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>Accommodating and approachable herbalists and local people</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Learning and getting information from the herbalists</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Doing the fieldwork</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Working as a group</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Total 30 100

The students learned the basics of herbal plants. They also realized the value of careful planning and brainstorming to ensure on time submission of required outputs. The 21st century skills which they developed were collaboration, technology skills in designing their output and how to give critical feedback to improve outputs.

Table 7

Learning of the Students after Doing the Activity

<table>
<thead>
<tr>
<th>Perception of the Students</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance and application of herbal plants</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>The value of working as a team</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>Technology skills</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>The value of brainstorming and planning</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>How to give feedback</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>How to manage time</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

Total 30 100

Conclusion

The designed WebQuests activity on Herbal Medicine improved the academic performance of the students. The activity also helped the students to develop 21st century skills such as collaboration, self direction, technology literacy and creativity.

In general, the student outputs were rated “Very Good”. They also expressed that they liked the activity because it allowed them to visit other places and gain knowledge about different herbal plants that can be found in the community which have healing effects. Although there were some challenges encountered, the students enjoyed doing the fieldwork.

Recommendation

The researcher recommends that teachers should design lessons that will connect course content and community issues.
References


STARLAB AS AN ASTRONOMY TEACHING TOOLS IN SCHOOLS: AN ENGAGING CURRICULUM

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Abstract
How planetariums educate young people effectively about the wonders of the universe? Traditional way has led teachers and students to present themselves at the planetariums that provide astronomy related exhibitions, full dome star fields and astronomical shows, as well as special informal educational programs. Their experiences at planetariums are expected to be delivered back to the classroom upon returning school. Starlab is a portable version of mini planetarium that allows astronomy experiences to be taken to the distant or rural areas especially to those underserved teachers and students who could not afford to tolerate the travel expenses to visit planetariums. The Starlab plays a significant role in astronomy and space science education. It serves as an introduction to systematic study of the sky and thus to study science as a whole. For this reason, Planetarium Negara is planning to rent out the existing Starlab for expanding its usage at schools level and to enrich current school lessons at least in astronomical content. This paper describes the use of the Starlab as an astronomy teaching tool in schools.

Keywords: portable planetarium; starlab; astronomy

Introduction
Astronomy and space science is an important part of science curriculum for primary and secondary schools in Malaysia. But how planetariums play an important role in educating young people about the universe most effectively? Teachers, however, have often found the teaching of astronomical concepts difficult because of the complex nature and also meet the difficulty in teaching astronomy in a classroom environment in the daytime.

Some schools teachers will organize visit trip to Planetariums because of their ability to reproduce the evening sky in daytime and present astronomical concepts in a way not possible in the classroom. But there is only 5 permanent planetariums in Malaysia, namely Planetarium Negara, Planetarium Sultan Iskandar, Terengganu Science and Creativity Centre, Al-Khawarizmi Complex and Melaka Planetarium. Not all the schools in Malaysia have chance to organize visiting trip to the planetariums.

Due to the difficulty and limitations of permanent planetariums in Malaysia, Planetarium Negara is planning to rent out the existing Starlab to schools for expanding its usage and to enrich current schools lessons at least in astronomical contents.

Gary (1997) had done a study to identify educators’ perceptions of the impacts of the Starlab on teaching and learning tool among Starlab users around the world in year 1997. With the results of this study, one could easily demonstrates the effectiveness of Starlab as an
important, viable teaching and learning tool that could generate student excitement and love for learning.

In 2003, the Houston Museum of Natural Science, in collaboration with Rice University has organized an outreach program taking portable digital planetarium to schools and community sites for over five years. Research by Sumners, Reiff and Weber (2008) showed that subjects taught with more than one modality (hearing, seeing) can be learned more effectively than using one modality alone, and that learning through discussion and experience are more effective than just through hearing or seeing. The study showed that the Starlab plays a significant role in astronomy and space science education. It served as an introduction to systematic study of the sky and thus to study science as a whole.

This paper will describe the overview on how to use the Starlab by educators as an astronomy teaching and learning tool in schools.

**What is Starlab?**
Starlab is a small portable planetarium made of fabric, which is inflated by a fan and can accommodate about 35 children or 25 adults. A star projector recreates the sky, including the Sun, the Moon and the planets’ position on the dome, for any time or place on the Earth. There is very little doubt in the minds of anyone who steps into the Starlab dome, that it has a unique ability to draw everyone into a wonderful and magical world of astronomy. The sky we see every night reveals many mysteries of our existence. By changing the projection cylinder, the projector can also produce constellation outlines, a globe of the Earth or a diagram of a human cell.

Starlab equipment fits into three small cases and a duffle bag. It is easily transportable, when folded up, the dome and associated equipment can fit into a minivan. It can be easily setup in 20 minutes. It can also be easily operated by a single classroom teacher and can be used by classes of every level.

**Components of Starlab**
The Starlab consists of an inflatable dome (4.8m in diameter and 3.2m ceiling height), a projector and a high volume fan that is used to inflate the dome.
Before Setting Up the Starlab
Before setting up the Starlab, the following factors should be taken into accounts:

**Room Requirements**
A minimum ceiling height of 3.4m is needed with a cleared floor space of 6.4m.

**Floor Surface**
The Starlab should be set up on a carpeted floor, wood floor or tile floor. The floor must be cleaned because grit and dirt on the floor can cause damage to the dome. Gym mats, canvas and carpet can also be placed to cover the floor beneath the dome.

