# IMPACT OF SIMULATIONS ON THE MENTAL MODELS OF STUDENTS IN THE ONLINE LEARNING OF SCIENCE CONCEPTS

By

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*ABSTRACT*

*Numerous flash or java applet based simulations have been developed to improve students' comprehension of Science concepts, particularly the more complex or 'dry' ones. Simulations have been reported to be effective as instructional aids in scaffolding scientific learning by students since simulations support the explication of implicit understandings. Simulations are usually designed to allow students to actively manipulate variables to experientially explore the relationships between these variables and their scientific applications. Rich associative thinking skills can also be infused in students by encouraging them to actively manipulate the simulations and learn on their own new science concepts without being prescriptively taught to by teachers as it often happens in Science classrooms. Misconceptions in the learning of Science concepts can more easily be identified and corrected in a timely manner. This paper examines in-depth research studies that have been conducted on the effectiveness of integrating simulations in the teaching and learning of Science and the effects of simulations in developing sound understanding of Science precepts. Studies done by one of the author of this paper have also been described in explaining the performance of a group of in-service teachers in the applied use of simulations in the delivery of Science education.*

*Keywords: Simulations, Science learning, Active Engagement, Educational Technology.*

## INTRODUCTION

A simulation is a representation or model of a real or imagined specific object, system or phenomenon (Merrill, Vincent, Reynolds, Christensen and Tolman, 1996). The professional flight trainer is a good example of a high-fidelity simulation that comes with hydraulic arms to move the pilot trainee around, functional 'surround cockpits' with mock-up controls and instrument panels and video-graphic pictures of the terrain. Operating within such a simulated environment the pilot trainee feels that s/he is really flying in an airplane or space shuttle and are not required to spend too much of time in the real cockpit (Zhou, Martin, Brouwer & Austen, 2000).

Alessi and Trollip (1991) have described the capabilities of simulations in facilitating quality learning discourses:

"A simulation is a powerful technique that teaches about some aspect of the world by imitating or replicating it. Students are not only motivated by simulations, but learn by interacting with them in a manner similar to the way they would react in real situations. In almost every instance, a simulation also simplifies reality by omitting or changing details. In this simplified world, the student solves problems, learns procedures, comes to understand the characteristics of phenomena and how to control them, or learns what actions to take in different situations."

This paper looks at the ways in which simulations could be integrated within Science curriculum to stimulate students' learning of 'dry' or difficult Science concepts and make Science pedagogy more engaging and experiential. Another purpose of this paper is to explore the pedagogical affordances of simulations in the design, development and implementation of high-quality Science education syllabus in schools. Existing research literature on the studies that have been done in investigating the impact of simulations on students' cognition of learning of scientific phenomena are explicated in the following sections. Case studies carried out by one of the authors of this paper on the implementation of Science lessons integrating simulations in association with hands-on tasks have also been explicated.

### Pedagogical benefits of simulations

Alessi and Trollip argue that a simulation simplifies reality by omitting extraneous details. According to Grabe and Grabe (1996) such simplification allows learners to focus on critical information and streamline learning. Educational simulations have also been found to be useful in supporting constructivist pedagogy since they present simulated real life scenarios for students to play authentic roles and engage in solving complex tasks (Harper, Squires & McDougall, 2000). On the other hand, Thomas and Hooper (1991) were of the opinion that simulations are best suited for the acquisition of diagnostic skills. Optimal learning occurred when students first learnt the required factual concepts and principles and then used the simulations to apply that knowledge in realistic contexts.

In relation to a simulation supported context of learning, Merrill, Hammons, Vincent, Reynolds, Christensen & Tolman (1996) enumerated the following six reasons to promote simulations as an effective educational tool:

- Simulations provide a safe environment involving less risk than in reality. During the simulation training, if learners do crash their airplanes, the mistakes do not result in fatalities.
- Training costs can substantively be reduced since a real plane crash can cost a huge sum of money for repair or replacement and loss of precious lives.
- Simulations are more convenient to use than real-life situations since they are not affected by weather and situational constraints.
- Simulations can minimize the negative effects of time especially if the phenomenon that needs to be experience takes place over a long period of time in reality. Simulations can help to shorten this time frame and let learners experience the critical elements of the phenomenon repeatedly within a shorter period of time.
- Multimedia elements such as graphics and animations can heighten aspects of a phenomenon to be focused upon and improve learner attention on critical information.
- Learners' responses can be automated since they can interact with the simulations over and over again.

