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Developing Science Content Knowledge Through the Creation of Slowmations

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Abstract: "Slowmation" (abbreviated from "Slow Motion Animation) is a new yet simple form of stopmotion animation which enables learners to create their own animations of science concepts. This paper presents a study of preservice elementary teachers in a science method classes (14 in one class in 2009) to ascertain if they improved their science knowledge when using a three phase framework requiring them to: (i) create their own Slowmation about a science concept; (ii) upload them to a web site (www.slowmation.com.au) so that they could be reviewed by a peer and a content expert; and (iii) if necessary, modify the animation and reupload it to be published on the Slowmation website. The two research questions were: (i) How did the three phase framework change the preservice teachers' science content knowledge and (ii) What was the value and motivation of the web site, for uploading and reviewing the animations? Qualitative data (three interviews, two concept maps and the animations as knowledge artifacts) collected from each preservice teacher showed that all of them increased their science content knowledge as a result of using the framework. Uploading the Slowmations to the website was successful for the students and enabled them to view other animations and created a social motivation to make and improve their animations. Getting preservice teachers to create Slowmations is a new way for them to engage with science content knowledge and is a new way for them to represent their science understandings.

Keywords: Slowmation, Science, Teacher Education, Qualitative, Constructionism

Introduction

Research studies and national reviews of science teaching report that many elementary school pre-service teachers do not have an adequate understanding of science content knowledge and this decreases their confidence in the teaching of science (ASTE Committee, 2002; Committee for the Review of Teaching and Teacher Education, 2003; DEET, 1989; Goodrum, Hackling & Rennie, 2001). One consequence of this is that science is one of the least taught subjects in the elementary curriculum in Australia (except for Languages other than English) averaging 41 minutes or 2.7% of teaching time each week (Angus et al., 2004). Some science concepts are particularly problematic for pre-service teachers and tend to be avoided or are taught incorrectly. For example, elementary teachers often have difficulty understanding concepts such as day and night (Atwood & Atwood, 1997), phases of the moon (Trundle, Atwood, & Christopher, 2002), the water cycle (Stoddart, Connell, Stofflett & Peck, 1993; Stofflett & Stoddart, 1994) and energy (Trumper, Raviolo & Shnersch, 2000). In a study conducted in Israel which explored the conceptions of basic aspects of astronomy, only 36% out of 645 pre-service elementary teachers answered the questions correctly (Trumper, 2003). What is needed in teacher education programs are innovative approaches to teaching and learning that engage pre-service teachers in developing a better understanding of science content knowledge (Hoban, 2005, 2007, 2009).

Using technology is one way to engage pre-service teachers in learning science content, especially using a popular medium such as digital animation. However, as Jonassen, Myers, and McKillop (1996) reported, learning science content with technology usually involves showing pre-service teachers expert-generated multimedia products which is not much different from learning science from a book with learners having to “acquire knowledge in the *sponge* or *banking* way” (p. 94, emphasis in original) i.e., expecting students to absorb knowledge and putting it away into their bank of knowledge. Therefore the potential of digital animations to engage pre-service teachers in learning science has been limited because they are mostly made by experts for learners to use as consumers of technology. Like Chan & Black, (2005) we believe that animations would have more value if the learners themselves became the designers and creators of animations (Chan & Black, 2005). The view of Chan & Black (2005) is supported in previous work by Bransford, Brown, and Cocking (2000), who assert that technology is a powerful tool for learning especially as “learners might develop a deeper understanding of phenomena in the physical and social worlds if they could build and manipulate models of these phenomena” (p. 215).

We decided it would be opportune to develop a simplified technique of animation that could be used to engage pre-service teachers in science and investigate whether this approach improved their content knowledge as they constructed their own animation artifacts. Our rationale is supported by the work of Jonassen *et al* who stated, “when learners construct knowledge from multimedia they acquire a cognitive, metacognitive and motivational advantage over learners who attempt to absorb knowledge” (1996, p. 97).