**Electrical Requirements**
The Starlab fan and projector are designed to plug directly into a regular 120 volt, 60 cycle grounded AC outlet. A separate power cord with an outlet strip inside the dome can also be used.

**Temperature**
The Starlab has no climate control of its own, so should be setup in the room temperature. The dome should neither be setup under skylights nor next to windows where direct sunlight can shine on the dome.

**Noise Level**
The Starlab should be setup in a room that can be closed off from other classes so that they don’t interfere with each others.

**Set Up Time**
It takes about 30 minutes in setting up the Starlab.

**Setting up the Starlab**
Steps to setting up will be explained in Table 1 (Gerald, 1990).
Table 1

*Steps to setup the Starlab*

<table>
<thead>
<tr>
<th>No</th>
<th>Steps</th>
<th>Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unrolling the dome across the floor where the setup is planned.</td>
<td><img src="image1" alt="Unrolling Dome" /></td>
</tr>
<tr>
<td>2</td>
<td>Connect the fan to the dome (inflation tube) securely and inflating the dome</td>
<td><img src="image2" alt="Inflation Tube" /></td>
</tr>
<tr>
<td>3</td>
<td>Setup the Starlab projector in the centre of the dome and place it on carrying case (as a stand)</td>
<td><img src="image3" alt="Starlab Projector" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Attach cylinder on the projector by four magnets carefully</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Adjust the projector brightness to the desired conditions</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Set the projector to the desired date and time</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Set projector to the desired location by adjusting the latitude</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Starlab ready to be used as an astronomy teaching tool</td>
<td></td>
</tr>
</tbody>
</table>

### After Using Starlab

After completed presentation in the Starlab, users should remove all planet projectors and moon phases from the Starfield cylinder and put them back into accessory box. Take the Starfield cylinder off the projector and slide it back into compartment in the casing. Turn off the projector and place it on the floor. Exit the dome and turn off the fan. Unplug the fan and projector and place them back into carrying case. Then roll and pack the Starlab dome.

### Starlab for Teaching Astronomy

Astronomy topics included day time and night time skies, Moon phases, the rising and setting of the Sun, constellation identification, use of star maps and much more which can be easily presented by the Starlab.

### Teachers Tips on Using Starlab Projection Cylinder

There are 3 main projection cylinders that can be used as an astronomy teaching tools, namely starfield, constellations and deep sky (Gary, 2008).

The starfield cylinder simulates the night sky at any time, season or location on the Earth. Over 3000 stars are projected to a limiting magnitude of 5.5 with the brightest stars individually lensed to produce intense pinpoint images.

Besides that, the starfield cylinder has twelve magnetic light blocks around its circumstances. These light blocks mark the position of the Sun along the ecliptic and when one is removed, it shows where the Sun would appear in the sky for each month of the year. We will be able to observe the elevation of the Sun, location of sunrise, sunset and the relative amount of time it
takes to across the sky for each month of the year making it easy to demonstrate the reasons for the seasons.

Because the Moon normally travels close to the ecliptic and since it has the same apparent diameter as the Sun in the sky, the same light ports used to project the Sun can be used to project the Moon in the sky. Two identical sets of 5 magnetic moon phase inserts included can be used to show the phases of the Moon. One set of inserts can be used to show the waxing phases while the second set can be used to show the waning phases.

Planets can be displayed to the night sky by using the planet projectors. The planet projectors have same type of magnetic attachment system as the moon phases and they use the same light ports on the starfield cylinder. Set the starfield cylinder for the desired date and time and then locates the position in the sky where the planet should be.

The constellations cylinder features the 48 major constellations, the ecliptic and celestial equator, colorfully displayed for the ultimate visual retention. The applications include star identification, planetary positions as well as the path of the sun and moon.

Meanwhile the deep sky cylinder shows variable and double stars, open clusters, nebulae and galaxies. Detailed identification numbers/symbols and the object's location in right ascension and declination, as well as its relation to a nearby constellation, are shown.

**Correlation of Starlab Cylinders to the Malaysia Integrated Curriculum for Primary and Secondary Schools**

The various Starlab cylinders that were used with the analog standard projectors were developed with the concept of participation as a central theme (Gary, 2008). The following Table 2 showed three main Starlab cylinders (Southern and Northern) can be used to help students meet each of the Malaysia Integrated Curriculum for science subjects in primary and secondary schools in the field of astronomy and space science.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Correlation of the Starlab cylinders to the science subjects in Malaysia Integrated Curriculum for primary and secondary schools.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science Year 4: Investigating the Earth and the Universe</strong></td>
<td></td>
</tr>
<tr>
<td><strong>The Solar System</strong></td>
<td>NS</td>
</tr>
<tr>
<td>Understanding the Solar System</td>
<td>✔</td>
</tr>
<tr>
<td>Understanding the relative size and distance between the Earth, the Moon and the Sun</td>
<td>✔</td>
</tr>
<tr>
<td>Appreciating the perfect placement of the planet Earth in the Solar System</td>
<td>✔</td>
</tr>
</tbody>
</table>

| **Science Year 5: Investigating the Earth and the Universe** | |
| **Constellation** | NS | SS | NC | SC | ND | SD |
| Understanding the constellation | ✔ | ✔ | ✔ | ✔ | | |
| The Earth, the Moon and the Sun | ✔ | ✔ | | | | |
| Understanding the occurrence of day and night | ✔ | ✔ | | | | |
| Understanding the phases of the Moon | ✔ | ✔ | | | | |

| **Science Year 6: Investigating the Earth and the Universe** | |
| **Eclipses** | NS | SS | NC | SC | ND | SD |
| Understanding the eclipse of the Moon | ✔ | ✔ | | | | |
Understanding the eclipse of the Sun

