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Simplifying Animation with "Slowmation" to Encourage Preservice Teachers' Science Learning and Teaching

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Abstract. Preservice elementary teachers often lack science content knowledge which reduces their confidence to implement the subject in school classrooms. "Slowmation" (abbreviated from "Slow Animation") is a new yet simplified form of stop-motion animation that encourages preservice teachers to engage with science content because they create their own animations to represent key concepts. This paper presents a study of 29 preservice elementary teachers in a science method class to ascertain if they improved their science knowledge when they created their own animations and whether they used the approach to teach science in classrooms on practicum. Qualitative data (three interviews, two concept maps and the animations as knowledge artifacts) collected from each preservice teacher showed that 28/29 increased their science content knowledge as a result of creating their own animations and four of the preservice teachers used the approach for teaching science on practicum. Slowmations is a new way for preservice teachers to learn science knowledge at university and is an emerging pedagogy for teaching science in schools.

Introduction

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). One of the causes of this alarming trend is the inadequate science content knowledge of preservice elementary teachers which decreases their confidence to implement the subject when they teach in schools (Goodrum, Hackling, & Rennie, 2001; Traianou, 2006). This problem, however, is not unique to Australia. Preservice elementary teachers' lack of science content knowledge has been reported in the USA (Davis, Petish, & Smithey, 2006), the United Kingdom (Goldsworthy, 1997), Canada (Opwood & Souque, 1985), Italy, (Borghi, Hendrich, & Vosniadou, 1991), and Israel (Trumper, 2001).

Using technology is one way to engage preservice teachers in learning science content, especially when using a popular medium such as digital animation. Well funded National Science Foundation projects in the USA such as the Technology-Enhanced Learning in Science Center and the Concord Consortium have produced many computer animations to promote science education (Viadero, 2007). In Australia, The Learning Federation, which is an $80 million initiative of the state, territory and federal governments of Australia and New Zealand, has produced many animations about science as learning objects that are freely available on a web site or CD. However, even though many expert-generated animations of science concepts exist (most are constructed using the computer program Macromedia Flash), research has shown that their value for enhancing student learning has been limited (ChanLin, 1998; Rieber & Hannafin, 1998; Weerawandhana, Ferry, & Brown, 2005).

Tvertsky, Morrison, & Betrancourt (2002) recommended that the educational value of animations could be improved if they were slower and annotated with explanations to highlight the key features to be learned. Moreover some researchers argue that the educational impact of animations has also been limited because they are mostly made by experts for learners to use as consumers of technology, whereas animations would have more value if the learners themselves became the designers and creators of animations (Chan & Black, 2005). Hence one way for preservice teachers to learn science content is to encourage them to make their own animations to represent their understandings. According to Bransford, Brown, and Cocking, 2002 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).

However, making animations is usually very complex there has been very little research on the value of learners creating their own animations of science concepts. A review of literature using the terms "learner-generated animation" and "student-generated animation" covering five journal databases, Proquest Educational Journals, Educational Resources Information Library (ERIC), ACM Digital Library, ISI Web of Knowledge and JSTOR found two research publications for science education. In one study (Chang & Quintana, 2006), an animation program called *Chemation* was specially designed to enable middle school students to produce visual representations of chemical equations and to document their explanations. Working with seventh grade students (N = 73), pre and post test results revealed that there was a significant effect on the learning of the student participants. In the other study, 12 computer science undergraduates used a specially designed program called *Carousel* to design their own representations of three different algorithms involving text, pictures, video, animations and speech which also could be shared with other students on a web site (Hubscher-Younger & Hari Narayanan, 2008). After they were uploaded to a web site the students reviewed and evaluated each other's animation. Pre and post tests suggested that authoring and evaluating representations was a positive learning experience for most of the students. What is common to both of these research studies on student-generated animations is that special software needed to be designed by experts to enable the students to create an animation. What would be useful is to simplify the process for creating animations so that learners can design their own which does not require the writing of specific software.

