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## **Slowmation: A Twenty-First Century Educational Tool for Science and Mathematics Pre-service Teachers**

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*Abstract: Slowmation is a twenty-first century digital literacy educational tool. This teaching and learning tool has been incorporated as an assessment strategy in the curriculum area of science and mathematics with pre-service teachers (PSTs). This paper explores two themes: developing twenty-first century digital literacy skills and modelling best practice assessment tools. In the growing debate about the impact of multi-model representations, researchers such as Hoban and Nielsen, and Brown, Murcia and Hackling emphasise the development of conceptual understandings and semiotics. This paper focuses on PSTs' experiences of and reflections on Slowmation as an educational tool. Data was collected from a cohort of final year PSTs who created, presented and reflected on their Slowmation process.*

### **Introduction**

There has been growing global interest in the impact of multi-modal software representations to develop students' understandings of science and mathematics concepts. Slowmation (abbreviated from slow animation) is one of several applications that have become prominent in classroom practice in primary and middle school classrooms. In response to these innovations, we have trialled and implemented over a three-year period a suite of assessment items with final year pre-service teachers (PSTs) who complete an elective interdisciplinary pathway in science and mathematics; these include vivas, round tables, paired posters and digital narratives (Paige, Lloyd & Chartres, 2008; Grant & Paige, 2007). In this paper, we investigate the educational assessment tool Slowmation. The use of Slowmation as a learning and teaching tool is of particular interest as it invites PSTs to move away from traditional methods of communicating complex understanding through pen and paper methods and to utilise contemporary resources, inherent in particular digital literacies.

The Slowmation application used by the PSTs in this study involved the construction of a three-to-four minute video animation using a series of digital still images to demonstrate an understanding of a scientific or mathematical concept. Furthermore, when creating Slowmations, the primary/middle pre-service teachers were called upon to develop a digital narrative to represent the story of their concepts. For example the students created narratives on topics such as paleontology, forces, genetics, Pythagoras' theorem and cell structures.

In this paper, we investigate how pre-service teachers can be encouraged to reflect more deeply upon twenty-first century skills, to be fully conversant with the use of digital literacies in mathematics and science in their graduate year and ongoing professional life. Accordingly, within this context, we chose to research how Slowmation can be used as a twenty-first century digital literacy educational tool (Keane, 2012).

Current research about Slowmation has been inspired by semiotic approaches to creating meaning via substantive dialogue and collaborative interactions (Brown, Murcia, & Hackling, 2013; Hoban & Nielsen, 2010). Additionally, some researchers have proposed a different theoretical model based upon Hoban's 5 Step Representation model. This includes background, storyboard, models, digital photographs and animation (Hoban 2005; Hoban, Loughran, & Nielson, 2011). This approach enables students to engage in higher order thinking such as problem solving and to use multi-modal representation to enhance their learning (Waldrup & Prain, 2006).

Within the contemporary education framework the term 'authentic' provides a potentially useful way of understanding Slowmation. This term has been appearing in educational literature for some time now, with different meanings and understandings (Eisner, 1999). In the USA, it has been connected with assessment practices and the use of multiple choice standardised testing in particular. This was done because multiple-choice as true-false was easily administered, leading to high reliability and purported fairness and equity. We would argue that authentic assessment tasks are more than recall and recognition associated with multiple-choice questions. It involves the opportunity to demonstrate transference of knowledge and skills to situations and contexts found in the real world in an active, meaningful, dialogue-based manner. Such an understanding provides a useful framework to help PSTs understand the importance of quality in assessment.

Therefore, one of the aims of teacher educators is to provide pre-service teachers in their fourth year with a range of learning experiences and assessment strategies that they can use in their final placement and as early career teachers. In this study, in the first workshop we provided an overview of the assessment requirements. The first assignment required the PSTs to work in pairs to plan two units of work, a science unit and a mathematics unit around a key concept. One of the criteria was to construct a Slowmation to demonstrate/communicate conceptual understanding. We modelled previous examples of Slowmations from past student cohorts and provided links to websites. We told the PSTs that we expected them to work together, experiment and create a three-to-four minute video animation using a series of digital still images. In week six as the oral component of the assignment each pair had to select an investigation from one of their units of work to teach their colleagues and to engage in critical scientific and/or mathematical thinking and working. Finally, the PSTs presented their Slowmation to half of their class and were provided with peer feedback concerning its effectiveness in communicating ideas and its scientific accuracy. The feedback also contributed to their final grade.

Our approach supports Hoban's view that a Slowmation is a simplified process for students to make a stop-motion animation and provides a novel way to learn about a science concept (Hoban & Nielsen, 2010). PSTs can use their own digital devices, digital still cameras, iPhones or iPads to design a stop-motion animation. Slowmation can use a technique involving the manipulation of models with a digital still photo taken after each manual movement. A range of objects and materials can be used, such as plasticine, cardboard or plastic models, with some students taking 300 to 400 frames. PSTs also embedded both text and narration to support the communication of detailed explanations.