Science Form 3: Astronomy and Space Explorations

<table>
<thead>
<tr>
<th>Understanding the stars and galaxies in the Universe</th>
<th>NS</th>
<th>SS</th>
<th>NC</th>
<th>SC</th>
<th>ND</th>
<th>SD</th>
</tr>
</thead>
</table>

Abbreviation:
- NS – Northern Starfield
- SS – Southern Starfield
- NC – Northern Constellation
- SC – Southern Constellation
- ND – Northern Deep Sky
- SD – Southern Deep Sky

From the Table 2, we can know which of the three Starlab cylinders can be used to help educators and students to meet each of the Malaysia Integrated Curriculum for primary and secondary schools in term of astronomy in the science subject. So teachers or educators are encouraged to rent out the Starlab from Planetarium Negara as a teaching and learning tool. The teachers who are interested will be trained in using the Starlab.

We provide the teachers in the program with background knowledge in basic astronomy. Then we teach them how to involve their students actively in the planetarium lessons. Finally they are trained in the use of Starlab. After training, these teachers then can rent the Starlab to use in their own school. The result is a partnership between teachers and National Planetarium, with the students as the main beneficiaries.

**Conclusion**

The Starlab is an important and viable teaching and learning tool especially for teachers or educators that could generate students excitement and love for learning astronomy. It also served as an introduction to systematic study of the sky and thus to study science as a whole.

**References**


VISUALISING FRACTIONS

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Abstract
Learning Mathematics is something difficult for many students, as they cannot visualise the abstract concepts. Fraction is one of them. Student cannot visualise the process of operations on fractions. The algorithms of those processes are too complicated for them. By modelling the fractions (fullness) and its operations with Geometer Sketchpad (GSP) and medic box (container), the same operations on fractions can be made easier and provide a better understanding to students. The main idea of this paper is try to show the transformation of abstract fractions into countable natural numbers so that can be used in operations.

Introduction
The main objective of this paper is to help students get a better understanding in fractions, both the concept and the operations on fractions. A fraction is one of the most difficult topics in primary mathematics. “Difficulty with fractions (including decimals and percentage) is pervasive and is a major obstacle to further progress in mathematics, including algebra” (National Mathematics Advisory Panel, 2008). Natural numbers are discrete and countable for students. It is difficult for students to visualise the concept of fractions as a ratio of two numbers since it is an abstract concept. There are so many fractions can be found on a number line between any two natural numbers. This makes fractions uncountable for primary students, as they cannot place them on the number line as they do with natural numbers. This also make operations on fractions are much more complicated compared to operations on natural numbers. They cannot “count on” for fractions to do additions as they do count on for the natural numbers. There are too many conditions and rules for the students to follow while performing the operations on fractions. Most of them are very much different from operations on natural numbers. The main idea in this paper is try to transform fractions into the form of natural numbers so that operations can be easily performed.

Difficulty in Learning Fractions
Students have to master two main skills to learn fraction. The first skill is related to the concept of fractions such as recognise-read-write fractions, convert proper-improper-mixed number and compare fractions. The second skill is the knowledge of applying the four basic operations on fractions. Table 1 shows the summary of the skills and the difficulties involved.
Table 1
Skills, Difficulties and Normal Strategies

<table>
<thead>
<tr>
<th>Skills</th>
<th>Difficulties</th>
<th>Normal Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>recognise-read-write fractions</td>
<td>At least 3 different concepts: part-whole, part of collection, ratio.</td>
<td>Using real materials such as: cake or pie</td>
</tr>
<tr>
<td>convert improper-mixed number, compare fractions</td>
<td>operations: multiply with suitable number</td>
<td>using semi-concrete materials such as fractions circle or fractions bar</td>
</tr>
<tr>
<td>operations on fractions</td>
<td>different operations involve different procedures</td>
<td>standard algorithm, with key point: “Least Common Multiple for denominator”</td>
</tr>
</tbody>
</table>

Representing Mathematical Idea
The using of supporting material is usually parallel to Bruner modes of representing mathematical idea such from enactive (concrete objects) to iconic (pictures or drawing) to symbolic (abstract symbols) shown in Table 2.

Table 2
Bruner Modes of Representing Mathematical Idea

<table>
<thead>
<tr>
<th>Enactive</th>
<th>Iconic</th>
<th>Symbolic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractions as Part of a Set</td>
<td>Fractions as Part of a Whole</td>
<td>Fractions as Ratio of Two Numbers</td>
</tr>
<tr>
<td><img src="image1" alt="Enactive Image" /></td>
<td><img src="image2" alt="Iconic Image" /></td>
<td><img src="image3" alt="Symbolic Image" /></td>
</tr>
</tbody>
</table>

It is difficult to represent the operations on fractions in such strategies. The operations usually are through standard algorithm as shown in Table 3.