Empowering learners to make their own animations of science concepts is consistent with the theoretical framework of "constructionism" promoted by Seymour Papert (Papert, 1980, 1991). He contended that students engage in deep learning when they have to research, design and construct an artifact or model with technology to represent their knowledge. Constructionism draws on both the Piagetian notion of constructivism, whereby learning occurs when individuals construct models or artifacts to represent their own understandings of concepts, and Vygotskian social influences when the artifacts are shared with a wider audience. Hence, one way for learners to understand a concept is to conduct their own research and then to create an animation that represents their knowledge because the "quickest way to learn about subject matter is to have to teach (design) it" (Jonassen, Myers, & McKillop, 1996).

Background to Slowmation

"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; 2008). 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 and is seen by the human eye as moving by itself because of a phenomena called "persistence of vision". This 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' Window's Movie Maker or SAM animation which is cross platform to create the animation. Slowmation is a similar process to clay animation, however, it is different in six key ways as shown in Table 1. These differences mean that slowmation is usually a simpler and less time consuming process than clay animation.

Table 1. Comparative Features of Slowmation and Claymation

Feature	**Claymation**	**Slowmation**
Purpose	To tell a narrative or story	To explain a science concept
Content	English	Science
Orientation	Models are made in 3-D to stand up vertically and are moved	Most models are made in 2-D flat on the floor or table and moved in the horizontal

	incrementally as they are photographed with a digital still camera mounted on a tripod looking across at the models.	plane as they are photographed with a digital camera mounted on a tripod looking down at them (this is not always the case, however, as existing 3-D plastic models can be photographed in the usual way).
Materials	Models are made from clay or plasticine	Models are made from a wide variety of materials such as soft play dough, plasticine, 2-D pictures, drawings, clip art, existing 3D models, leaves, rocks, paper, fruit, felt, cardboard cut outs and many everyday classroom materials.
Enhancers	The art of telling the story explains the experience	Prompts are included to help explain a scientific concept such as narration, real life photos, diagrams, labels and static images.
Frame Speed	20-25 frames/second to simulate real movement	2 frames/second to explain a science concept in slow motion hence the name "Slow Motion Animation" which is abbreviated to "Slowmation."

Most slowmations are short 1-3 minute videos explaining a science concept. Because slowmations are played 10 times slower (2 frames/second) and are much easier to make than traditional clay animations (played at 25 frames/second), learners can represent their own understandings of science concepts in comprehensive ways (Hoban & Ferry, 2006). Over the last two years over 400 slowmations have been made by preservice elementary teachers demonstrating many science concepts such as day and night, seasons, lunar cycles, life cycles of various animals, particle motion, magnets, fungi life cycle, plant reproduction, weather, movement of the planets, water cycle, simple machines, mitosis, meiosis and phagocytosis. Features called learning prompts are added such as narration, labels, music and diagrams to help explain the science content.

A possible problem with learner-generated animations, however, is that the learners may not fully understand or represent a science concept correctly. This is especially the case with elementary preservice teachers who may not have a good understanding of science in the first place. For this reason, a three phase framework was designed to encourage preservice teachers to create an animation about a science concept and upload them to a web site (Teacher Tube) to enable them being displayed and reviewed. The purpose of this study, therefore, involved addressing these two research questions using a study of 29 preservice elementary teachers:

1. How did the three phase framework of creating, reviewing and publishing slowmations to a web site (Teacher Tube) change the preservice teachers' science content knowledge?
2. How many preservice teachers used the approach to teach science on practicum in schools and how was this organized?

Methodology

The preservice teachers were enrolled in a 13 week science method course in a four year Bachelor of Education degree at a university in Australia. This study involved two cohorts in a science method course with 24 students in each course. Students in each course were invited to volunteer to be in the research project and 18 elementary preservice teachers (16 females and two males) volunteered in 2007 and 13 preservice elementary teachers (9 females and 4 males) volunteered in 2008. The procedure for introducing slowmation was the same for each cohort. The preservice teachers were taught how to create a slowmation in a two hour workshop and then had to create their own slowmation as an assignment on a designated topic that they had been allocated at the beginning of the course. The software program used by the students was SAM animation which is an adaptation of QuickTime Pro and available for free at www.samanimation.com. Both PC and Mac versions are available.

This study involved three phases of data collection to correspond to the three phases of the framework. Data gathering methods to monitor each student's science learning included three semi-structured interviews, sketching and reviewing concept maps of their understandings (White & Gunstone, 1992) and noting how they represented their knowledge in the animation as an artifact of their learning. The three phases of the framework with further details on the methodology are now described.