This focus on transferability and real-world tasks is also supported by Brady and Kennedy (2011), who argue that if an assessment task is to be considered authentic it must be challenging, relevant, engaging and reflect real-world contexts and situations that students will confront outside schools. These two perspectives reflect the relevance of authentic learning, ensuring that PSTs are able to implement rich assessment tasks such as Slowmation, in their final placement and as early career teachers.

In subsequent sections of this paper we propose a conceptual framework to understand Slowmation as a twenty-first century educational tool. Thereafter, we will present an

empirical example of Slowmation from pre-service teaching and the results of a student survey. To conclude we will discuss our findings. The question posed in our research is: *How is Slowmation a twenty-first century educational tool for PSTs?*

## Conceptual Framework

There is no single definition of or agreement on twenty-first century skills. It may well be that flexible definitions are valid because the knowledge and skills vary according to the context in which they are learnt (formally or informally) and practised (e.g. in education arenas or the workplace). Presently, the Australian Curriculum, Assessment and Reporting Authority (ACARA), responsible for the development of the national curriculum from kindergarten to Year 12 has highlighted what are referred to as twenty-first century skills but does not use the name because the skills are not unique to the twenty-first century (Griffin, McGaw, & Care, 2012). The skills typically referred to include communication, personal and social skills, information technology and problem solving. For the Australian Curriculum, the name 'general capabilities' was chosen and there are now seven: literacy, numeracy, ICT capability, critical and creative thinking, personal and social capability, intercultural understanding and ethical understanding (ACARA, 2015).

Other groups such as the *Assessment and Teaching of 21<sup>st</sup> Century Skills* project based in Melbourne have attempted a definition incorporating four processes across ten twenty-first century skills: ways of thinking (creativity and innovation, critical thinking/problem solving/decision making, learning to learn), ways of working (oral and written communication, collaboration), tools for working (information literacy, ICT literacy) and living in the world (citizenship, life and career, personal and social responsibility including cultural awareness). We would suggest that the Slowmation task embraces all of these skills and processes to varying degrees. We are cognisant that these twenty-first century skills are what educators have always pursued, but in the age of the internet more tools are accessible (Keane, 2012).

Accordingly, when observing the students prior to the week six assessment presentations, it was of interest to note the range of skills required to complete the task successfully. Initially, students were required to identify a colleague to work with collaboratively, to complement their skills. The PSTs needed to ensure between them: an accurate understanding of science and mathematics concepts; excellent problem solving skills; competency with ICT; and creativity to visualise how to communicate complex ideas effectively. Over the years in which we have given PSTs these tasks, there has been a range of quality, from an animated PowerPoint slide show to one that was submitted and came second in a national Slowmation competition. For many it is a time consuming but rewarding process. Slowmation constitutes an innovative way of representing knowledge that motivates the PSTs to develop richer links between science concepts and their everyday experience in the real world (Loughran, 2010).

The issue of motivation is integral to the successful completion of the Slowmation task. Motivation to complete the task can be viewed from various perspectives. One may be, in this instance, that it is a required task as part of a summative assessment. One of the questions that students pose, according to motivation researchers (Broussard & Garrison, 2004), is 'what do I have to do to succeed in this task?' This question is central to the PSTs' learning. In understanding motivation two theories are pertinent: volition and socio-cultural understanding of motivation. Volition considers how motivation might lead to a PST's decision to act and choice of goal orientation. Put simply, volition is the will which supports the execution of the act. Corno (1993) uses the term 'volition' to refer to both the strength of

will needed to complete the task, and the diligence of pursuit. Volition is, accordingly, the management and control mechanism where the strength of will integrates discipline, self-direction and resourcefulness.

Considering motivation and learning theories from the perspective of volition pertains to a self-directed cognitive approach. It is also necessary to consider the manner in which motivation is also connected with socio-cultural mechanisms and structures. This entails thinking about the manner in which peers, critical friends and teachers can provide motivation to the individual through among other things praise, teaching and communicating expectations. In such cases the generative mechanisms at play might be the manner in which students identify with and seek to confirm the expectations teachers communicate in the course of teaching.

The socio-cultural perspective on motivation additionally reaches beyond the relationship between the teacher and student and between peers. It also includes communities of practice (Wenger, 1998), for example the classroom or the Slowmation piece of work with others in which this learning is situated (Lave & Chaiklin, 1993). In such groups a form of collective efficacy and collective meaning making can arise. An important component is the degree to which group members develop and sustain a shared belief and understanding. We are suggesting that to complete a Slowmation successfully shared beliefs and understandings should permeate the work of members of the community as they work on their individually allotted tasks, and also when they are working collectively, evaluating the work of the individual and incorporating and weaving it into the final product. The technologies offer them the opportunity to work collaboratively in small groups to clarify their alternative understandings of science and mathematics concepts through digital narratives. Such a socio-cultural approach thus supports a focus upon shared, co-operative meaning making through the scaffolding of collaborative learning (Engeström, 1999; Leont'ev, 1978; Wertsch, 1985).