Table 3
Standard Algorithm for Operations on Fractions

<table>
<thead>
<tr>
<th>Addition / Subtraction</th>
<th>Multiplication</th>
<th>Division</th>
</tr>
</thead>
</table>
| \[
\frac{1}{3} + \frac{2}{7} = \frac{1 \times 7 + 2 \times 3}{3 \times 7 + 7 \times 3} = \frac{7 + 6}{21} = \frac{13}{21}
\] | \[
\frac{1}{3} \times \frac{2}{7} = \frac{1 \times 2}{3 \times 7} = \frac{2}{21}
\] | \[
\frac{1}{3} \div \frac{2}{7} = \frac{1 \times 7}{3 \times 2} = \frac{7}{6}
\] |
Inconsistency in Using Supportive Learning Materials
The change of strategies or inconsistency in using supportive materials may confuse students. The complicated procedures in standard algorithm also make learning fraction more difficult for many students.

Table 4
*The Change of Strategies in Learning Fractions*

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Semi Concrete</th>
<th>Symbolic</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Concrete Image" /></td>
<td><img src="image2.png" alt="Semi Concrete Image" /></td>
<td><img src="image3.png" alt="Symbolic Image" /></td>
</tr>
<tr>
<td>$\frac{1}{3}$</td>
<td>$\frac{2}{7}$</td>
<td>$\frac{1 \times 7}{3} + \frac{2 \times 3}{7} = \frac{7}{21} + \frac{6}{21} = \frac{13}{21}$</td>
</tr>
</tbody>
</table>

The ‘Fractions Circles’ and ‘Fraction Bars’ are not suitable to use for visualising operation on fractions. “Visualising Fractions with Rectangle” (2nd National Conference on Graphing Calculator and GSP, 2008, Benny Kong) which refers to the strategy of representing fractions by using rectangles has been found to be more effective.

Table 5
*The Representation of Fraction by Rectangles*

<table>
<thead>
<tr>
<th>Operations</th>
<th>Concrete</th>
<th>Semi Concrete</th>
<th>Symbolic</th>
</tr>
</thead>
<tbody>
<tr>
<td>compare</td>
<td>$\frac{1}{3}$</td>
<td>$\frac{2}{7}$</td>
<td>$7 &gt; 6$</td>
</tr>
<tr>
<td>add</td>
<td>$\frac{1}{3} + \frac{2}{7} = \frac{7}{21} + \frac{6}{21} = \frac{13}{21}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>subtract</td>
<td>$\frac{1}{3} - \frac{2}{7} = \frac{7}{21} - \frac{6}{21}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>divide</td>
<td>$\frac{1}{3} \div \frac{2}{7} = \frac{7}{21} \div \frac{6}{21}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rectangles With 7 Rows & 3 Columns = 21 pcs

<table>
<thead>
<tr>
<th>Operations</th>
<th>Concrete</th>
<th>Semi Concrete</th>
<th>Symbolic</th>
</tr>
</thead>
<tbody>
<tr>
<td>multiply</td>
<td>$\frac{1}{3} \times \frac{2}{7} = \frac{2}{21}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (overlap) of 21 pcs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Alternative Strategy in Learning Fractions by Transforming into Whole Number

Learning must be fun and meaningful for the students. Fun relates to student centred and materials centred learning. Meaningful always relates to contextual learning and learning based on real life experience.

These effective learning method or representation of fraction should happen only at the early stage of learning fractions where most students were exposed to real or concrete materials when fractions were first introduced. The using of concrete materials any sooner will bring changes to the process of abstract symbols at the later stage of learning fractions. Students may have to memorise mechanical steps to compare and perform operations on fractions. This is meaningless and is of no fun for many students.

A Consistent Use of Supporting Materials

Based on the findings of a research conducted by the researcher himself on “Visualising fractions With Rectangles” which was presented at the 2nd National Conference Graphing Calculator” in 2008, forming rectangles is one of the better ways in representing fractions. Based on the feedback from the teacher trainee after completing their teaching practicum, concrete materials play an important role in helping students to understand and master fractions concept-operations. “Pocket Fraction” by Tan (KPLI, 2009) and “Egg Tray” by Siti Aminah (PISMP, 2011) both show that students can understand the concept of fraction and master the operation (addition and subtraction) on fractions.

Fractions as “Fillness” or “Fullness”

The researcher tried out a new concept by using newly developed supporting material for learning fractions. This was done by introducing another concept of fractions such as “fillness” or “fullness” which is also referred to as “rectangular container”. Table 5 compares the difference of using different supporting materials.
Table 5
The Representation of Fraction by using Rectangles

<table>
<thead>
<tr>
<th>Concept</th>
<th>Comparing</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Of A Whole</td>
<td><img src="image" alt="Fraction Representation" /></td>
<td><img src="image" alt="Fraction Representation" /></td>
</tr>
<tr>
<td>Part Of A Set</td>
<td><img src="image" alt="Fraction Representation" /></td>
<td><img src="image" alt="Fraction Representation" /></td>
</tr>
<tr>
<td>Ratio</td>
<td>1/3</td>
<td>1/3</td>
</tr>
<tr>
<td>Fullness</td>
<td><img src="image" alt="Fullness Representation" /></td>
<td><img src="image" alt="Fullness Representation" /></td>
</tr>
<tr>
<td>Fullness On Rectangular Container/Base</td>
<td><img src="image" alt="Fullness Representation" /></td>
<td><img src="image" alt="Fullness Representation" /></td>
</tr>
<tr>
<td>Fullness On Rectangular Container/Base (GSP)</td>
<td><img src="image" alt="Fullness Representation" /></td>
<td><img src="image" alt="Fullness Representation" /></td>
</tr>
</tbody>
</table>

The “Fullness” concept can transform the operations back to normal number with the common base or reference (the capacity of the container). Table 6 shows the using of “Fullness” concept for operations on fractions.

