Web-Based Resources for Learning

A Case Study of Year 10 Students’ Perceptions of Learning Concepts of Motion Using Java Applets

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Abstract

In the last decade, there has been a big push for computer-based technologies to be used in all subject areas in classrooms around the world. While there is a reasonable amount of literature on the positive aspects of using these technologies in education, the issues surrounding the use of these technologies in the classroom and how to address them are discussed in lesser amounts. There are issues of cost, technical support, teachers’ skills and time, the availability and reliability of computers and associated equipment, the availability of user-friendly software, classroom management as well as issues of appropriate methodologies for measuring the effectiveness of computer-based technology use in learning. These issues are interlinked and solving one issue does not automatically put the others in place. In real terms, many of these issues are difficult to address.

The issue of the cost of software packages could be alleviated to some degree by using Web-based technologies. The World Wide Web is a rich source of information and contains tools that can assist with learning. This paper discusses the issues associated with the use of computer-based technologies in the classroom, and proposes the use of cost-free Web-based resources for learning. A case study of the use of one such resource, Java applets, in year 10 students’ learning of science concepts on the topic of Motion is reported in this paper. The study is based on qualitative research methodologies to elicit the students’ perceptions of the usefulness of the applets in assisting them develop conceptual understanding of abstract concepts on the topic of Motion.

Keywords: World Wide Web resources, Science learning, Constructivism, Use of simulations for conceptual understanding of science, Year 10 students’ perceptions

Introduction

Since the mid-1990s, policy makers across the globe have made technology an explicit priority in educational policies and associated planning documents (Meredith, Russell, Blackwood, Thomas & Wise 1999 cited in VCAA 2002). Millions of dollars (Fulton 1999, McKenzie 1999) have been invested in getting schools connected in the different countries but questions regarding the benefits technology bring to students’ learning in the classroom remain to be answered. At the global level, there is insufficient detailed research in this area and there is little definitive research data to support the positive impact of technology in the classroom that leads to improved learning (Johnson 1996, McKenzie 1999, Hardin & Ziebarth 2000).

Evaluating and measuring the effectiveness of technology in teaching and learning is complex and complicated by a number of variables such as the teachers’ skills, ability and/or instructions, the student’s ability, the user-friendliness of the software and quality of the equipment used, and the contribution of the social environment to the learning in a setting which is technologically enhanced. New methodologies to measure the full potential of technology on the learning process need to be developed.

Apart from the lack of effective methodologies to measure the contribution of technology to the learning process, the implementation of technology usage itself in the classroom is plagued by a number of issues (Mckinsey 1997, Stevenson 1997, Ofsted report 2001, Tebbutt 2000, Ng & Gunstone 2003). The use of technology in teaching is ad hoc, ranging from enthusiasts who have explored and put into place strategies for their frequent use in the classroom to those with varying degrees of enthusiasm and skills for these technologies, many of whom have reacted only in response to non-pedagogic pressures such as the necessity to include in their performance review the use of technologies in their teaching, or because the use of technologies is in the school charter. The issues relate to obstacles that prevent the frequent use of computer-based technologies in the classroom. Fulton 1999 asserts that the obstacles relate to access, teacher professional development and school support. This is supported by findings of Ng and Gunstone 2003 who identified the six main obstacles to the greater use of technology in the area of science teaching and learning as (a) the difficulty in getting access to computers and associated equipment (b) the lack of time to investigate and plan computer-based teaching and learning activities (c) the lack of financial support to purchase equipment and software (d) the lack of teachers’ skills and...
knowledge of appropriate applications using computer-based technologies (e) the lack of suitable software programs at the school level and (f) management issues in terms of student behaviour related to lack of equipment and technical skills in using the hardware or software programs. These issues are interlinked and solving one issue does not automatically put the others in place. Financial and technical support from administrations, both at the government and local level to ensure adequate equipment is available for teaching is necessary as is the need to support teachers with preparation time and professional development opportunities to develop skills, and time afterwards to plan and practice.