## **Context**

The priorities of the science and mathematics education team at the School of Education, University of South Australia include investigating best practice through authentic assessment tasks and adopting twenty-first century classroom skills to ensure our students are prepared as early career teachers. The cohort of students in this study was part of the fourth year primary/middle professional pathway science and mathematics class who previously had completed three integrated science and mathematics courses and four general study courses in science and/or mathematics. The assessment strategies that model authentic educational tools that we require PSTs to use include Slowmation, vivas, digital narratives, roundtables, interviewing children and oral evaluations. In particular, Slowmation can be considered an authentic digital literacy tool due to its innovation and broad skill set, and because it requires students to clarify their science and mathematics understandings while utilising technologies available today. Furthermore, we encouraged the PSTs to use the Slowmation tool in their final teaching placement.

## **Method**

We collected data several weeks after the completion of the Slowmation task and once ethics approval was granted. We invited 36 students to complete an anonymous online survey on surveymonkey (see Appendix 1) at the beginning of a class session in the form of a Likert questionnaire. Self-reporting has been undertaken using various types of measuring tools, and

the Likert scale has proved to be a reliable statistical measure (Paas, Tuovinen, Tabbers, & Van Gerven, 2003; Paas, Van Merriënboer, & Adam, 1994). This type of measure can be easily transferred to an online format, making this method highly appropriate for this study. Furthermore, a significant advantage of using Likert scales in this setting is that they only require a computer and the data can be readily accessed. Eight of the eleven questions in the survey were designed to elicit both a written and numerical response (see Figure 1). Two questions sought only written responses, while another question sought information about the length of time spent on the project. We considered using various numerical scales identified in previous research ranging from a 5-9 point scale (De Jong, 2010). Several researchers have used written expressions and matched them with a numerical value (Paas, 1992). In particular, Ayres (2006) used a 7-point scale with reference to terms and numerical values such as extremely easy (1) to extremely difficult (7). In this study the project team designed an initial set of questions that formed part of a pilot questionnaire. These questions were given to a small sample of students prior to the commencement of the study.

Would you use Slowmation in your own class as a form of assessment?

Absolutely not	No	Unsure	Yes	Absolutely yes
1	2	3	4	5

<p>Why? If yes can you provide some information re which year level, topic, etc.?</p>
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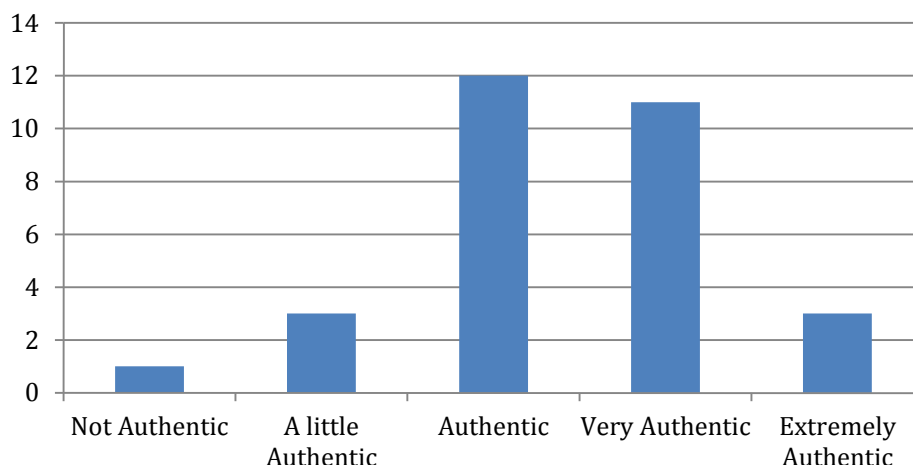
**Figure 1: Question 5 of Likert scale and questionnaire**

The survey consisted of 10 questions and was completed during class taking approximately 15 minutes. A total of 31 responses were received. The questions focused on both the technical and conceptual understandings. Examples of technical questions were, ‘What did you find most challenging about using the technology?’ and ‘How long did it take you and your partner?’ Examples of conceptual questions were ‘What impact did creating a Slowmation have on your understanding of the science?’ and ‘How would you use it as a beginning teacher to challenge your learners’ understanding?’

### Analysis of data

The data were sorted into sets of common responses and the analysis of the data identified several themes. From these tallied responses, we identified emergent themes and undertook further analysis to discover any sub-themes and to check the validity of the original analysis. In response to the question ‘In what way was it authentic?’ 26 out of the 31 participants thought using Slowmation was authentic to extremely authentic (see Figure 2). We grouped these responses into the three themes of professional learning, technology and conceptual understanding.