The Three Phase Framework

Phase 1: Creation
At the first class of the course, the preservice teachers were each allocated different topics from the kindergarten to grade 6 Science curriculum of the state of New South Wales in Australia. On the same day they were allocated their topic, the preservice teachers were interviewed by a research assistant to ascertain their prior knowledge. The interview also involved the students drawing a concept map of the topic, identifying the words they knew about the topic and noting the relationships amongst them (White & Gunstone, 1992). The drawing of the concept map was in conjunction with semi-structured interview questions to ascertain what preservice teachers understood about the topic. Typical questions in the interview were "What are the main concepts in this science topic?", "Tell me what you know about the topic?", "What do these terms mean on the concept map?","What is the relationship amongst these terms?", "How are you going to find information about the topic?" and "How confident are you with your scientific content knowledge in this topic?". The preservice teachers then had two weeks to create their slowmation which involved planning and researching the topic. Some students voluntarily created storyboards which allowed them to reflect upon their understandings of a science concept and break it down or analyse it into episodes or a sequence of steps that could be digitally photographed for making the animation.

Phase 2: Reviewing
A special group site was created on the web site Teacher Tube so that the preservice teachers could upload their slowmations to be displayed to the whole group in order to facilitate the review process. The slowmations were first marked by the course instructor for assessment purposes. The purpose of this initial review was to provide feedback on the scientific accuracy of the content and the use of technology. To facilitate the process the slowmations were uploaded to a specific part of the web site that was only accessible by the members of the class and the instructors. A rubric was provided to the preservice teachers that had been specially designed to facilitate this feedback from other preservice teachers and the instructor. Each slowmation video was reviewed by two preservice teachers in the class and by one of the instructors. After the review process the preservice teachers were interviewed a second time to ascertain if their science knowledge had changed as a result of creating their slowmation and receiving feedback from the three reviews.

Phase 3: Publishing
After the preservice teachers received their feedback from the review process, if necessary, the preservice teachers modified their animations and resubmitted them to the web site for sharing with the whole community of preservice teachers. The preservice teachers were interviewed a third time after they had uploaded their slowmation to "Teacher Tube" and received their review from other class members. The preservice teachers also examined their concept map sketched during the first interview and if necessary modified it to represent any changes in understanding about the concept.

Data were analysed according to the preservice teachers' understandings of the topic that they were allocated at the beginning of the course and any subsequent change in understanding. Data were analysed from the interviews, concept maps as well as their slowmations collected as knowledge artifacts. Change in science knowledge was monitored according to the number of new concepts or insights about existing concepts for each topic explained in the interviews and/or added to their concept maps. A major increase in science knowledge was identified by the addition of 4 or more new concepts or by delving into one concept in depth. A minor increase in science knowledge was identified by the addition of 2 or 3 new concepts and little or no increase was the addition of one new concept or no change. No increase in science knowledge was identified by having no changes in understanding or the addition of new concepts for each topic.

Results

The first research question focused on any change in the preservice teachers' science content knowledge as a result of them using the three phase framework of creating, reviewing and publishing their slowmations to a web site

(Teacher Tube). Summative data from the two cohorts will be presented followed by a case study from one of the preservice teachers to demonstrate the learning process more clearly.

Research Question 1: Change in Preservice Teachers' Science Content Knowledge
Using both cohorts, Table 2 shows 19/29 experienced a major increase in scientific knowledge and 9/29 experienced a minor increase and one person experienced no increase in knowledge.

Table 2. Change in Science Content Knowledge

	Major Increase in Science Knowledge	Minor Increase in Science Knowledge	Little or No Increase in Science Knowledge
Cohort 1 (2007) and 2 (2008)	19	9	1

Most students increased their science knowledge during the creation phase when the students made their own slowmation, but there was also an increase in some students' knowledge after the review phase. Although it cannot be claimed that the increase in knowledge was only due to the slowmation process, interview data collected from all the students pointed to the fact that it was the three phase framework that influenced their change in science knowledge especially when they researched a topic to create the animation in phase 1.