Table 6
The “Fullness” concept for operations on fractions

<table>
<thead>
<tr>
<th>Concept</th>
<th>1 row of 3 rows</th>
<th>2 columns of 7 columns</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition</td>
<td><img src="image" alt="Addition Representation" /></td>
<td><img src="image" alt="Addition Representation" /></td>
<td>(7 pcs + 6 pcs) of 21 pcs</td>
</tr>
<tr>
<td>Subtraction</td>
<td><img src="image" alt="Subtraction Representation" /></td>
<td><img src="image" alt="Subtraction Representation" /></td>
<td>(7 pcs - 6 pcs) of 21 pcs</td>
</tr>
<tr>
<td>Multiplication</td>
<td><img src="image" alt="Multiplication Representation" /></td>
<td><img src="image" alt="Multiplication Representation" /></td>
<td>2 (overlap) of 21 pcs</td>
</tr>
<tr>
<td>Division</td>
<td><img src="image" alt="Division Representation" /></td>
<td><img src="image" alt="Division Representation" /></td>
<td>7 pcs ÷ 6 pcs (1st number divide by 2nd number)</td>
</tr>
</tbody>
</table>

Students will operate using one number (the numerator). The denominator is referred as the container which is fixed during the process of operations. The numerators are natural number. They are countable and normal operations can be easily performed.
Students’ Perception

“Fractions as Fullness” concept was shared with 27 students from the ‘Ijazah Sarjana Muda Perguruan’ (PISMP) Mathematics major students who took MTE 3109 course (Teaching Numbers, Fractions, Decimals, and Percentage). Table 7 shows their perception.

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Agree (3)</th>
<th>Strongly Agree (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do you agree Maths (Fractions) difficult to learn?</td>
<td>4</td>
<td>6</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>14.8%</td>
<td>22.2%</td>
<td>48.1%</td>
<td>14.8%</td>
</tr>
<tr>
<td>2. Do you agree Maths (Fractions) is abstract?</td>
<td>0</td>
<td>5</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>0.0%</td>
<td>18.5%</td>
<td>44.4%</td>
<td>37.0%</td>
</tr>
<tr>
<td>3. Do you agree visualising can help to master Mathematics (Fractions) Concept / Operations?</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>0.0%</td>
<td>0.0%</td>
<td>63.0%</td>
<td>37.0%</td>
</tr>
<tr>
<td>4. Do you agree “Fractions as Fullness” can help to Visualise Maths (Fractions) Concept / Operations?</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>0.0%</td>
<td>0.0%</td>
<td>26.0%</td>
<td>74.0%</td>
</tr>
<tr>
<td>5. Will you try to use “Fractions as Fullness” in you teaching of Maths (Fractions) Concept / Operations?</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>0.0%</td>
<td>0.0%</td>
<td>37.0%</td>
<td>63.0%</td>
</tr>
</tbody>
</table>

10 or 37.0% of the respondents disagreed that fraction is a topic that is difficult to be learnt (14.8% strongly disagreed and 22.2% disagreed) while more than half (62.9%) agreed. Majority too agreed that fraction is an abstract topic to learn. This probably is because they are good students and most of them obtained good results in Mathematics and thus do not face difficulties in learning Mathematics.

All of them agreed that visualisation helped in learning fractions (63.0% agreed and 37.0% strongly agreed) and all of them also agreed that “Fractions as Fullness” can be used to learn fractions (26.0% agreed and 74.0% strongly agreed). All of them agreed that they tried to use “Fractions as Fullness” in teaching of fractions (37.0% agreed and 63.0% strongly agreed).

Conclusion

The PISMP Mathematics major students agreed that “Fractions as Fullness” method is effective in learning fractions. Some of them applied “Fractions as Fullness” method during their practicum.

References


APPLICATION OF MATHEMATICS PROFICIENCY MODEL IN TEST DEVELOPMENT

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Abstract
Mathematics is widely regarded as one of the most important subjects in the school curriculum. Indeed, it is likely that more lessons of mathematics are taught in schools throughout the world than any other subject. When concern is expressed about the performance of pupils, mathematics is usually singled out as being a particularly worrying problem. It seems that the whole world regards it as important that children should be able to demonstrate a high level of proficiency in the subject. The purpose of this conceptual paper is to explain the mathematics proficiency model as proposed by Kilpatrick, Swafford, and Findell (2001) that consists of five strands, namely conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Furthermore, this article discusses how these strands and their respective characteristics can be used as a foundation to develop the Form Two mathematics test which is closely aligned with the Malaysian mathematics curriculum specification. Examples of the test item representing each strand and combination of strands are also presented.