“Slowmation” (abbreviated from “Slow Motion Animation”) is a new form of stop-motion animation that simplifies the usually complex process of making animations so that they can be created by learners (Hoban, 2005, 2007, 2009). Slowmation involves the manual manipulation of materials with a digital still photo taken at each change in position of the materials. The digital photos are then uploaded into a computer program that plays the photos in a sequence to create an illusion of movement. It is seen by the human eye as moving by itself because of a phenomena called “persistence of vision.” The Slowmation process involves students researching information, scripting, storyboarding, making models, photographing digital still images of small manual movements of the models, and using a computer program such as Apple’s QuickTime Pro or Windows Movie Maker to create the animation.

Literature Review: Sharing Artifacts on the Internet

Using technology to construct artifacts and then linking these artifacts to the internet has been well researched. There have been several studies carried out linking constructionist learning and the Internet whereby students construct artifacts (Stager, 2003; Hopkins & McDougall, 2003; Mitchell, Andreatta & Capella, 2004; Stager, 2003; Willett, 2007). All these studies took a different approach to the linkage of these two areas (use of the internet and constructionism). The studies carried out by Stager (2003) and Hopkins and McDougall (2003) both focused on the impact of creating an artifact using technology in what was an after school program run in Fitzroy, Melbourne, Australia called The Computer Clubhouse. In this program, the children had the opportunity to construct projects of interest to themselves using robotics, multimedia development and website building activities. “They were encouraged and supported to work as designers and creators” (Hopkins & McDougall, 2003, p. 1). Both papers reported on the same study using The Computer Clubhouse,

and highlight the need for the process of construction to be within the capacity of the students attempting it. Both papers focused on the technique of teaching in this fashion as well as the challenges involved but not the affect that the construction technique has on learning outcomes, or motivation for achievement.

The study by Willett (2007) focused on a group of students who were developing an online game (i.e., an artifact). The game as an artifact is produced by the students on the computer and then shared with peers through the Internet. The key factor was that the construction material(s) available to the students were limited to computer software. This meant that although some of the students had prior knowledge they were able to apply to the use of the software, others were restricted through a lack of familiarity. Although the students may have had the concept planned in their minds (there was no mention of having a paper version) in the way they wished to have it look and perform, their lack of skill in the use of the software restricted their progress. Because of the simplicity of the Slowmation approach there is very little restriction on materials to produce the actual artifact, except for the ability to take a photo and download it to a computer - a skill that is easily taught if not already present. Willett went on to state in relation to achieving the aims of the project, “the production tools disempowered the students, making their knowledge of games fairly useless” (2007, p. 179). Other studies have also considered artifact production. Mitchell *et al* (2004) reported on how “educational doctoral students ... demonstrate their understanding of key concepts through the creation of multimedia learning products” (2004, p. 1). The similarity to the study which I have undertaken is in the fact that the doctoral students in the Mitchell study are producing an artifact (their multimedia production) for use with undergraduates. These artifacts were shared with the undergraduates through digital presentations. The outcome of the study “appeared to result in the doctoral students thinking more carefully about effective design of multimedia learning experiences as well as leading to a higher level of student engagement with the academic content of the course” (Mitchell *et al*, 2004, p. 6)

As evidenced from the studies above, the production of an artifact may assist the students in using technology to promote greater engagement with content. The sharing of artifacts seems to have a positive effect on the production but there appears to be little research in the area of the effect on the producer of public display of artifacts via the Internet.

Theoretical framework

This study looked at both the personal and motivational influences of creating and reviewing student created animations supported by a website <http://www.slowmation.com.au>. Constructionism involves both personal and social aspects of learning. Empowering learners to make and display their own animations of science concepts is consistent with the theoretical framework of ‘constructionism’ which draws from Vygotskian social influences when the artifacts are shared with a wider audience and personal knowledge creation through constructivism. The “quickest way to learn about subject matter is to have to teach (design) it” (Jonassen *et al.*, 1996, p. 45).

Constructionism and Pre-service Teachers

Constructionism is a theory proposed by Seymour Papert which became well known through his grant application to the National Science Foundation called *Constructionism: A New Opportunity for Elementary Science Education* (1987). The idea of constructionism “extends Piaget’s notion of constructivist learning by stating

that the key way to ensuring learning is through the act of constructing something outside of one's head" (Stager, 2003, p. 1). Papert himself extends that to "something external or at least shareable ... a sand castle, a machine, a computer program, a book" (1990, p. 3).