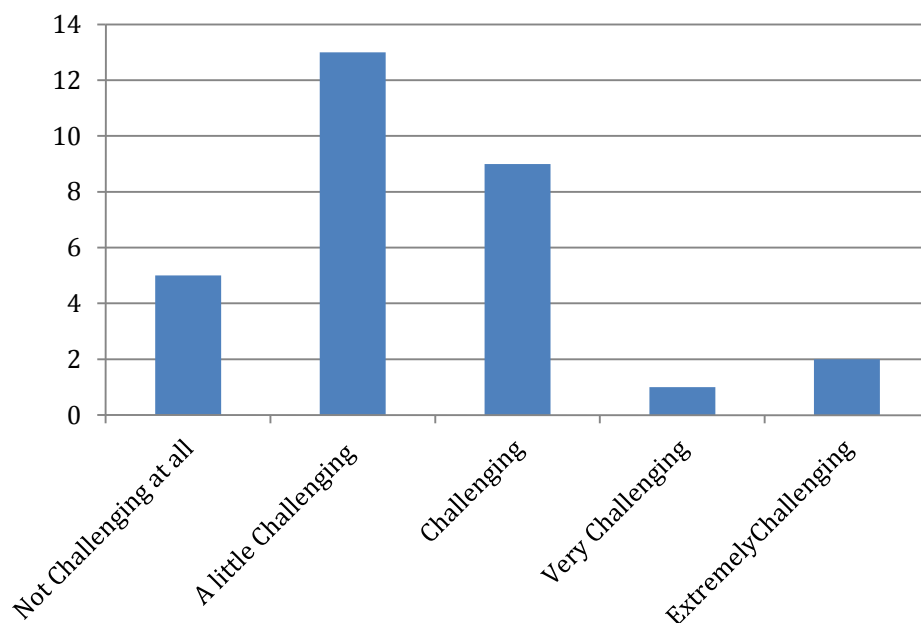
Interestingly, the responses to all questions reflected aspects of creative innovation and elements of unique practice. Responses from the PSTs affirming this were: ‘Provided me with creative and different ways of assessing students’ learning through incorporating ICTs’, and ‘It allows you to express what may be a mundane topic task in a really creative way’. Another PST response was, ‘I don’t think it’s a challenging assessment but I think it’s about doing something enriching and creative’.



**Figure 2: Answers to ‘In relation to other forms of assessment you have experienced how would you rate Slowmation as an authentic form of assessment?’**

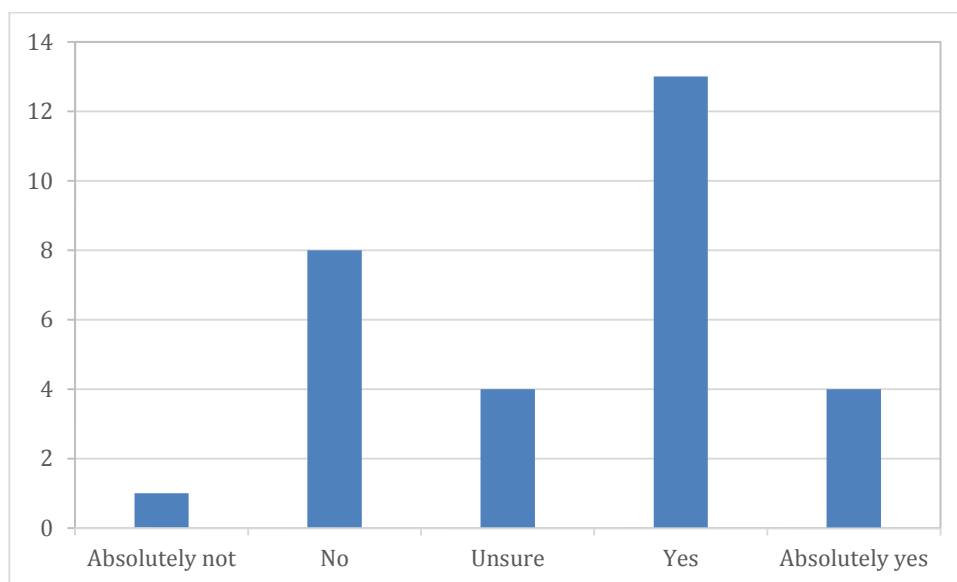
A key aspect of professional learning was the PSTs’ identification of the application of Slowmation in their own professional practice. This is reflected in the comment that the students will ‘drive what they want to include to be creative in their learning’. Further, Slowmation incorporated the use of technology in the sense that it ‘required us to work out how we would use it as part of our [integrated] unit ... the course provided us with a new form of assessment we can take with us to our classroom’. The students articulated their conceptual understanding in the following manner: ‘it makes you think critically by the concept you are trying to convey, and how to simplify it into a short video to present to the class’.

The data from the question ‘How technologically challenging did you find the Slowmation task?’ suggested they did not see the Slowmation activity as technologically challenging, with 18 out of the 31 students finding the technology not or a little challenging, suggesting a positive skew towards being digitally literate (see Figure 3). Only three students responded that they found it very challenging or extremely challenging. Those finding it challenging were divided into two groups: those who blamed the technology and those who had insufficient skills. Comments about technical equipment included: ‘computer/laptop wasn’t able to run the movie maker program after my Slowmation reached about a minute long. It kept freezing. It was a painstaking process’ and no ‘Access to camera or tripods’. The group who considered their lack of perceived expertise included comments such as, ‘I was somewhat unfamiliar with the movie making software’.