Introduction
Since the publication of Bloom’s taxonomy in 1956, psychological and educational research has witnessed the introduction of several theories and approaches to learning which make students more knowledgeable of and responsible for their own learning, cognition, and thinking (e.g. constructivism, metacognition and self-regulated learning). In addition, the use of Bloom’s taxonomy in test development is not uncommon among test developers. It included six major categories, namely knowledge, comprehension, application, analysis, synthesis and evaluation. It was intended to provide for classification of educational system goals, especially to help teachers, administrators, professional specialists, and research workers to discuss curricular and evaluation problems with greater precision (Bloom, 1994, p.10). One of the most frequent uses of Bloom’s taxonomy has been to classify curricular objectives and test items in order to show the breadth, lack of breadth, of the objective items across the spectrum of the six categories.

The structure of Bloom’s taxonomy is a cumulative hierarchy: hierarchy because the classes of behaviours are arranged in order of increasing complexity and cumulative because each class of behaviours is presumed to include all the behaviours of the less complex classes. It is assumed that mastery of each simpler category is prerequisite to mastery of the next more complex one (Krathwohl, 2002, p.213).
In the application of the Bloom’s taxonomy, several weaknesses and practical limitations have been revealed. A notable weakness is the assumption that cognitive processes are ordered on a single dimension of simple-to-complex behavior. As required in a cumulative hierarchy, the categories were presumed not to overlap. Anderson, Krathwohl, Airasian, Cruikshank, Mayer, Pintrich, Raths and Wittrock (2001) point that the term “cumulative hierarchy” which indicates the mastery of a more complex category requires prior mastery of all the less categories below it is inflexible. However, in applying Bloom’s taxonomy, Ormell (1974) reported contradictions in the frequent inversion of various objectives and tasks. For example, certain demands for knowledge are more complex than certain demands for analysis or evaluation. In addition, evaluation is not more complex than synthesis; synthesis involves evaluation (Krietzer & Madaus, 1994).

In the context of mathematics testing, the use of Bloom’s taxonomy can be seen as too general in test development. For example, knowledge in Bloom’s taxonomy is described as the thinking skill that a student can recall or recognise information, concepts and ideas. This description does not focus on mathematics but rather a general statement on the meaning of knowledge. It is already known that mathematics comprises many important concepts, procedural and analytical skills. As a consequence, a model that focuses on mathematics is therefore suggested to describe these concepts, procedural and analytical skills. One of the models that employed the constructivism theoretical framework is the mathematics proficiency model as proposed by Kilpatrick, Swafford and Findell (2001). It is suggested that this model can be incorporated into the test development structure. This article explains the five strands of the mathematics proficiency model and discusses how these strands and its respective characteristics can be used to develop a Form Two mathematics test.

The Mathematics Proficiency Model
The mathematics proficiency model is a model that describes comprehensively how students can learn mathematics successfully. The description of the model helps us to understand how students acquire mathematical proficiency and has implications on how teachers can develop that proficiency in students, how teachers can be educated to achieve that goal and how teachers can test their students’ proficiency through assessments.

The term mathematical proficiency empowers learners with the expertise, competence, knowledge, and facility in mathematics. Proficiency, as defined by Kilpatrick et al., (2001) encompasses five strands namely conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. These strands are interwoven and interdependent which means that the strands must work together for students to learn successfully. In other words, when learning proceeds, each strand should be developed with others. Mathematical proficiency is not a one-dimensional trait, and it cannot be achieved by focusing on just one or two of these strands. It is believed that to help children acquire mathematical proficiency, these five strands need to be addressed in any instructional programme.

Conceptual understanding is the comprehension of mathematical concepts, operations and relations. It refers to the ability of students to grasp mathematical ideas, understand the importance of these ideas and see them as useful (Kilpatrick et al., 2001). For example, if students understand the idea of approximation, they are able to see the usefulness of rounding numbers in estimation. This characteristic of conceptual understanding can be used to develop a test item. An example is as follows: Estimate the value of 8216 + 699. First, the
students round off 8216 to the nearest thousand which is approximately equal to 8000. Then, the students round off 699 to the nearest hundred which is approximately equal to 700. Therefore, 8216 + 699 is approximately equal to 8000 + 700 that is 8700. Another characteristic of conceptual understanding is the ability of students to relate new ideas to those ideas that they have already known as in understanding the concept of mixed numbers. Here, students relate the concept of whole number and a fraction, as the ideas that they have already known, to understand mixed number as the new idea. An example of test item to show this characteristic is as follows: Write the mixed number represented by the shaded parts in Figure 1. Students will write 3 as the whole number because there are three big squares that are shaded in full and \( \frac{4}{9} \) as the fraction as there are three small squares out of 9 that are shaded in the fourth big square. Therefore, the mixed number is \( 3 \frac{4}{9} \).

![Figure 1. Representation of a mixed number.](image)

Meanwhile, **Procedural fluency** is the skill that students should acquire in carrying out procedures flexibly, accurately, efficiently and appropriately. It refers to “knowledge of procedures, knowledge of when and how to use them appropriately, and skill in performing them flexibly, accurately and efficiently” (Kilpatrick et al., 2001, p. 121). In other words, students with procedural fluency are able to carry out basic computations flexibly without always having to refer to tables or other aids. If it involves complex computations, they are able to use the calculator efficiently. Therefore, these students know the similarities and differences between methods of calculating. This characteristic of procedural fluency can be seen in the following example when these students find the sum of 398 and 235 flexibly. They are able to modify 398 as 400 less than 2 and by adding 400 and 235; they then subtract 2 from that sum. The case would be different for students without procedural fluency as they may need to use paper and pencil to solve the above addition. In addition to that, procedural fluency is especially needed to support conceptual understanding. This is illustrated when tools are used in computing, some algorithms are important as concepts in their own rights. This characteristic can be seen in the following test item: Find the value of \( (-0.56)^3 \) correct to 3 decimal places. Here, students need to know the concept of cube of a number as the number multiplied by itself twice before using calculators. In this case, students need to know that \( (-0.56)^3 \) is the same as \( (-0.56) \times (-0.56) \times (-0.56) \) before computing them using calculator.