Constructionism: Linking Personal and Social influences on Learning

Papert (1980, 1990) contended that students engage in deep learning when they research, design and construct an artifact or model as a representation of their knowledge. He later explained how constructionism links personal and social influences on learning because the artifact produced is the output from the personal and social construction of meaningful knowledge which is made public.

Constructionism – the N word as opposed to the V word – shares constructivism's connotation of learning as "building knowledge structures" irrespective of the circumstances of learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the Universe.
Papert, 1990, p. 1

Constructionism draws from both Piaget's individual notion of constructivism (von Glaserfeld, 1984, 1987, 1989) and Vygotsky's notion of social influence on learning (Vygotsky, 1978, 1986).

Using the Internet as an Environment to Enhance Constructionism

Papert was a strong proponent of using technology within the classroom. One of his early uses was the making of Logo language to teach mathematics to children. In later work he argued that the relationship students establish with the computer transfers to their relation/s with the rest of the world (Papert, 1980). The idea of utilizing the internet is two fold – firstly to enable access for other students who may wish to use the artifact, and secondly, as a possible extra incentive for students to create, knowing that their artifact will be more than a piece of work to hand to a lecturer. The artifact in the current project, the Slowmation video, is now no longer just a piece of work produced to satisfy the needs of an assignment but could be a meaningful, useful resource. By posting the artifact on a public website, this resource will not only be available for personal use but will be available for use and review by others. Uploading the animation to the Internet may increase the social influences of sharing an artifact as well as possibly promoting other social impacts which are unknown at this stage and hopefully will be revealed by the research in this and later studies.

The theoretical framework of constructionism for this study is captured well in pragmatic terms by Papert who stated, "If you can use technology to make things you can make a lot more interesting things. And you can learn a lot more by making them We are entering a digital world where knowing about digital technology is as important as reading and writing" (1990, p. 3). The research questions investigated in this study were:

- 1 What influence does the creation of a Slowmation have on pre-service teachers' science content knowledge?
2. What are the motivational influences on the pre-service teachers when they upload and review Slowmations on the website?

Methodology

This study researched the connection between motivation, the internet and its impact on scientific content knowledge and pre-service teachers. It focussed on the personal

knowledge construction and motivational influences while creating and reviewing Slowmation animations via an internet site that was designed specifically for the project.

The Internet Site www.slowmation.com.au

The internet site was developed to facilitate the upload and review of student created Slowmations. We did use TeacherTube for one cohort of students but this proved quite problematic and also did not afford the easy option of review which we wanted built into the process. The Slowmation site has a number of galleries that allow for different levels of access. The Personal Gallery is for the user only, the Decision Gallery holds Slowmations that the owner has created that are awaiting review and Slowmations that they are required to review. These videos are available only to the owner of the video and the reviewers. The Internal Published Gallery contains videos that are available to anyone who has access to the site, and the World Gallery is open to the public. Videos are moved from one gallery to another by either an administrator or the student. Videos can only be placed in the World Gallery by the administrator.

The review process is automated and can be set by an administrator who determines how many and who reviews each Slowmation. This is generally done as a random selection from a cohort of students and in our case meant two students and a content expert (the lecturer) reviewed each video. There is a rubric which assists students in their evaluative process as well as links to helpful websites to assist reviewing.

Participants

The students involved in the research came from a cohort of fourth year students who are involved in an elective science subject. All students taking the subject were required to create, post and review their Slowmation animations to the website. 14 students from a cohort of 18 agreed to become part of the research.