**Figure 3: Answers to ‘How technically challenging did you find the Slowmation task?’**

The level of technological expertise reflected in the survey indicated that 17 students from 31 found the Slowmation enhanced their own conceptual understanding. Nineteen out of the 31 students stated that they would use Slowmation in their own classroom. In regard to the results obtained from the remaining students, 9 of the 31 PSTs were of the opinion that Slowmation did not enhance their conceptual understanding, with four PSTs being unsure. Further investigation is required to determine whether the PSTs had an alternative conceptual framework or possibly a conceptual and technological understanding that was not challenged by the Slowmation task.



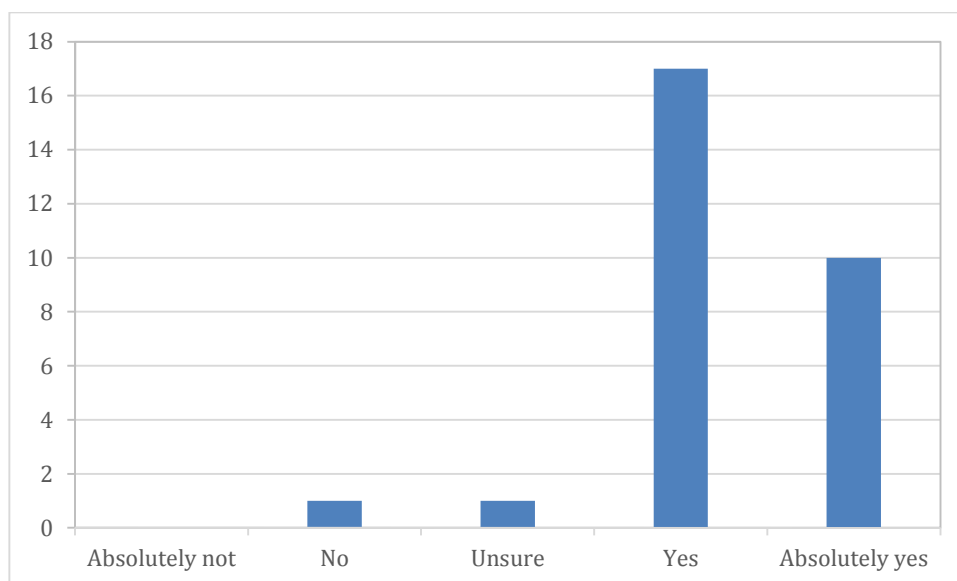
**Figure 4: Answers to ‘Did the use of Slowmation enhance your conceptual understanding of your selected science concept?’**

Comments from the PSTs that affirmed that Slowmation was an opportunity to explore their scientific understanding included ‘Explaining the concept required a little research and required some thinking to explain it in a simple way’. This was further enhanced/supported



by comments such as ‘In relation to our specific slowmation it allowed us to look into and develop a better understanding for the concept we wished to learn’ and ‘We were able to demonstrate a concept in a different manner that can engage students to develop their understandings’.

Several responses indicated that not all of the PSTs were conceptually challenged. This alternative perspective may possibly be explained by PSTs’ naivety and lack of teaching experience preventing them from recognising the implications of communicating complex scientific ideas to students with clarity. The level of sophistication and clarity needed to communicate successfully is difficult for novice teachers to recognise. Comments included ‘Didn’t enhance my understanding of the concept being taught but I can understand how it would enhance a student’s understanding of a new concept being taught in the classroom, was putting information already known to make Slowmation out of it’ and ‘We presented content that we had learnt already so we didn’t really learn much from the Slowmation’.



**Figure 5: Answers to ‘Would you use Slowmation in your own class as a form of assessment?’**

The data from the question, ‘Would you use Slowmation in your own class as a form of assessment?’ provides strong support for using Slowmation as an assessment tool (see Figure 5). Seventeen PSTs responded yes with ten further responding ‘absolutely yes’. Only two suggested they were unsure or no. This positive response validates the use of Slowmation as a form of assessment where students make connections between teaching, learning and assessment. Slowmation provides an authentic, rigorous and challenging teaching and assessment strategy and it was highly appealing to the PSTs as a form of assessment and as a tool that they could implement in their final placement. The high level of PSTs embracing and using this technology is also confirmed by their responses to the question ‘Did you find it motivating?’ where 67 per cent of PSTs found it motivating or absolutely motivating (see Figure 6).

The PSTs’ comments reflected the creativity and novelty of Slowmation, its use of IT and its practical applications for middle schooling:

*I felt I had to research my topic in a totally different way in order to present it in such a form of assessment. It is a fun and engaging way to get students interested in learning as well as having incorporated IT elements within the classroom. It was fun to manipulate the clay and put into an explanation.*

Other comments included:

*Making movies is a lot more interesting than writing essays. Slowmations also allow for creativity which is often left out in more traditional assessments. It felt like it was a good demonstration of what we can use in the middle years to assess our students when we become teachers.*

Another stated: ‘The motivation was intrinsic for me. It also allows you to express what may be a mundane topic or task in a really creative way.’