**Strategic competence**, on the other hand, is the ability to “formulate, represent and solve mathematical problems” (Kilpatrick et al., 2001, p. 124). This refers to the ability of generating a mathematical representation of a problem, which may be facilitated by making a drawing, or writing an equation that involves formulae. This strand is similar to what has been called problem solving and problem formulation. Students with strategic competence have broad knowledge for solving non-routine problems and not just routine problems. Routine problems are problems that students know how to solve based on their experience (Mayer & Hegarty, 1996). An example of test item that involves a routine problem showing this characteristic is finding the product of 235 and 47. This is because they know what to do and how to do it. In contrast, non-routine problems are problems for which students do not immediately know a usable solution but need to invent a way to understand and solve the problem (Kilpatrick, 2001). This characteristic of strategic competence can be used to develop test items such as in the following example of a non-routine problem: Ahmad owns a
cycle shop and has a total of 72 bicycles and tricycles. There are altogether 160 wheels. How many bicycles and how many tricycles are there? An approach to this problem is by using algebra. Let $b$ be the number of bicycles and $t$ be the number of tricycles. Then, the students need to formulate the problem and be able to write $b + t = 72$ and $2b + 3t = 160$. The solution then yields $b = 56$ and $t = 16$.

Adaptive reasoning is the capacity for “logical thought, reflection, explanation and justification about the relationships among concepts and situations” (Kilpatrick et al., 2001, p. 129). This refers to the capacity of students to think logically that involves careful consideration of alternatives. Their ability and knowledge give reasons for their thought and justify their conclusions. Students use it to explore the many facts, procedures, concepts and solution methods and see that they all fit together in some way and make sense. In mathematics, deductive reasoning is used to settle disagreements. Agreements arise when the given answers are correct based on the series of logical steps. When facing with disagreements about a mathematical answer, students with adaptive reasoning only need to check that their reasoning is valid (Kilpatrick et al., 2001). There is no need to rely on teachers or asking opinions from friends. The characteristics of this strand can be used to develop test items. For example: Determine whether a triangle with sides 5 cm, 6 cm and 8 cm is a right-angled, obtuse-angled or acute-angled triangle. In this case, students need to find the square of the longest side, that is, $8^2 = 64$ and the sum of the squares of the other two sides, that is, $5^2 + 6^2 = 25 + 36 = 61$. Students then need to justify their conclusions that the triangle is an obtuse-angled triangle because $8^2 > 5^2 + 6^2$.

Productive disposition is the “tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off and to see oneself as an effective learner and doer of mathematics” (Kilpatrick et al., 2001, p. 131). This refers to the ability of students to recognise that mathematics is sensible and useful, developing positive attitudes and gain confidence as mathematics learners. In contrast, students who have not developed a productive disposition have negative attitude towards mathematics and see themselves as incapable of learning mathematics (Riddle & Rodzwill, 2000). An example of test item to show the characteristics of this strand is as follows: How confident are you in the following situations? (i) When you measure angles using a protractor (ii) When you count $8 - 1 = \underline{} + 3$. A. Completely confident B. Confident C. Fairly confident D. Not confident at all. Students who believe that they have the knowledge will opt for A. This type of item is normally found in student questionnaire in researches that focus on attitudes towards mathematics, beliefs about one’s own ability and beliefs about the nature of mathematics.

To summarise the above discussion, there are five mathematics proficiency strands as proposed by Kilpatrick et al. (2001), namely conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition. In short, these researchers view mathematical proficiency as the ability to understand, compute, solve, and reason, and goes beyond to include disposition toward mathematics. These five strands are to work together for students to learn mathematics successfully. The knowledge of these strands together with each strands’ respective characteristics can provide guidelines to teachers in test development. This mathematics proficiency model can then be used as a foundation to develop a mathematics test.
Development of Mathematics Test Items

Testing serves many important purposes. Tests are used to (1) diagnose individual student’s strengths and weaknesses, (2) monitor student’s progress, (3) assign grades to students (4) determine the teacher’s own instructional effectiveness (5) motivate improved student, school, district, and state performance, and (6) make school and college entrance decisions (Centre for Assessment and Evaluation of Student Learning (CAESL), 2004). In accordance with learning mathematics, test can be developed to determine students’ mathematical proficiency based on Kilpatrick et al. (2001) mathematics proficiency model. Table 1 shows the strands of mathematical proficiency, the characteristics of each strand and some illustrative examples of items that can be developed based on the criteria of each strand. The examples given are focused on the topic Pythagoras’ Theorem of Form Two mathematics (Ministry of Education, 2004).