Interview data revealed that many of the participants found creating a slowmation to be a different way to learn science as they had to research their topic first in order to represent their understandings in the animation:

> *Making the slowmation extended my scientific knowledge. It made me realise that science isn't just about chemists with white coats and… Yeah, it can actually go in so many different directions and cover so many different topics, which I think is important for students trying to understand the concepts at an early age.*
> Student A, Cohort 1, Final Interview
>
> *I definitely got a lot out of it. . I ended having to do a fair bit of research. . . . I found out a lot about density and displacement of water and sort of more key things.*
> Student B, Cohort 1, Final Interview
>
> *Actually I did learn, I didn't even know what a cog was. . . . I learned about how when you changed from first gear it changes the size of the gear and you know that makes pedalling easier.*
> Student C, Cohort 2, Final Interview
>
> *Even if you're not actually putting the new knowledge into the slowmation, you still have to know it to start with… to understand the topic first and then you can work out what parts of the topic are best suited to being presented in the slowmation.*
> Student T, Cohort 2, Final interview
>
> *It means you have to learn it to be able to present it. It means you've done the work, you have got all the background knowledge and everything and you've gained the knowledge to do it.*
> Student R, Cohort 2, Final interview

The following case study shows in more detail how one student in the second cohort developed his science knowledge using the three phase framework.

***Case Study of Brad*.**

Brad was a student in his early 20s who had taken science through to the end of high school and had completed one elective subject in his first year at university. He had been allocated the topic, "Static Electricity," which was a topic that suited grades 5 and 6 (ages 10 – 12). In the first interview it was revealed that he had a positive attitude toward science, although he had limited knowledge of the topic. He realized that rubbing your feet on carpet created static electricity and that he believed it happened more in winter but he wasn't sure why.

During the first interview, he was also asked to construct a concept map to represent his knowledge of the topic. When constructing his map he identified 3 examples — car door zapping, hair standing on end and rubbing feet that he believed related to the topic as shown in Figure 1. He did not, however, in the interview know the reason why static electricity occurred and hence there is no "reason" shown in the concept map.

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Figure 1. Brad's First Concept Map of Static Electricity

In the interview Brad recalled memories from school days of rubbing his feet on the carpet to cause static electricity but was vague about the reason:

> I have memories of school, when we used to sit down in winter and you would rub your feet on the carpet a lot and then you'd lift your feet up and touch someone, and you'd zap them, I don't know why. I just remember doing it. I think it was obviously something to do with holding a charge or something, holding the electricity, I don't know.

When questioned on what would be the focus of his Slowmation, he was a little unsure. He knew he could represent some examples but was unclear about the reason and he would have to research it:

> I'm not sure, because when I think about that – like, I can't necessarily generate any of those things, can I? I'm not envisaging doing it in a real sense, just more trying to represent it happening, maybe I could represent it somehow. I'd probably need some figures or something for taking the photos. It's easy enough to take a photo of rubbing feet – photo, photo, photo — with the feet moving and a little zap or something for a sound effect. But I need to research that yet, I haven't found out why that happens. So I think the explanation will need to be part of the narration.

Brad was employed in an elementary school as a teacher of technology so he was quite confident that the technological side would not cause any problems.

Interview 2 was carried out immediately following the completion and submission of the students' Slowmation videos, which occurred four weeks after the topic had been allocated. The purpose of the interview was to ascertain whether Brad had developed his scientific content knowledge through designing and creating a Slowmation video. Brad's primary focus in the video was explaining how static electricity occurred showing how electrons could be transferred from atom to atom to create a charge.

Brad started his animation with the example of getting a shock from a car and asking the question, "Has this ever happened to you?". He then went on to show how electrons could be transferred from one atom to another to build up a charge and that touching charged objects earthed the charge which is the spark. It showed that a positive charge came from an object loosing electrons and a negative charge came from an object gaining additional electrons. It was from the rubbing of objects that creates the force to transfer the electrons from one object (the positive charge) to the other (the negative charge).

When asked about knowledge gained from creating the video Brad said:

> I didn't know that you picked up the static electricity off other things, I didn't know where it came from, I didn't know why it was coming off the end of my finger. So that basic fact of what charge I was actually carrying on those windy days or rubbing your feet on the carpet… because I remember that from school, my mates would always rub their feet on the carpet and then they would touch your ear and zap you. That was part of that zapping business, the whole why that happened, I never understood that, but now I do.