Gredler (1996) distinguishes between two types of simulations: symbolic and experiential. With symbolic simulations, the student is not an active participant in the program environment. Although students may execute some or all of the presented tasks, the student remains in the periphery in relation to the main sequence of learning events. On the other hand, experiential simulations immerse the students in high-fidelity, complex learning environments, where the student is an active participant in the learning processes. They allow students to execute multidimensional problem-solving strategies in interacting with the simulation program. They also provide learners with opportunities to develop higher-order cognitive skills and independently manage their own learning. Learning in an experiential simulation is embedded in the context of a scenario narrating a complex task or problem that unfolds in part response to learner actions. Contingent upon the decisions learners make in responding to the problem representation, multiple plausible problem solving paths are possible. A greater degree of learner control enables reflective learning to occur through meaning-making of experiences (Gredler, 1996).

De Jong and Van Jooling (1998) have categorized computer simulations into two main categories: simulations containing a conceptual model, and those based on an operational model. Conceptual models are simulated representations of underpinning principles, concepts, and facts necessary for knowledge codification. On the other hand, operational models include sequences of procedural actions that need to be performed in the learning environment of the simulated systems.

Shlechter and Basserner (1992) investigated the effectiveness of a computer-based training system (SIMNET) combined with appropriate role-playing activities. SIMNET is a simulated battlefield environment consisting of combat vehicle simulators with simulated combat support. The simulation is conducted under constraints reflecting actual battlefield conditions. Data analysis of performance levels revealed the effectiveness of SIMNET for training military students to apply their newly acquired knowledge in real life situations. The researchers concluded that using interactive computer-based simulation systems provided learners with opportunities for role-playing activities to facilitate transference of skills and knowledge needed for successful performance in a dynamic vocational environment.

### Simulations in Science Education

Akpan and Andre (1999) define a simulation in the context of science education as the use of the computer to mimic dynamic systems of objects in a real or imagined world. Computer simulations may assume many different forms such as 2 or 3-dimensional animations interactive, scaffolded inquiry environments. In the domain of Science education, simulations can be employed with a good level of fidelity to create authentic learning environments. For example, if students are to experience the growth of plants or the fission of nuclei, traditional lab wouldn't be very feasible. Computer simulations might afford an alternative and affordable way of allowing students to observe such scientific phenomena (Zhou et al., 2000).

### Simulations as problem solving and inquiry tools

Mintz (1993) found that simulations can be situated as inquiry tools to enhance learning attention and motivation. Similar to Mintz, the potential for combining sophisticated visual and graphics display with other features of the microcomputers has been recognized as very promising by science educators and researchers for quite some time. For example, when combined with the interactive capability of the microcomputer, good simulations may provide students with meaningful opportunities for thinking, problem solving and decision making. Students could be actively involved in identifying variables, defining hypotheses, and determining methods of measurement, treatments, procedures, and proposed techniques of data analyses. Such simulations can also allow students to examine models and relationships of the real world under controlled conditions. Tamir (1985/86) had recognized such a potential for quite some time.

Rivers and Vockell (1987) studied computer simulations used by high school biology students in attempts to enhance their problem solving skills. The simulations were administered under two conditions: guided discovery, and unguided discovery; a control group received no simulations. The results indicated that: (a) students using the simulations met the unit objectives equally well when compared to the control students, and (b) students using the guided simulations surpassed the other students on subsequent simulation pretests, on tests of scientific thinking, and on a test of critical thinking. The evidence suggested that students using the computerized simulations were developing generalizable problem solving strategies that could be transferred to novel settings.

Geban, Askar and Ozkan (1992) found that students using simulation problem-solving approach achieved significantly better in chemistry content and science process skills. They found improved attitudes among this group of students.

### Simulations in the development of Science process and thinking skills

Simulations can facilitate the development of science process skills of students, necessary for students to engage in authentic scientific inquiry (Roth and Roychoudhury, 1993). Some science process skills include observing, inferring, measuring, classifying, predicting, formulating hypotheses, interpreting data, experimenting, formulating models etc. In their study, Lazarowitz and Huppert (1993) examined the impact of computer simulations in promoting science process skills of 10th grade biology students. Their findings revealed that computer simulations can enable students to master science process skills through applied use of skills of experimental graph plotting, control and manipulation of variables and data analysis.