Table 1
Strands of Mathematical Proficiency, Characteristics of Strands, Learning Objectives, Learning Outcomes and Examples of Test Items

<table>
<thead>
<tr>
<th>Strands</th>
<th>Characteristics of Strand</th>
<th>Learning Objective</th>
<th>Learning Outcome</th>
<th>Examples of Test Item</th>
</tr>
</thead>
</table>
| Conceptual understanding – comprehension of mathematical concepts, operations, and relations | Students are able to understand the concept of a right-angled triangle                   | 6.1 Relationship between the sides of a right-angled triangle | I. Relationship between the lengths of the sides of a right-angled triangle                  | Write the relationship between the sides of the following triangle.  

\[ y^2 = x^2 + z^2 \]

This item measures students’ proficiency in conceptual understanding. This item asks students to relate the sides of a right-angled triangle. Students’ ability to relate concepts is a characteristic of conceptual understanding. Students recognise the above as a right-angled triangle and relates this to the Pythagoras’ theorem concept:

| Procedural fluency – skill in carrying out procedures flexibly, | Students are able to compute fluently numbers to find the  | 6.1 Relationship between the sides of a right-angled triangle | ii. Finding the length of the unknown side of a triangle                               | Find the value of x in the following right-angled triangle. |

\[ y^2 = x^2 + z^2 \]
accurately, efficiently, and appropriately

| squares of numbers and the square root of numbers |
| Procedural fluency is needed to support conceptual understanding |

| Students are able to formulate problem and write equation that involves formula. In this case, the formula of trapezium and triangle. This strand is similar to what has been called problem solving and problem formulation. |
| 6.1 Relationship between the sides of a right-angled triangle |
| v. Solving problems involving Pythagoras’ Theorem |

| The diagram shows a trapezium PQRST and a right-angled triangle PTQ. Calculate the area, in cm$^2$, of the shaded region. |

| This item measures students’ problem-solving abilities, which is a characteristic of students’ proficiency in strategic competence. |

| Students initially find the length of PQ using Pythagoras’ Theorem. |

This item measures students’ fluency in operating with squares and square roots of numbers.

Students relate the sides of a right-angled triangle, and compute the value of squares of numbers. Correctly completed problem shows that students have developed procedural fluency.

\[ x^2 = 12^2 + 5^2 \]
\[ = 144 + 25 \]
\[ x = \sqrt{169} \]
\[ = 13 \text{ cm} \]
Then, students formulate:

Area of shaded region = Area of trapezium – Area of triangle

\[
\frac{1}{2}(a+b)h - \frac{1}{2}bh = \frac{1}{2}(4+10)12 - \frac{1}{2}(6)(8)
\]

<table>
<thead>
<tr>
<th>Adaptive reasoning – capacity for logical thought, reflection, explanation, and justification</th>
<th>Students are able to explain and justify conclusions</th>
<th>6.2 Converse of Pythagoras’ Theorem</th>
<th>ii. Solving problems involving converse of Pythagoras’ Theorem</th>
</tr>
</thead>
<tbody>
<tr>
<td>A scout has three bamboo stems. The lengths of the stems are 7 cm, 24 cm and 25 cm respectively. The scoutmaster asks him to use the bamboo stems to form a right-angled triangle. Can he do it? This item measures students’ proficiency in adaptive reasoning, in conjunction with other strands. This item asks students to reason about the properties of triangles and also assesses their conceptual understanding. Students relate the properties of a right-angled triangle. (25^2 = 24^2 + 7^2) Then, students justify and explain that the triangle is right-angled triangle based on the above calculation.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Productive disposition – ability to see mathematics as sensible and useful, have positive attitude and confident</th>
<th>Students are able to perceive themselves as good at mathematics and view mathematics as useful.</th>
<th>-</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>How confident are you in the following situation? When you determine whether a triangle with the following sides, in cm, is a right-angled triangle. 8, 15, 17. A. Completely confident B. Confident C. Fairly confident</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
D. Not confident at all

This item measures the students’ level of confidence in doing the above sum. This test item is especially useful when studying the relationship of students’ perception in mathematics with achievement.

As a whole, the above illustrative examples show that test items can be developed based on the five strands of mathematical proficiency and their corresponding characteristics. While the fifth strand is a difficult characteristic to be measured among students, students’ ability to solve such questions successfully is an indicator that they are confident. Another possible difficulty is the overlapping of one proficiency strand with another proficiency strand or strands. For example, in a test item, the proficiency strand involved could be a combination of other strands. This is expected as these five strands are not independent but are interwoven and interdependent which are complementary with each other.

**Conclusion and Implication**

The present conceptual paper suggests that a mathematics proficiency model can be used in test development. The use of a mathematics proficiency model in test development is seen as an advantage because test item is developed based on the model that specifically describes about proficiency in mathematics. The five strands and their respective characteristics help mathematics test developers to understand better the nature of each of the test item developed. The application of Bloom’s taxonomy in mathematics test development, on the other hand, does not focus primarily on mathematics. In addition to that, the assumption that cognitive processes are ordered on a single dimension of simple-to-complex behaviour is a notable weakness in test development. This is not the case in the mathematics proficiency model that describes the strands of proficiency as interconnected and not ordered on one dimension of single-to-complex but rather is interacted with one another. This illustration is seen as more appropriate in test development. As a conclusion, it is our belief that the application of mathematics proficiency model can be used as a foundation and be incorporated in test development.

**References**