Data Gathering Methods

1. Interviews

Each of the 14 participants was interviewed three times. The interviews were semistructured in that there was a set of generalized questions that were delivered in a set order to each participant (Berg, 2001). During the interview, the responses were probed to elicit further detail within each question. This enabled the key questions of the research to be answered. A concept map was also constructed as a means of determining prior knowledge. It was necessary to interview, as each participant had a different story to tell and needed to explore different paths during the interviews. It was important to outline the intent and purpose of the interviews to the participants as an “understanding of the interview goals, ... would lead to improved validity of results” (Cannell, Miller & Oksenberg, 1981, p. 433)

A second interview was carried out as soon as the participants had completed their own Slowmation. This was accompanied by modification of their initial concept map reflecting on what they have discovered during the construction.

The third interview was carried out at the completion of the review process. This was once again recorded on a digital recorder and the concept map outlining new knowledge was constructed.

2. Concept maps

During the interviews the pre-service teachers constructed concept maps as a method for determining knowledge. This method was “developed by a team of educational psychologists led by Novak (1998) as a means of studying the learning of science concepts” (Derbentseva, Safayeni, Canas, 2007, p. 449). Using constructionism theory, a learner’s “growing understanding of content knowledge is considered a process of enlargement of interrelations” (Van Zele *et al*, 2004 p. 1043) which can effectively be represented through the use of concept maps. Using concept maps allows the students to demonstrate their understanding of interlinking ideas and the connectedness between concepts.

As the concept maps were used as a means of assessing gained knowledge between the initial and subsequent stages of the process, a method of evaluation was essential. “A quantitative approach does not truthfully represent the potential of a concept map as a demonstration of a students knowledge structure while a more detailed picture of a student’s understanding can be extracted from a qualitative analysis.” (Van Zele *et al* 2004, p 1054). The method used for the scoring of the concept maps was, each new concept will score 2 points, each new link will score 4 points and each new link with a label will score 5 points. This scoring method is consistent with the methods used by Novak and Gowan (1984).

An example of the concept maps is included below.

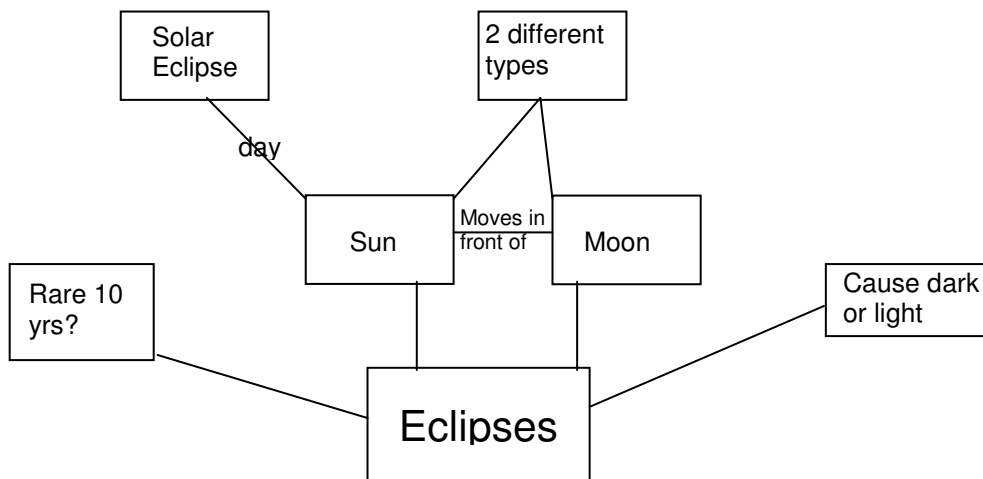
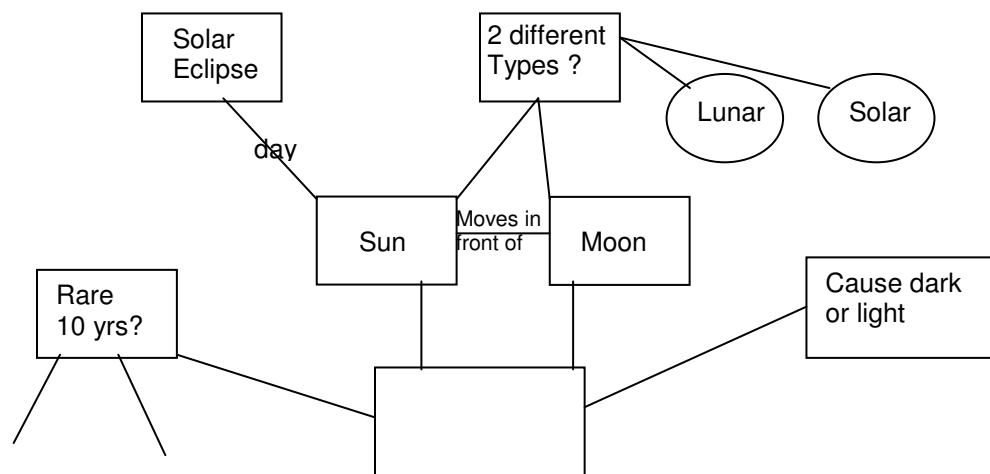