He also emphasised the fact that what was happening when the shock occurred was the electrons finding balance between a higher charged atom and a lower charged atom "and that is called earthing. It's the same with lightning, lightning always occurs when there's lots of wind and there's friction and the friction builds up the charge and then the discharge is the lightning."

The interview included modifying the concept map shown in Figure 1 with any new knowledge gained. Figure 2 shows the revised concept map with the "clouds" indicating new understanding. It shows the addition of one more example and a reason for static electricity occurring which was "transfer of electrons" to build up charge. Because Brad had a much deeper understanding of what caused static electricity and this was clearly demonstrated in the animation it was deemed that he had a major increase in science knowledge.

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Figure 2. Brad's Second Concept Map Displaying New Knowledge Gained

Figure 3 shows a sequence of hand movements from his animation to represent static electricity.

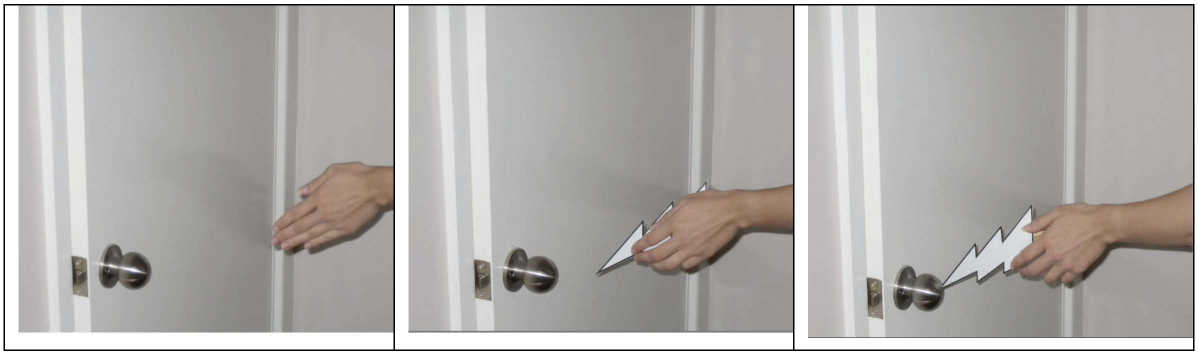

Figure. 3 Model of an Electric Shock from a Door Handle

Interview three was carried out after the students had reviewed two other students' videos. It also gave the students an opportunity to reflect and review on the three phase process. During the review process Brad reviewed a Slowmation on "Kitchen Chemistry" and another on "Nuclear Power". When asked about suggestions he had made as feedback he replied:

> One of them I just thought just extend the length and explore more than the one concept that was explored, because it was a bit short. And it was really good and I just simply said, 'I could've watched more' and because it was such a smooth running animation and really easy to watch, the girl's audio was really clear and was really good explanations I think I could've watched more. Basically that's the only suggestion.

When asked if it had helped increase his science content knowledge he replied that for the Kitchen Chemistry one he assumed it was accurate – "it made sense with what I was seeing in the pictures and having some ideas of some of the subjects as well it made perfect sense. And the language was not overly technical so it was in that everyday language that made it easy to understand." In regard to the other slowmation he read science content on another web site to check his understanding, "I did check something but I just went onto the Science Made Simple website and just quickly read up about it and it was all right."

Research Question 2: Use of Slowmation for Teaching Science on Practicum in Elementary Classrooms

The 13 preservice teachers in the second cohort in 2008 were sent an email later two months after their method course to ascertain if any of them had used the slowmation approach on practicum. Four of the students replied that they had used it on practicum for teaching science although there were variations in the topics and how it was organised. Each of the students sent emails describing how they used slowmation and one student was observed by one of the authors in three lessons:

Preservice teacher 1: This preservice teacher used slowmation to teach "Water Movement" to year 2 students over a period of 4 lessons. The preservice teacher divided the class into four groups with each focusing on one stage of water movement — water falling as rain, rain collecting in rivers, water stored in dams and water pumped into people's houses. The approach was implemented over 4 lessons. Lesson one involved the children learning about the overall movement of water; Lesson two involved the children doing role plays about their allocated part and storyboarding movements about their particular section; Lesson three involved the children taking digital still photos of their section and lesson four involved the children creating the narration as a whole class.