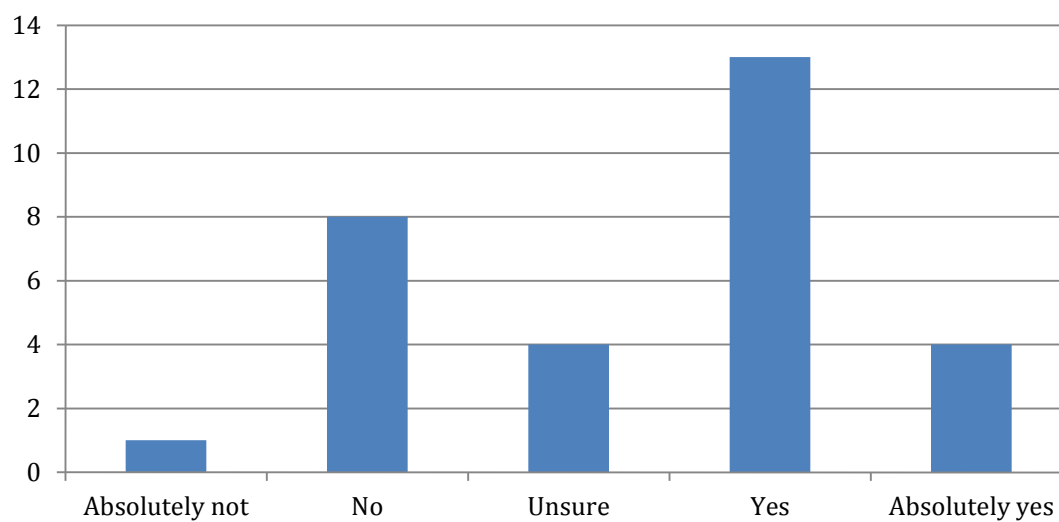


Figure 6: Answers to ‘Did you find it motivating?’

## Discussion

Analysis of the data collected provided an insight into the PSTs’ thoughts about the use of Slowmation as an authentic educational tool. In general, the PSTs’ responses were positive, showing they embraced the use of Slowmation. The responses from the students identified the themes of the growing global interest in technologies that are applicable to learning communities. PSTs were able to transfer their learning, and represent this clearly and articulately in their Slowmations. This transference also reflected their increased confidence, volition and active participation in their learning process through dialogue, as suggested by Wiggins (1989). Embedded within these skills was the students’ high level of motivation in their application of Slowmation within this study.

In what follows, we frame our discussion and analysis in terms of the processes considered relevant in the debate about twenty-first century authentic teaching and learning skills. These skills embrace ways of thinking, ways of working, tools for working and living in the world.

## Ways of Thinking

Analysis of the data highlights the PSTs’ skills focusing on ways of thinking. Central to the PSTs’ responses were the terms creativity, problem solving, decision making and thinking. They used these terms in relation to implementing Slowmation as an assessment task and for

future practice in the classroom. What was surprising was that the terms critical or higher order thinking were not highlighted by any of our respondents.

### **Ways of Working**

The PSTs' engagement in the project showed that they found that working in a collaborative setting was positive and no students chose to work individually. As these students were fourth years we anticipated that they had previously had the opportunity to work collaboratively and that working with Slowmation would further reinforce their experience. Students working in small groups scaffolded the development of collaborative learning in the sense of the opportunity to co-create meaning interactively through the work process (Engeström, 1999; Leont'ev 1978). Specifically, the learning communities offered students the opportunity to confirm their alternative understandings in science and mathematics. Students were able to create new ways of thinking about their current work and how through Slowmation these ways of thinking might inform their future ways of teaching and understanding learning.

### **Tools for Working**

While it appeared all the PSTs found Slowmation to be motivating, a deeper analysis found three distinguishable groups. PSTs who had high mastery of digital literacies and regularly constructed iMovies and YouTube clips responded that they would incorporate Slowmation in their classroom and also found it highly motivating. These PSTs identified Slowmation as a tool that accurately reflected both their learning and their final grade and feedback. This affirmed our assertion that it was an authentic teaching and learning tool. Further our results suggest that a small group of PSTs who found the technology challenging also found Slowmation motivating and responded that they would use it in their classroom. The third group of PSTs who would not use it in their class and who did not find it motivating were all challenged by digital literacies. These PSTs who were novices in digital literacies had difficulties accessing basic digital technology and equipment. The presence of this latter group supports the importance of improving general information and communication technology capabilities in a cross-curriculum fashion.

### **Living in the World**

Of all the four processes, the living in the world process was least evident and perhaps required further prompting. No respondents identified any associations with citizenship or cultural inclusivity. Also personal and social responsibility was not evident. However, tentative links to this process might be drawn from their context. They are about to become early career teachers, enter a complex profession and live in a world where they are hesitant about whether they possess sufficient scientific and technological knowledge to teach primary/middle students successfully. It might also be added that the fourth process, living in the world, did not really feature in the responses of the PSTs because, in our opinion, they were operating at a functional level in terms of presenting their science concepts. Moreover, the PSTs did not engage in higher-level reasoning connected with transference to classroom contexts or interdisciplinary/transdisciplinary thinking. However, PSTs may develop these important higher order skills as they gain experience as early career teachers, once they have mastered the functional skills such as managing the learning environment.