**Resources on the World Wide Web**

The issue of the cost of software packages could be alleviated to some degree by using Web-based technologies. The World Wide Web (WWW) is a rich source of information and contains tools that can assist with learning. Essentially, the WWW is a collection of ‘pages’ of information on the Internet written in a coding system called ‘hypertext markup language’ (html). These pages may be interactive and contain texts, graphics, images, sound, video and/or animations. As the number of pages on the WWW continue to expand, the amount and variety of resources available to teachers and students at all levels of education has increased dramatically over the last few years. With vast amounts of textual material and information being available on all school-taught topics, project work that relies on computer-based research investigations has become very popular in the classroom (Becker 1999). Apart from information, there are a variety of resources available on the WWW, some of which are cost free for teachers and students to use. These Web-based resources include lesson plans for classroom use, homework and online tutoring services, shareware and multimedia and simulation resources. Advantages in using these WWW-based tools and resources include the fact that many of them can be used at no cost, and teachers and students are able to access them outside the school environment, making independent research and learning more possible for a wider number of learners. However, these resources and tools bring with them challenges and issues that educators have to focus on in order to bring about meaningful learning for their students (Wallace 2002, Ng & Gunstone 2002, 2003, Wallace, Kupperman, Krajcik, & Soloway 2000, Hoffman, Wu, Krajcik, & Soloway 2003, Warschauer & Kern 2003).

**Learning in a Technology Enhanced Environment**

The use of Web-based technologies and resources is inextricably embedded in the creation of effective learning environments that support this ‘learning paradigm’ shift in education. (Socio)-cognitive learning theories that provide understandings of the dialogic nature of how people learn, make it possible to suggest practical and effective strategies to facilitate learning in this ‘learning paradigm’. One of the most influential cognitive learning theories in education is that of educational constructivism. The two notable theoretical sources of educational constructivism were the divergent and in some respects conflicting works of Jean Piaget and Lev Vygotsky. The underlying principle in Piaget’s (1955, 1972) cognitive constructivism is that knowledge resides in individuals and that it cannot be given or transmitted complete to them by their teachers. Learners must construct their own knowledge in their minds and build upon pre-existing knowledge through reflection on experiences. Real learning can only take place when the learner is actively engaged in the process, either at the operational level where the learner is engaged in physical manipulations or at the cognitive level where (s)he is mentally processing information or stimuli (or some combination of both). Vygotsky’s (1962, 1978) social constructivism makes similar assertions to Piaget’s cognitive constructivism on how learners learn but places more emphasis on the social context of learning and the mediating role of mentors. In his theory, the learning process involves interaction with other individuals where culture and society will influence the learning not only directly by the natures of the experiences that are available, but also indirectly by virtue of the kinds of mediations offered by ‘teachers’ and technologies.

Educational constructivism, as applied in many classroom situations draws on the cognitive and social theories of both Piaget and Vygotsky (sometimes without acknowledging the differences between them) by focussing on the nature of learning as a dynamic and social process. An technology-enhanced environment is potentially consistent with the underlying assertions of constructivism in that in a well-constructed technology-enhanced environment, the learner is an active participant in the construction of knowledge and the existing knowledge and a socially interactive environment are built into the learning experience as factors that affect this construction of knowledge.

**Learning with Simulations**

A useful Web-based resource that fosters constructivist and self-paced learning is simulation programs. Simulations are software programs that attempt to replicate a real or imagined phenomenon or concept in a dynamic and interactive way. It is a non-linear and manipulable model (Thomas & Hooper 1991), and has inbuilt features for the learner to track his/her progress, providing feedback in realistic forms (Alessi 1991, Barab, Bowdish & Lawless 1997). Simulations are multimedia
resources, where element of graphics, text, audio, video and animations are integrated to make the investigation more interesting, and concepts easier to understand. In addition, with multimedia resource support, it is possible that students learn more information more quickly compared to practices such as traditional classroom lectures (Najjar 1996). Hargrave and Kenton 2000 reported that simulations designed for and used prior to formal instructions can change students’ learning significantly. Pre-instructional simulations are exploratory environments where students are able to manipulate variables to explore their own thinking and to generate questions about concepts that they experience difficulty with. The teacher’s preparation task changes as a result of being provided with such information regarding students’ learning in this type of environment.

Small simulation programs called applets are quite readily available without cost on the WWW, particularly for Mathematics and the different Science discipline areas. An applet is a name for a computer animation created using Java script or other appropriate programming language. Applets are interactive and most are intended for use over the WWW and are linked to Web pages, for example, the virtual frog dissection at http://curry.edschool.virginia.edu/go/frog/Frog2/. Web browsers (for example Internet Explorer, Netscape Navigator and Mozilla) will run the applets provided the appropriate ‘plug-in’ software has been installed for the browser. The Java Virtual Machine (free from Sun Microsystems – http://java.com/en/index.jsp) is required in order to use Java applets and Flash Player (free from Macromedia – http://www.macromedia.com) for using Flash animations.