Preservice teacher 2: The preservice teacher encouraged 24 year 2/3 students to grow bean seeds to show life cycles and to keep a diary on their progress. The slowmation approach was then at the end of the four week topic over three lessons to create a class animation of bean seed germination. The students spent one lesson storyboarding and one lesson making models and taking the photos. When taking photos one tripod and one digital still camera looking down was set up and the students came out in groups of 6 to do their movements and take photos. The teacher took

20 minutes to use a software program called SAM animation to create the slowmation and a third lesson was spent with the class making a class narration

Preservice teacher 3: This preservice teacher was teaching a topic on food groups to a year 4. One of the sections was how to make a pizza as a procedure. The approach was used over several lessons. The students were organised into 4 groups with each focusing on one part of the pizza making process. One workstation was set up and the students spent one lesson storyboarding their allocated part. In terms of making their models and taking photographs each group was allocated the same time slot over four days so that one group completed their model making and photographing each day. On the four day the last group completed the narration.

Preservice teacher 4: This preservice teacher was teaching a topic of the solar system to year 5 with 24 students. Students in the class took responsibility for different planets and were allocated into pairs. The approach was used over several lessons. In the first lesson the students conducted research on their part of the solar system. In the second lesson the students storyboarded how their planet would move and in the third lesson the students came out in pairs to move their planet and take photos. In the last lesson the students made their narration explaining aspects of each of the planet.

Discussion and Conclusions

This study shows that involving preservice elementary teachers in using technology to create, review and publish slowmations of science concepts increased their science content knowledge. Taking into account both cohorts, 19/29 developed a major increase in knowledge and 9/29 experienced a minor increase. Only one of the students in the first cohort experienced no increase in science knowledge as a result of participating in the three phases of the framework. These data supports the theoretical framework of constructionism (Papert, 1991) that proposes that people learn content when they design and create artifacts to represent their knowledge. The key insight from this study is that Slowmation provides a new way for preservice teachers to engage with science content and is a new form of assignment that can be used in science method classes. However it is questionable as to whether the value of learning science justifies the amount of time put into making the animations. The preservice teachers participated in a two hour workshop to learn the process and many spent between 8-12 hours making their animation. Clearly this time could have been spent learning the concept from other resources such as the world wide web. However, producing an artifact such as an animation is not only a tangible outcome of their learning but provides the preservice teachers with a product that they can share as a resource for teaching children in classrooms. Moreover, there is a possibility that this representation is a form of deep learning and is well remembered for later occasions.

An interesting aspect of this study was that 4/13 preservice teachers in the 2008 cohort used the approach on their practicum to teach science in schools. Although this seems like a small number, the approach can be challenging to implement for the first time in schools especially with limited resources. Also many preservice teachers would not normally implement a new approach on practicum but instead follow the suggestions and existing ways of teaching from their practicum supervisor. All the four teachers who used the approach on practicum to get their students to create animations stated that the approach was highly engaging for the children. All said that they would do it again. What was interesting in terms of how they organised the class using limited resources. In all four examples the preservice teachers only set up one workstation with one tripod and one digital camera looking down at a cardboard sheet and had the children organised in groups. In most situations the groups came out to the workstation one by one whilst the other children in the class were given set work. There was one class for teacher 3 who organised each group to come out day by day so that the group animation took 4 days to complete.

A limitation of this study was that the three interviews and concept maps collected are only “snapshots” of what the students were learning at a particular time. Although, this study did show that there was an increase in science knowledge in most of the preservice teachers, it did not show all the specific learning at each stage of the process. Further research is currently being planned involving more sustained monitoring of the preservice teachers’ learning process as they actually plan and create their slowmation to ascertain which actual parts of the slowmation process enhances students’ knowledge construction. Furthermore, an additional study will more closely track the preservice teachers who are implementing slowmation in schools to ascertain how it influences children’s learning of science using slowmation. Slowmation is a new way for preservice teachers to learn and represent science knowledge at university as an assignment in a method course and is an emerging pedagogy for teaching science in schools.

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