Figure 1 Concept Map prior to beginning task.



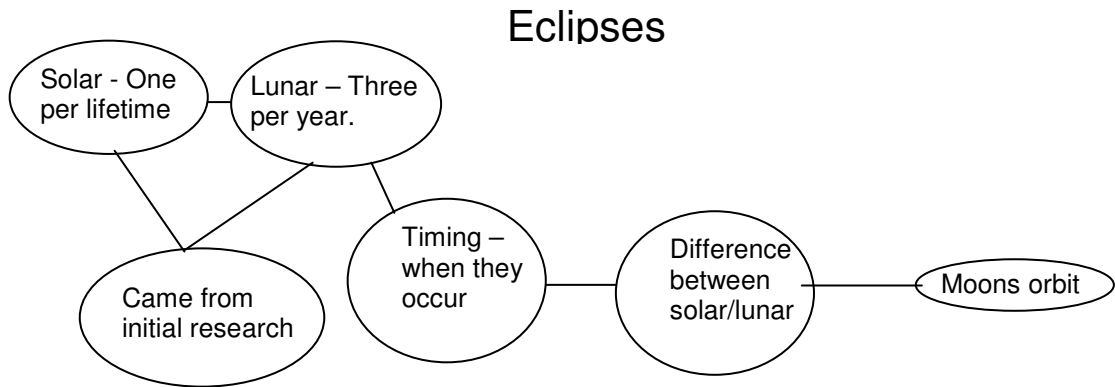


Figure 2 Concept Map after completion of Slowmation. New knowledge in circles and ovals.

3 Animations as Artifacts

During the second interview the students shared their Slowmations while they were being interviewed and constructing their concept maps. This aided in refreshing their memories as well as providing a further information source.

Data Analysis

From the transcriptions the interviews were analysed using the key knowledge constructs as an analytical framework. The concept maps were analysed using a coding system similar to the Novak and Gowan (1984) system where each concept scores points and each branch adds to the score. When using concept maps the new concepts scored two (2) points and any linking branch scored four (4) points and linking arms with labels five (5) points. The reasoning for this is that the links between the concepts are seen as representing gains in depth and understanding.

The refined concept maps were then added to the score. From the added scores, I was able to identify whether there had been a change in scientific content knowledge and the extent to which this had occurred. This was reinforced through triangulation of all findings, the concept maps, the interviews and the actual Slowmation artifact.

Results

Of the 14 participating students, four had been involved in creating a Slowmation in a prior course but for all students this was their first experience at uploading their University work to the internet.

As indicated in Table 1 all students gained new knowledge to some extent using the scoring system as described above, 2 points for new concept, 4 for a link, and 5 for an annotated link. This ranged from 12 additional points to a maximum of 48 additional points on one concept map. There appears to be no link between prior knowledge and post knowledge as the students that had the greatest gain in knowledge (48 points) varied in their prior knowledge, one had 6 points and the other had 22 points of prior knowledge. The student with the greatest prior knowledge score (34) still added

substantial new knowledge (28), and the students with the lowest prior knowledge scores (8&9) had both higher (30) and lower (12) additions of knowledge.

Student	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Prior Knowledge score	8	22	32	24	22	20	23	24	8	9	10	34	10	6
Post Knowledge score	36	70	56	44	50	46	49	36	38	21	28	62	30	54
Knowledge developed score	28	48	24	20	28	26	26	12	30	12	18	28	20	48

Table 1; Displaying Student Content knowledge.