## Conclusion

Our research suggests that Slowmation as a teaching and learning tool may provide authentic, rich and creative opportunities for novice teachers to engage in a rigorous form of twenty-first century skills. From the experience of working with this one strategy, Slowmation, the PSTs' responses highlighted three key factors. First, PSTs saw Slowmation as an authentic learning and teaching tool and there was an indication that their scientific conceptual understanding was enhanced. Second, in terms of twenty-first century skills Slowmation used a) ways of thinking (creativity and innovation, critical thinking/problem solving/decision making, learning to learn), b) ways of working (communication, collaboration) and c) tools for working (information literacy, ICT literacy). Thirdly, in terms of working with technology, students found it motivating and contextually relevant, indicating an intention to transfer and use it in their own future classroom practice.

Of note, the results from question one highlight that a majority of students did not find Slowmation challenging. However, it is plausible to suggest that the PSTs who were conversant in digital literacies and were also motivated, were same group who were more likely to use Slowmation in their own classroom as early career teachers. There was an opportunity for PSTs to develop deep thinking about the teaching and learning process on several levels, such as using Slowmation to explain a complex science concept where 'wobbly bits' emerge at the edges.

Our research can be possibly read as a focus upon how to develop exemplary teachers, where Slowmation might be one example of an authentic teaching and learning tool leading to the realisation of this goal. Our research also investigates the student experience of learning and the implications of Slowmation for future directed innovations in teacher practice. This differs from Hoban and Nielsen's (2010, 2012a, 2012b) current focus on Slowmation as a source of semiotic insights into the making of meaning.

The use of Slowmation raised a number of questions particular to twenty-first century learning. These included: Were all Slowmations scientifically accurate? Were there any issues with plagiarism? Could we be sure that it was 100 per cent their work? Several future research issues were raised, such as (a) exploring Slowmation as a formative process and summative product; (b) how and to what extent constructing a Slowmation relied upon prior knowledge of science and mathematics conceptual understanding and (c) whether for those PSTs who found Slowmations challenging was it a consequence of failing to engage with the task because of a lack of ICT skills or were there other reasons?

## References

- Australian Curriculum Assessment and Reporting Authority (ACARA). (2015). *General capabilities*. Retrieved from [http://www.acara.edu.au/curriculum/general\\_capabilities.html](http://www.acara.edu.au/curriculum/general_capabilities.html)
- Ayres, P. (2006). Using subjective measures to detect variations of intrinsic cognitive load within problems. *Learning and Instruction*, 16(5), 389–400. <http://dx.doi.org/10.1016/j.learninstruc.2006.09.001>
- Brady, L., & Kennedy, K. (2011). *Assessment & reporting: Celebrating student achievement*. Frenchs Forest, NSW: Pearson Australia.
- Broussard, S., & Garrison, M. (2004). The relationship between classroom motivation and academic achievement in elementary school-aged children. *Family and Consumer Sciences Research Journal*, 33(2), 106–120 <http://dx.doi.org/10.1177/1077727X04269573>

- Brown, J., Murcia, K., & Hackling, M. (2013). Slowmation: A multimodal strategy for engaging children with primary science. *Teaching Science*, 59(4), 14–20.
- Corno, L. (1993). The best-laid plans: Modern conceptions of volition and educational research. *Educational Researcher*, 22, 14–22.  
<http://dx.doi.org/10.3102/0013189X022002014>
- De Jong, T. (2010). Cognitive load theory, educational research, and instructional design: Some food for thought. *Instructional Science*, 38(2), 105–134.  
<http://dx.doi.org/10.1007/s11251-009-9110-0>
- Dobson, S. (2006). The assessment of student Powerpoint presentations: Attempting the impossible? *Assessment & Evaluation in Higher Education*, 31(1), 109–119.  
<http://dx.doi.org/10.1080/02602930500262403>
- Eisner, E. (1999). The uses and limits of performance assessment. *Phi Delta Kappan*, 80(9), 658–660.
- Engeström, Y. (1999). Innovative learning in work teams: Analysing cycles of knowledge creation in practice. In Y. Engeström et al (Eds.), *Perspectives on activity theory* (pp. 377–406). Cambridge: Cambridge University Press.  
<http://dx.doi.org/10.1017/CBO9780511812774.025>
- Grant, P., & Paige, K. (2007). Curriculum integration: A trial. *Australian Journal of Teacher Education*, 32(4), 1-12 <http://dx.doi.org/10.14221/ajte.2007v32n4.3>
- Griffin, P., McGaw, B., & Care, E. (Eds.). (2012). *Assessment and teaching of 21st century skills*. Dordrecht: Springer. <http://dx.doi.org/10.1007/978-94-007-2324-5>
- Hoban, G. (2005). From claymation to slowmation: A teaching procedure to develop students' science understandings. *Teaching Science: Australian Science Teachers Journal*, 51(2), 26–30.
- Hoban, G., Loughran, J., & Nielsen, W. (2011). Slowmation: Preservice elementary teachers representing science knowledge through creating multimodal digital animations. *Journal of Research in Science Teaching*, 48(9), 985–1009.  
<http://dx.doi.org/10.1002/tea.20436>
- Hoban, G., & Nielsen, W. (2010). The 5Rs: A new teaching approach to encourage slowmations (student-generated animations) of science concepts. *Teaching Science*, 56(3), 33–38.
- Hoban, G., & Nielsen, W. (2012a). Learning science through creating a 'slowmation': A case study of preservice primary teachers. *International Journal of Science Education*, 2012, 1–28.
- Hoban, G., & Nielsen, W. (2012b). Using 'slowmation' to enable preservice primary teachers to create multimodal representations of science concepts. *Research in Science Education*, 42, 1101–1119. <http://dx.doi.org/10.1007/s11165-011-9236-3>
- Keane, T. (2012). An investigation of the role of the information and communication technologies leader in secondary schools. *Leading and Managing*, 18(1), 50–64.
- Lave, J., & Chaiklin, S. (Eds.). (1993). *Understanding practice: Perspectives on activity and context*. Cambridge: Cambridge University Press.
- Leont'ev, A. N. (1978). *Activity, consciousness, and personality*. Englewood Cliffs, NJ: Prentice-Hall.
- Loughran, J. (2010). *What expert teachers do: Enhancing professional knowledge for classroom practice*. Sydney: Allen & Unwin.
- Paas, F. (1992). Training strategies for attaining transfer of problem-solving skill in statistics. *Journal of Educational Psychology*, 84(4), 429–434. doi: 10.1037/0022-0663.84.4.429  
<http://dx.doi.org/10.1037/0022-0663.84.4.429>