Based on their results, Shaw and Okey (1985) concluded that laboratory activities, simulations, and a combination of these two strategies yielded higher achievement than did conventional instruction on the process skills of observing, hypothesizing, testing, classifying, and recording data. They also found that students with middle and high levels of logical reasoning performed better on such process skills than students with low level of logical reasoning ability.

Hennessy et. al. (1995) found that students using a simulation on mechanics showed more sophisticated reasoning than their counterparts who did not use the simulation. Existence of alternative conceptions on motion was detected. Ronen and Eliahu (1997) suggest that simulation-based activities can be used to address students' common difficulties in a particular science topic.

**Simulations in supporting laboratory and experimental work**

Kennepohl (2001) investigated the benefits of incorporating computer simulations in a first-year general chemistry course. He found that the combination of simulations and laboratory offers advantages in saving time since the laboratory portion can be reduced in duration and students using the simulations were assessed to have a slightly better knowledge of the practical aspects related to laboratory work. Simulations can also be used in distance science education by offering online laboratory learning environments. Such distance education lab simulations are not restricted to synchronous communications between instructors and students; they can also provide constant access whenever needed by students (Forinash and Wisman, 2001). Forinash and Wisman (2001) mention that the safety factor, which is a prime concern of dangerous science experiments is diminished in distance labs. Computer simulations can also transcend the limitations of time and space, allowing experiments that monitor geographically distant phenomena such as weather and seismographic data to be carried out. Though the literature review indicate an abundance of research on the use of computer simulations in education, there is relatively little research done on the effectiveness of online science labs.

The effect of Faraday's lab simulation software on perception of students about Faraday's and Lenz's theory of electromagnetic induction (EMI) was studied (Hargunani, 2010). Students' perception about the topic before and after simulation was noted. It was found that teaching with Faraday's lab simulation creates a greater interest and curiosity about EMI phenomenon amongst students. It makes the studying of underpinning concepts easier and reduces the amount of laboratory work involved. This simulation helps the students to learn the EMI phenomenon independently on their own.

Mokros and Robert (1987) reported on the impact of microcomputer-based labs (MBL) on children's ability to interpret graphs. In a longitudinal study, seventh- and eight-grade students worked with MBL units on illusions, heat and temperature, sound, and motion for a minimum of 20 class sessions. The data indicated that there was a significant change in students' ability to interpret and use graphs (an effect size of 81 percent). Brasell (1987) studied the effect of a very brief MBL treatment with a kinematics unit on high school physics students' ability to translate between a physical event and the graphic representation of it, and the effect of real-time graphing as opposed to delayed graphing of data. Overall posttest scores form the treatment in which the graphs were displayed in real-time were significantly higher than scores from all other treatment groups. The evidence showed that a single class period was sufficient for high school physics students to improve their comprehension of distance and velocity graphs when compared with a paper-and-pencil control treatment. Most of the improvement (90 percent) was attributable to real-time graphing.

Other science educators have suggested that simulations allow for experiments that would normally be impossible due to safety, access, magnitude or time constraints (for example, Steed, 1992) and experiments that break the laws of nature (for example, Scanlon, O'Shea, Smith, Taylor & O'Malley, 1993).

Bourque and Carlson (1987) examined hands-on activities and computer simulations in chemistry. Three laboratory experiments (acid-base titration, determination of the equilibration constant of a weak acid, and determination of Avogadro's number) were designed to correspond three computer simulations. The data indicated that the hands-on activities produced higher scores for the acid-base titration and for the ionization constant, and they found no significant difference for the determination of Avogadro's number. The results further showed, however, that the highest cumulative scores were achieved for the format where hands-on experience were followed by the computer simulation for the first two experiments, but there was no apparent advantage in sequence of performance for the derivation of Avogadro's number.

### Simulations as communication and collaborative learning aids

Reiner (1998) employed class-observation techniques to study the effectiveness of a simulation-based computer micro-world on learning. The learning task was on optics. Students needed to generate hypotheses and predictions to be tested. Based on the reflection and refraction laws of light, the computer simulation helps learners to visualize the outcomes of the postulated hypotheses to determine their validity and exploratively conceptualize their thinking. Reiner found in his studies that the simulation program allowed for easier communication of diverse ideas amongst students and improved mental reasoning. Working in groups, students developed negotiation skills in discussing ideas and making consensual compromises where necessary to reach viable conclusions. Therefore it was concluded that scientific experiments conducted in online simulated micro-world environments are powerful cognitive tools for mediating collaborative learning.