Simulations provide the learner with close to ‘real’ learning situations and are particularly useful for learning science and Mathematics where some of the concepts are very abstract. With simulations, students are able to ‘visualise’ the abstract nature of concepts such as through the use of models, hence assisting with their active construction of meanings and understanding of the concepts. This paper reports on the findings of a case study of the use of Java applet simulations in the teaching and learning of concepts of Motion with year 10 students. The study sought to investigate (a) the students’ perceptions of the benefits that these simulations have brought in assisting them with the learning of the abstract concepts on the topic of Motion and (b) the effectiveness of these simulations in assisting with the learning.

Background Information of Participants in the Case Study
The participants in this study were from a small, co-educational government school located in a middle class suburban area. The class of year 10 students consisted of seventeen boys and three girls who displayed a range of academic abilities. The teacher was an experienced Physics teacher who was skilled in using computer technologies.

Method of study
The year 10 students studied the topic of Motion over a four-week period, where each week had four periods of 48-minute lessons. The strategy employed by the teacher in the teaching of this topic was to use a combination of interpretive discussions, laboratory work, written exercises and the use of two Java applet simulations that were readily accessible directly from the Internet. The Motion with Constant Acceleration and Projectile Motion applets were obtained from Walter Fendt’s website at http://www.walter-fendt.de/ph14e/acceleration.htm and http://www.walter-fendt.de/ph14e/projectile.htm respectively. Figures 1 and 2 show snapshots of these applets and the parameters within them. Air resistance is negligible in the Projectile Motion applet. It was the teacher’s intention to use the simulations as reinforcements for assisting with the students’ learning of the concepts on Motion and to complement the learning undertaken with practical work and the more traditional form of teaching. The use of the simulations was guided by a prepared worksheet as shown in the Appendix.
This qualitative study focused on student’s perceptions on the usefulness of simulations in assisting with their conceptual understanding of motion and the impact of the simulations on their learning. Two weeks after the completion of the unit on motion, nine of the students (one female and 8 males) were interviewed to elicit their opinions on the effectiveness of using laboratory work and simulations in learning about Motion. The interviews required students to reflect and recall key concepts studied and to explain how the simulations affected their understanding of some of these concepts. The period of 2 weeks’ lapse was chosen as a reasonable time frame to gauge how well the students have conceptually understood motion as students would still be able to recall the Java applets and relate any aspect of their understanding to the use of these applets. The semi-structured interviews took place on a one-to-one basis in front of a computer that had access to the Internet and the applets were shown, when appropriate, to students to assist them with their recall. The interviews were tape-recorded and transcribed.

The interview questions placed an emphasis on practical work and the Java applets the students used and the eliciting of how well the real-life and virtual components complemented each other with assisting the students’ understanding of motion concepts. The questions guiding the interviews were:
1. What aspects of motion have you learnt? Can you name/explain key concepts studied?
2. What practical work did you do while you were learning about motion? Briefly describe them.
3. Has the practical work helped you understand motion? (Exploration on why they think that).
4. What computer simulations have you used in the study of the unit on motion?
5. On the use of the Motion with Constant Acceleration applet, what did you learn from this applet?
6. On the use of the Projectile Motion applet,
   o Why do we study projectile motion – what practical uses can you see that can be applied with knowledge of how projectiles move?
   o What are the factors that will affect how projectiles move?

7. In exploring the understanding of the effects of angle, gravity and mass on the motion of projectiles,
   o Which angle of inclination for firing a projectile do you predict will enable a projectile to move the furthest horizontal distance, keeping the other variables constant?
   o (ii) What will be the effect of gravity on the projectile path in terms of the maximum height it will reach and horizontal distance it will travel, keeping the other variables constant?
   o (iii) What effect will the mass have on the horizontal distance travelled by the projectile, keeping the other variables constant?

8. Categorise the usefulness of the Java Applets in helping you understand motion: useful, not useful, somewhat useful, don’t know.

9. If they have been useful, how have they been useful? If not, why not?

10. Is there anything you would like to tell me about using the applets?

Results
The students were able to recall a variety of key concepts learnt in the unit on motion: forces, speed and acceleration, velocity, inertia, projectile motion and Newton’s Law(s). All except two were able to explain the relationship between speed, velocity and acceleration. The only practical work that all the students named was the ticker-timer experiment. They were able to describe the physical set up of the experiment and the purpose of the experiment. However, the explanation on how the ticker timer worked to produce data for them to work out speeds and accelerations varied quite considerably amongst the students.