- Paas, F., Tuovinen, J. E., Tabbers, H., & Van Gerven, P. W. M. (2003). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist*, 38(1), 63–71. [http://dx.doi.org/10.1207/S15326985EP3801\\_8](http://dx.doi.org/10.1207/S15326985EP3801_8)
- Paas, F., Van Merriënboer, J. J. G., & Adam, J. J. (1994). Measurement of cognitive load in instructional research. *Perceptual and Motor Skills*, 79(1), 419–430. doi: 10.2466/pms.1994.79.1.419 <http://dx.doi.org/10.2466/pms.1994.79.1.419>
- Paige, K., Lloyd, D., & Chartres, M. (2008). Moving towards transdisciplinarity: An ecological sustainable focus for science and mathematics pre-service education in the primary/middle years. *Asia-Pacific Journal of Teacher Education*, 36(1), 19–33. <http://dx.doi.org/10.1080/13598660701793350>
- Waldrip, B., & Prain, V. (2006). Changing representations to learn primary science concepts. *Teaching Science*, 54(4), 17–21.
- Wenger, E. (1998). Communities of practice: Learning as a social system. *Systems Thinker*, June, reproduced in *Community Intelligence Labs*. Retrieved from <http://www.co-i-l.com/coil/knowledge-garden/cop/lss.shtml>. <http://dx.doi.org/10.1017/CBO9780511803932>
- Wertsch, J. V. (1985). *Vygotsky and the social formation of mind*. Cambridge, MA: Harvard University Press.
- Wiggins, G. (1989). A true test: Toward more authentic and equitable assessment. *Phi Delta Kappan*, 70(9), 703–713

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## Appendix 1: Questionnaire

We are interested in your reflections about using Slowmation as one aspect of the professional development presentation.

*Please circle the most appropriate answer and add comments in the space provided.*

1. How technologically challenging did you find the Slowmation assessment task to complete?

Not challenging at all	A little challenging	Challenging	Very challenging	Extremely challenging
1	2	3	4	5

What were these technical challenges?

2. In relation to other forms of assessment you have experienced how challenging was the process of creating a Slowmation with a partner?

Not challenging at all	A little challenging	Challenging	Very challenging	Extremely challenging
1	2	3	4	5

What were these challenges?

3. In relation to other forms of assessment you have experienced how would you rate Slowmation as an authentic form of assessment?

Not authentic at all	A little authentic	Authentic	Very authentic	Extremely authentic
1	2	3	4	5

In what way?

4. Did the use of Slowmation enhance your conceptual understanding of your selected science concept?

Absolutely not	No	Unsure	Yes	Absolutely yes
1	2	3	4	5

In what way?

5. Would you use Slowmation in your own class as a form of assessment?

Absolutely not	No	Unsure	Yes	Absolutely yes
1	2	3	4	5

Why?

If yes can you provide some information re which year level, topic, etc.?

6. Was the Slowmation assessment task motivating?

Absolutely not	No	Unsure	Yes	Absolutely yes
1	2	3	4	5

How?

7. Did the use of Slowmation deepen your learning more than traditional forms of assessment techniques?

Absolutely not	No	Unsure	Yes	Absolutely yes
1	2	3	4	5

Why?

8. Did the use of Slowmation help you address any misconceptions you may have had?

Absolutely not	No	Unsure	Yes	Absolutely yes
1	2	3	4	5

How did Slowmation support you to address your misconceptions?

9. Approximately how long did it take you to design, create and modify your Slowmation?

1-2 hours	2-3 hours	3-4 hours	5-6 hours	6 hours +
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10. What advice would you give to a prospective student commencing the same Slowmation activity in 2015?

Are there in any other comments you would like to make in relation to how Slowmation contributed to your learning?