The impact of uploading their work to the internet proved to have varying importance. During the first interview all students were accepting of the fact that their work would be uploaded and may become used in a public domain. As can be seen from Table 2, five of the 14 students were neutral toward uploading to the internet. All of these students had Facebook accounts that they had uploaded material to (photos and videos). Of the remaining nine students three felt they would put in extra effort and be more careful about what they produced, two were a little concerned about their peers viewing their work and being compared to others, two were excited and two were a little daunted.

Once the students Slowmations had been reviewed within a secure section of the website, the students had the option of either allowing the videos to become part of the World Gallery (available to everyone) or to just be kept private. Two students choose to keep their Slowmations private. Both of these students had technical issues with their videos as they were uploaded. Of the remaining 12 seven were neutral about displaying saying things like “I don’t mind if people watch it” (Student 12), “Not everyone’s going to look at it, only the people that go searching I suppose. you’re going to be amongst the thousands so it’s no big deal” (Student 9). The remaining five students were positive toward the display of their work, three saying that they were proud of their work and the other two explaining how gratifying and ‘cool’ it was.

Student	Interview 1: Feelings toward uploading.	Interview 3: Feelings about having work publically available.	Self Confidence with Internet and Technology.
1	Daunting	Feels it is gratifying.	Minimal
2	Excited	Neutral.	Capable
3	Nervous – being compared to others	Didn’t publish. Technical issues.	Capable
4	Uncomfortable – never done before	Didn’t publish. Technical issues.	Minimal
5	I’ll put in extra effort	Neutral – “what will they do if they don’t like it?”	Capable
6	I’ll put in extra effort	Neutral	Adequate
7	I’ll be more careful	“I think its cool – a nice	Capable

		feeling”	
8	Positive	Neutral	Capable
9	Neutral	“It’s one among many – no problem”	Capable
10	Neutral	Proud of my work	Capable
11	More concerned about tutorial group.	Proud of my work	Capable
12	Neutral	Comfortable that it is accurate – hope it will help others.	Capable
13	Neutral	Comfortable that it is accurate.	Minimal
14	Neutral	Proud of my work	Capable

Table 2; Students Feelings toward uploading to the Internet

There appears to be no link between their initial feelings and their post feelings toward the impact of uploading to the website and having their work in the public domain. Some students who were neutral to begin with were proud and excited at the end, while some students who were excited to start with were neutral at the end. There was no pattern. Their prior self confidence in the use of technology also appears to have had little impact on the final outcome. Of the three students who believed they had minimal skills in the area of technology, one felt gratified to have her work displayed, one didn’t display her work and one was neutral believing their Slowmation to be accurate.

Discussion and Conclusion

There is evidence from this and previous research (Hoban, Macdonald & Ferry 2009a, 2009b) that the creation of a Slowmation provides an increase in student scientific content knowledge. This helps to address the concerns expressed about the lack of scientific content knowledge displayed by many pre-service teachers (ASTE Committee, 2002; Committee for the Review of Teaching and Teacher Education, 2003; DEET, 1989; Goodrum, Hackling & Rennie, 2001).

The use of the Slowmation website as a motivational factor for students to display their animations appears to be less clearly defined. While it did provide motivation for many students, there was no clear pattern as to those who benefited although it had no reported negative affect on any. However the site did facilitate the peer review process. Thirteen of the fourteen students had at least one social networking site, Facebook, MySpace or similar, that they had uploaded photos to. This impacted on their willingness to have their work displayed as it was common ground and they had uploaded and viewed images before.

The Slowmation website was designed to facilitate the sharing and reviewing of Slowmations by pre-service teachers. There are a number of ‘galleries’ which enable student privacy and security, as well as a world gallery on which all videos can be shared. We hope that it will lead to early career teachers having a resource they are able to use to enable engagement with science.

Further extensions to this study lie in the possibility of students working collaboratively on a Slowmation via the internet, which would move toward distributed constructionism as proposed by Resnick, (1996a, 1996b).

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