Interacting with the Applets
Most of the students were unsure of how to interpret the data in the Motion with Constant Acceleration applet. Only two students were able to demonstrate good understanding of the use of this applet. They provided a useful insight into the effectiveness of the applets in assisting with their study of acceleration and projectile motion. In the interviews they were able to relate the ticker timer experiment to the motion applet, and demonstrated understanding of the purpose of the applet motion graphs on the computer screen as well as being able to predict and explain when a change to acceleration was made. On the usefulness of this motion applet, the following are two quotes from these students:

Student 1: ‘(the applet) shows the speed and acceleration better than the ticker timer does’
Student 9: ‘the graphs made it easier to understand…you can stop it and pause it…this one is telling you how many metres you have travelled per second….if you increase the acceleration here, the velocity will go up higher/steeper and take less time to cover the distance’

The dialogue with the students regarding the Projectile Motion applet elicited more uniform views and understanding of the purpose and use of the applet from all the students. The students were able to relate practical uses for learning projectile motion. Examples they provided were in the areas of sports such as throwing a ball, kicking a football, throwing a discus or javelin, playing basketball and shooting a rifle or cannonballs.

Student 1: ‘I play basketball and shooting projectile helps me a lot because you have to get the ball in the basket and you have to project it at the right angle.’
Student 5: ‘footy ball, judge how far you can kick.’
Student 6: ‘javelin, the angle you have to aim.’

The students were also able to name the factors that will affect the motion of a projectile, such as speed, angle of inclination, force, resistance and gravity. Except for one student, all were able to explain the effect of gravity on the path constructed by a projectile. For example when asked about the effect of decreasing the gravitational acceleration, students responded that the object will:

Student 7: ‘go higher and more distance.’
Student 2: ‘go high up and much further’

The 45-degree angle of inclination that will enable a projectile to move the furthest distance was correctly identified by all except two students. Those who correctly identified the relationship between the angle of inclination and largest were also able to outline the general shape of the projectile curve when asked about other angles. The effect of mass on the motion of the projectile, however, was incorrectly explained by all the students. Every student indicated that the heavier mass will travel the lesser distance. The response by one of the students is outlined below:

Interviewer: ‘does the mass have anything to do with it (distance travelled)?’
Student 5: ‘yes, because it’s harder to throw if it’s heavier, if it’s too light the wind catches it and pulls it back.’

Interviewer: ‘what if it is an ideal situation without any friction? If 10 kg goes that distance, what happens with 5 kg?’

Student 5: ‘it will go further than 10.’

Interviewer: ‘try it with the applet.’ (student carries out the simulation)

Student 5: ‘mass does not matter.’

**Usefulness of the Simulations**

All the students in this study said that the applets were useful and assisted them with their learning although one said that the ticker timer and

‘the cart was more interactive ‘cos you are doing it, not just clicking it ... (but) you get problems with the cart.’ (Student 6)

Being able to change the parameters in their exploration of the concepts of motion and being able to visualize the motion itself were features of the applets that the students cited as being useful in helping them learn these abstract concepts. These simulations were also useful due to the difficulty in carrying out experiments, varying factors and measuring the motion with school equipment.

Student 3: ‘you don’t actually see what’s going on (in a text book), you can imagine it and if you think of it a lot you can probably draw it up but actually seeing how it works really makes your mind just click, you skip the bits in between and see how it works properly.’

Student 4: ‘gives you a good visual thing, using a text book you read about it and not everyone can visualize a cannonball going that distance or understand as well, so the software is better to use...gives you a chance to see what that does and you can remember things more than reading out of a text book. It’s very hard to do these (simulation) experiments in the classroom. Schools don’t have cannonballs and its very hard to predict your velocity and your coordinates to get it exactly right and change it one by one. That’s where this better you can change all things.’

Student 1: ‘the applets made it easier (to learn) and were more fun. I enjoyed the applets, it was good to get out of class and all the writing and get to do something actually fun. If you are enjoying what you are doing you are going to absorb more information than if you are bored and doing the same thing over and over again’

Student 2: ‘it’s just more fun because you actually see it happen when you change things whereas on paper you just write down and don’t get to visualize what’s happening.’

Student 3: ‘really using the computer was the bit that I enjoyed most, all the other stuff I didn’t find that interesting. Enjoyment was definitely a big factor. I don’t think it’s worth trying to teach someone to learn something unless they enjoy it ‘cos they can just say no I don’t want to learn this, I’m not going to try and they will get that mindset and they won’t learn anything.’
Student 4: ‘I think we won’t pick up as easily because it’s not as enjoyable. Watching diagrams on the board is nowhere as much fun as experimenting it yourself.’