Tao and Gunstone (1999) examined the role of collaborative learning in computer-supported learning environments in effecting conceptual changes. In their study, a suite of computer-simulations were developed to diagnose students' alternative conceptions and integrated in physics curriculum in a Grade 10 science class in high school. Pre-test, post-test and delayed post-tests were administered to determine students' levels of conceptual change. Analysis of collected data revealed that computer-supported learning approaches allowed students to consensually co-construct shared understanding of scientific concepts and collaboratively resolve peer conflicts. Zietsman and Hewson (1986) used computer simulations to identify and correct misconceptions on the topic of velocity. They concluded that simulations could be used as valid external representations of students' cognitive realities and instructional remediation produced significant conceptual changes in rectifying students' alternative conceptions. On the other hand, Carlsen and Andre (1992), in a study on electrical circuits, found that using a computer simulation in addition to text produced no greater change in better performance in tests than text alone did.

### Instructional guidance for students in using simulations

In their research analysis, De Jong and van Joolingen (1998) found the need for instructional support, including hints, suggestions, and just-in-time background knowledge, to be essential in incorporating simulations in teaching. Rieber, Tribble and Tseng (2004) have conducted a series of studies of a computer game designed to simulate the relationship between velocity and acceleration. They found that although students were successful with the game, they needed guidance in the form of explanations and feedback during the game in order to explicitly describe the principles involved. In a pilot study of 60 eighth grade students, Zydney (2005) found that students benefited from scaffolds for organization and higher-order thinking that were built into a multimedia learning environment on pollution.

However, the availability of support within the software is not always sufficient-students may not access such support if left to themselves. In a study by Lajoie, Lavigne, Guerrera, & Munsie (2001) 40 high school biology students used a hospital simulation program as a part of their curriculum. Students worked in one of three groups: one with a teacher providing guidance, one with a graduate student serving as a coach, and one working independently without the aid of a teacher or coach but with the availability of an online consultant. Although they had access to this support, this group did not use it at any time. They spent more time than the other two groups in determining how to clarify misconceptions.

### Internet-based simulations

Information technology has evolved into a stage where the use of the Internet for hosting various interactive simulations has become almost inevitable. Presently, there are at least two main types of internet-based simulations available for science educators to exploit viz. Applets and Shockwave simulations. One example of an applet is the following thin lens applet in Figure 1 that allows one to change various properties of an object and also different types of lenses and mirrors together with their focal lengths. It is available at http://www.phy.ntnu.edu.tw/java/index.html

Yap (2007) has suggested such thin lens applet can be used to inculcate thinking beyond typical textbook and classroom teaching. Typically the textbook and classroom teaching discuss image formation of a thin lens with respect to various object distances from the lens (focal length fixed). With a thin lens applet, the teacher can ask students to discuss the image properties for various focal lengths if the object distance is fixed.

It could also be used to discuss and address potential misconception that the image is formed by two or three rays only. One could introduce another thin lens applet by Sergey Kisalev (http://www.physics. uoguelph. ca/ applets/ Intro_physics/kisalev/java/clens/index.html) shown in Figure 2 to illustrate that the formation of an image is formed by multiple rays.

Yap (2007) also suggested that a refraction applet (e.g. http://www.walter-fendt.de/ph14e/refraction.htm) could be used in a pedagogically sound manner. Typical refraction activity in school laboratory is limited to one involving light travelling from air to a medium (e.g. glass). There are no opportunities for activities involving light travelling from a more optically dense medium to a less optically dense medium. With such simulations students could explore further as homework exercises.

An example of a Shockwave simulation is the following density simulation shown in Figure 3 that allows one to measure the mass and volume of an object and then

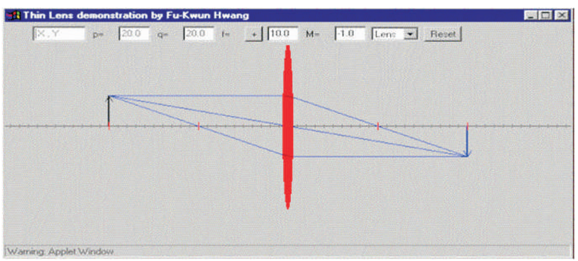


Figure 1. Thin lens applet

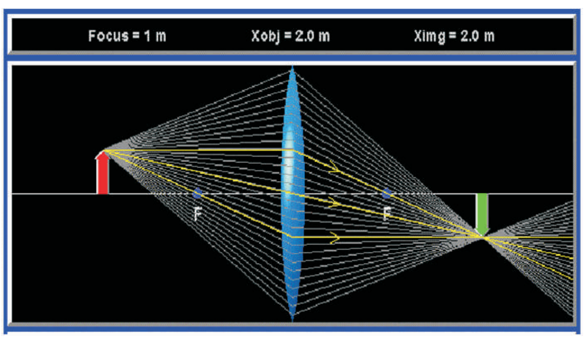


Figure 2. Another thin lens applet

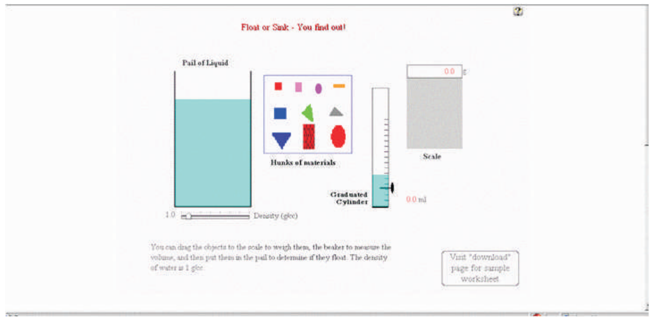


Figure 3. Density simulation

determines whether it will float or sink in a pail containing a liquid whose density can be varied too. It is available at the following website http://www.explorescience.com

Yap (2002, 2007) had suggested that such internet-based simulations not only allow for active and interactive hands-on activities but also have the potential to enhance thinking and learning. Creative teachers can design minds-on activities with these simulations. Such internet-based simulations also have the potential to (i) increase opportunities for individualized or guided learning, (ii) provide global access and hence global collaborative and cooperative learning, (iii) accommodate different learning styles, and (iv) provide an alternative assessment mode.

**Exploiting the internet-based density simulation**

In recent years science educators have increasingly begun to recognize the potential of interactive simulations in teaching and learning. While interactive simulations cannot replace actual laboratory experience, they could complement laboratory work.

One could begin to exploit such simulations for web learning if they fulfill some meaningful objectives. Yap (2002) had adapted and designed a web-learning activity (Appendix I found at the end section of this paper) based on the density simulation from the website (http://www. explorescience.com/). He had used this internet-based activity with a group of pre-service teachers. Teachers could open the file, conduct a number of hands-on manipulations, record the data and finally respond to various questions that would draw upon their ability to think.

Like a number of other internet-based simulations, this density simulation allows for scientific constructivism. A dose of social constructivism can easily be injected by having more than one student working on the task together. Students will need to respond to questions on the relationship of various factors/variables with an object's ability to float or sink based on the data collected, with some help in re-organizing their data. This simulation could also help address and assess potential alternative conceptions among respondents who are beginning to study this topic. Deep processing/thinking would be required of respondents in using spreadsheet software to display appropriate relationships so as to determine whether there is any pattern in the data collected. To have a better grasp of the respondents' conceptual understanding, they will be asked to explain their initial responses.

**Pre-service teachers' performance on Internet activity based on density simulation**

In order to assess and reflect on the use of the internet-based simulation, the Internet activity based on the density simulation was administered to a group of first-year pre-service teachers undergoing a two-year programme at the diploma level. Such a cohort may, upon graduation, teach science at the primary level (Grade 1-6). Academically they may be weaker in science when compared to other groups of pre-service science teachers. Some preliminary findings of the performance of this group of pre-service teachers are presented below.

Responses to question "What does the initial 0 ml (0 $cm^3$) reading of the graduated cylinder indicate?"

This question is consistent with the minds-on approach advocated by Yap (1997), that it is appropriate to think about certain procedural steps in conducting experiments or laboratory work. It appears that a number of respondents associate the initial 0 ml reading to alternative conceptions such as:

(i) volume of liquid in the graduated cylinder

"… no volume of the liquid …"

"… does not contain any form of liquid"

"… (cylinder) is empty"

"…initial volume of water in the cylinder"

"… initial volume of the water without any object"

(ii) accuracy of measurement

"… measurement of the volume of the object is accurate"

A number of respondents could associate this initial 0 ml reading to the context when there were no object in the cylinder. For example, they responded with descriptions like:

"… calibrated to exclude volume of water …"

"… no object in the cylinder …"

"… base measurement of volume …"

"… starting point of volume measurement …"

"… initial water level of beaker before any object is being placed in …"

"… reading before object placed inside cylinder …"

However, none of them made any attempt to relate the initial 0 ml and subsequent readings to the volume readings when the water is displaced by an immersed object. This is how we then obtain a measure of the volume of the object.

Responses to questions on the relationship between mass, volume and density of an object and its ability to float or sink.

Since respondents were allowed to discuss with one another it was not difficult to obtain the correct 'answers' in terms of "Yes" or "No" to the questions asking for the relationship between mass, volume and density of an object and its ability to float or sink. However, real understanding is better assessed from their explanations.

The respondents had to rank the data they have obtained from their hands-on activity with respect to mass, volume and density. Yet none of them made any attempt to use the data to help them answer these questions. It was apparent that they did not realize the use of such an activity or how it was meant to be of some help.

It was apparent that they may know that one factor that determines whether an object will float or sink is the density of the object relative to the density of the liquid. However, mere ability to regurgitate this fact for explaining why there is no pattern between the mass of an object and its ability to float or sink does not show meaningful understanding. Such responses include:

"Ability to sink or float depends on density, not mass."

"The mass of an object does not indicate the ability to float and sink …"

Even when explaining why there is a pattern between the density of an object and its ability to float or sink, almost all responded in a manner similar to:

"Anything with density less than 1 floats."

What is surprising in this activity is the total neglect of using the data from the hands-on exercise to help answer the questions. A few of the respondents did make feeble attempts to use the data in their explanations:

"Bigger mass doesn't mean the object will not be able to float. Example: grey triangle of mass 24g can float, red rectangle of mass 42g can float too."

In a Piagetian sense, such a response will fit thinking at a concrete level. Thinking at a higher (or abstract) level will respond to giving examples of objects with smaller masses that will float and sink and similarly bigger masses that will float and sink.

One should not be surprised that this group of respondents had the prior knowledge. In fact one would expect them to have it. However, it is the lack of using "experimental data" to help provide evidence and support explanations that should provide some concern amongst science educators. Perhaps they have been so used to regurgitating facts and scoring that they do not see the need to do otherwise. Perhaps that is the only way they know how to respond to such questions.

### Responses to question on using the spreadsheet

One common IT tool that is introduced to most students is the use of spreadsheet software, for example, Microsoft Excel. In science teaching and learning such software would be appropriate to investigate the relationship between two variables, for example force and acceleration. Oftentimes, the two variables have continuous values and hence line graphs are used to look at their relationship. For this task, the ability to float or sink is represented by two category values. Nevertheless, it is still possible to determine whether there is a pattern in the respective data set. Such relationships can be displayed through the Excel table of data or histogram plot. This task certainly requires deep processing with an IT tool.

While the majority of respondents are familiar with the general use of Excel, they were not able to use Excel to display appropriate histogram plots and to interpret from such plots. The Figures 4 and 5 could be examples of these plots using Excel.

This indicates a need for more practice and use of such IT tools in a science teaching and learning context.

### Conclusion

Simulations have been increasingly used for educational purposes. The rapid advances in computer software engineering and networking technologies have allowed simulations to become a powerful and innovative tool for use in engineering education. Often simulations can also provide a viable alternative in science when experimental phenomena are not observable or measurements are impractical or too expensive. Simulations have been found to be effective in motivating students to learn and encourage engaging exploration for many students. Simulations can provide a challenging environment in which students can explore new ideas and correct misconceptions in their thinking by allowing them to test out formulated hypotheses. While simulations have a useful role to play in science education, it is timely to remind oneself that simulations of themselves do not bring upon positive results in learning - simulations have to be exploited

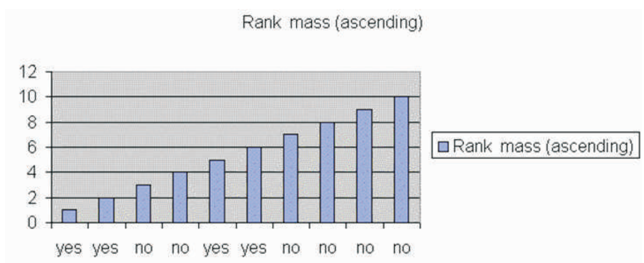


Figure 4

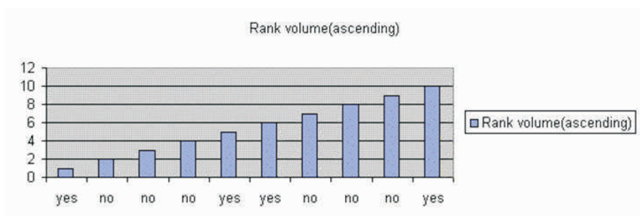


Figure 5

Figure 4 & 5. Excel histogram plots

in educational delivery in more meaningful ways to enhance classroom teaching and learning.

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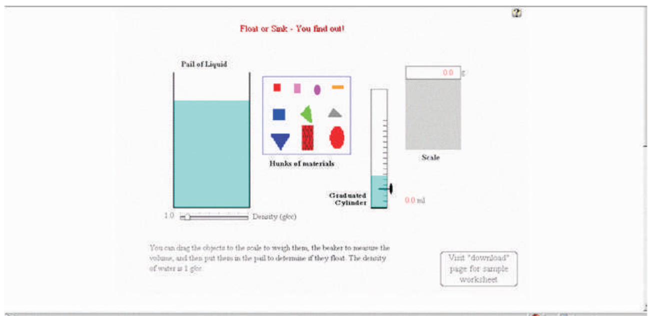
**Appendix I**

**Interactive Hands-on and Minds-on Investigation Using an Internet Resource**




(Virtual Experiment based on Raman Pfaff ExploreScience at http://www.explorescience.com)

You are going to conduct a virtual laboratory to investigate why certain objects float while others sink.

Before you begin, record your name and that of your partner (if you have one) at the time that this virtual laboratory was conducted.


Set the density scale so that it reads 1.0 g/cm$^3$.

You can grab an object by holding the left button of the mouse down over it.

You can then drag and drop the object (a) on the big scale to measure the mass of the object, (b) into the graduated cylinder to measure the volume of the object (note the sophisticated thumb tack that hold things underwater at the time), and (c) into the pail to see if they sink or float.

For each object (identified by colour and shape), measure the mass and volume and then calculate the density (mass/volume). Also determine whether it will float or sink.

| Record the results in the table below. Object Description (Start top left) | Mass (g) | Volume (ml) | Object Density (g/ml) | Does it float? | Rank mass (ascending) | Rank volume (ascending) | Rank density (ascending) |
|---|---|---|---|---|---|---|---|
| Red Square | | | | | | | |
| Purple Rectangle | | | | | | | |
| Purple Oval | | | | | | | |
| Orange/Golden Rectangle | | | | | | | |
| Blue Square | | | | | | | |
| Green Triangle | | | | | | | |
| Grey Triangle | | | | | | | |
| Blue Triangle | | | | | | | |
| Red/Black Rectangle | | | | | | | |
| Red Oval | | | | | | | |

**Questions**

1. What does the initial 0 ml (0 $cm^3$) reading of the graduated cylinder indicate?

2. Is there a pattern between the mass of an object and the ability of the object to sink or float?

Why? Yes No

3. Is there a pattern between the volume of an object and the ability of the object to sink or float?

Why? Yes No

4. Is there a pattern between the density of an object and the ability of the object to sink or float?

Why? Yes No

5. For questions 2 to 4, can you suggest how you could use a spreadsheet software to help you answer the questions?

6. If the density of the liquid is changed to 3.0 g/ml (3.0 g/$cm^3$), which column(s) in the table above will be affected?

Why?

Confirm your prediction by carrying out the experiment with the new density value.

(When you are done, click the "Submit" button to send your report to your lecturer!)

Submit Reset

## ABOUT THE AUTHORS

*Dr. Kumar Laxman graduated with Ph.D in Instructional Design and Technology from Macquarie University, Australia. He has worked in various capacities both as an educator and instructional designer with many reputable educational organizations and tertiary institutions. He has been outstanding in his efforts at promoting the use of technology to advance innovation in teaching and learning and has served well as a catalytic leader in participating in e-leaning initiatives. He is knowledgeable in the field of instructional design and learning technologies, having published widely in reputable journals and presented at numerous international conferences.*

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