Student 5: ‘won’t learn as much from notes and books and prac work ’cos you are not getting as much experience watching how it moves and getting all the proof.’

Student 6: ‘I enjoyed it (simulations) and we should use it more often.’

Student 7: ‘this is more fun and your probably learn more. If you use the text only you will learn less, here you can see how it is working.’

Student 8: ‘the fun bit is important ’cos if you are bored, you just get distracted and cannot concentrate. Motion I found a little boring, playing with this like increased my excitement a bit more.’

Student 9: ‘I enjoyed it, better than bookwork and stuff. This should be done more often.’

There are numerous reports, for example Dywer (1994); Pedretti, et. al., (1998), Mistler-Jackson and Songer (2000) and Ng and Gunstone (2002) that indicates that students are motivated to learn in a technologically enhanced classroom environment. In such an environment, students are able to self-direct and have ownership of their own learning, hence increasing their motivation to learn. Educators should capitalize on this aspect of students’ learning and encourage the use of technology-based resources, such as simulations, in the learning of abstract concepts of the curriculum.

Conclusion

The year 10 students in this study were motivated to learn with Java applet simulations. The study was not designed to measure the amount of knowledge gained by the students as a result of learning with the simulations. Such studies would require research methodologies that distinguish learning as being an outcome of interactions with computer-based technologies only and separate from other variables associated with the teaching and learning processes inside the classroom such as teachers’ instructions, practical work and the social environment. Nevertheless, the findings of the study suggest that students have found the use of simulations to be beneficial with assisting them learn some of the concepts of motion and that the interactive engagement with the Java applets was a useful complement to the conventional delivery of teacher’s instructions, class discussions and experimental work.

Well-designed simulations are useful learning materials where students are able to interact with the software and actively engage with the learning, drawing on prior knowledge in constructing meanings of the learning. Future research into the use of applets for learning should address questions on the nature of learning with simulations, the timing of the introduction of simulations in the sequence of the teacher’s instructions and the gain in conceptual understanding as a result of interacting with simulations. Research questions could include the following:

What impact does the timing of the introduction of simulations into students’ learning have on conceptual development and understanding? What differences are there in the learning between pre-instructional and post-instructional introduction of the simulations?

How do students fair in pre and post-tests when learning in environments with and without the availability of simulations?

What types of facilitation and guidance are needed when students learn in environments where simulations are used?

How does the design of the simulations impact on students’ learning in terms of cognitive overload and skills required?

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About the Author

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Appendix

Year 10 Science Worksheet

Motion: Forces and Acceleration.

Go to this site: http://home.a-city.de/walter.fendt/phe/acceleration.htm
Let the applet load, then press the start button and watch the car.
Write a sentence to describe its motion:

Reset.
Change the acceleration to 2 m/s² and restart the car.
Write a sentence to describe its motion:

Read the text on the screen.
You will have to move the red and green barriers to answer these questions:
When the acceleration is 1 m/s² what time does it take the car to travel:
20 metre from the 10 metre position to the 30 metre position
20 metre from the 30 metre position to the 50 metre position

Write a sentence to explain what you observed:

Now change the acceleration to 2 m/s².
With this acceleration what time does the car take to travel:
20 metre from the 10 metre position to the 30 metre position
20 metre from the 30 metre position to the 50 metre position

Write a sentence to explain what you observed:
**Projectile motion** - this is the way things move when they are thrown, kicked (or shot from gun): moving forward and falling down at the same time.

Load the projectile motion applet at:  
[http://home.a-city.de/walter.fendt/phe/projectile.htm](http://home.a-city.de/walter.fendt/phe/projectile.htm)

Set the initial height to 0 m  
Set the initial speed to 10 m/s  
Leave the acceleration (for the moment) at 9.81 m/s\(^2\) - this is the strength of gravity at the earth’s surface.  
Change the angle of inclination and fire the projectile.  
Describe the differences you observe when the angle is 20 degrees and 70 degrees:

Experiment and find what angle allows the projectile to travel furthest?  
On Mars the acceleration due to gravity is less.  
Change the value to see the effect of firing the projectile on Mars.  
Describe the difference between motion on Earth and on Mars:

On the Moon the acceleration due to gravity is 1.7 m/s\(^2\)  
Put in this value.

How much further will a projectile travel on the Moon compared to on Earth?  
[ you might need to reduce the initial speed to a small value so that you can see the whole motion on the moon.  
Don’t forget to use the same value for earth. ]

Does the mass of the projectile alter the height it rises or the distance it travels?  
Fire projectiles (on screen !) with different masses and report on what you find: