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Developing Middle School Students' Interest in Learning Science and Geology through Slowmation

Abstract

Given that interest is associated with learning in educational research, understanding how its development can be supported in different learning contexts represents an important line of inquiry. In this study, we investigate the influence of the slowmation construction process on middle school students' interest in learning science and geology. Both quantitative and qualitative data were generated from four classes of ninth grade students; two classes participated in the construction of a slowmation about tectonic plate boundaries (n = 52) and two classes experienced a state-mandated program of instruction (n = 43). The students completed the *Student Interest in Learning Science Survey*, a Likert-style instrument, which examined their level of situational and individual interest prior to their participation in the study and upon their completion of the construction task or mandated instruction. Statistical analyses of these data revealed that the students who constructed a slowmation demonstrated significant increases in their interest in learning science and geology, while the students who experienced regular classroom instruction demonstrated lower levels of interest by the end of the study. Interview data obtained from students who constructed a slowmation suggest that the construction process afforded opportunities to work and learn in active, hands-on and collective ways; to exercise creativity; and to engage with technology. Importantly, increases in students' interest appeared to emerge from the early attentional and affective stages of their interest development, rather than through a meaningful connection to the geological subject matter, which has theoretical implications for interest research in learning contexts.

Keywords: Geology education; situational interest; individual interest; digital media; slowmation.

Developing Middle School Students' Interest in Learning Science and Geology through Slowmation

Learning about Earth's physical systems is becoming increasingly important in school science education. Despite its importance, a number of challenges and complexities surround the enactment of quality Earth science education in Australia, which are paralleled internationally (Mills, Tomas, & Lewthwaite, 2016). Importantly for this paper, research demonstrates that school students have difficulty coming to understand abstract geological concepts and processes (Mills et al., 2016). More specifically, students have incorrect or incomplete understandings about key ideas such as rock formation and classification (Froyland, Remmen, & Sorvik, 2016), and plate tectonics (Dolphin & Benoit, 2016; Mills, Tomas, & Lewthwaite, 2017), and they struggle to comprehend the vast temporal and spatial scales inherent to learning about geology (Yoon & Peate, 2015). Moreover, school students are disinterested in learning such topics. In Australia, for instance, where the current study was conducted, enrollments in post-compulsory geology education are the lowest of all mainstream science education courses (Kennedy, Lyons, & Quinn, 2014), and students describe their experiences of learning geology as difficult, boring, and irrelevant to their lives beyond school (Dawson & Carson, 2013). Given that there are both longstanding and emerging associations between learning and interest (Janson, Lüdtke, & Schroeders, 2016; Schiefele, Krapp, & Winteler, 1992), it is important that students' interest in learning about science and geology is developed, and instructional interventions that arouse students' interest be studied in their own right (Rotgans & Schmidt, 2017).

In response to this context, our study utilized Hidi and Renninger's (2006) four-phase model of interest development to investigate the influence of a type of student-constructed stop motion animation (i.e., 'slowmation') on middle school students' interest in learning about science and geology. More specifically, we compared the interest development of students who constructed a slowmation with those who experienced a state-mandated program of instruction. For those students who constructed a slowmation, we sought to develop a deep understanding of how the construction process influenced their interest development. In the following sections, we begin with a review of contemporary conceptualisations of interest development, the association between interest and student learning, and the motivational affordances of slowmation for learning science.

Interest Generation and Development in Learning Contexts

Although interest development has been conceptualised from a variety of perspectives, there is agreement within the research literature that it involves two broad levels of interest: situational interest and individual interest. While situational interest is an immediate attentional and affective response to environmental stimuli (such as a novel instructional approach), and may be long-lasting or not, individual interest is a more stable dispositional quality that arises from knowledge about and value for given content (Krapp, Hidi, & Renninger, 1992; Krapp & Prenzel, 2011). There is no consensus on the interaction between these two levels of interest (cf. Hidi & Renninger, 2006 & Rotgans & Schmidt, 2017); however, the dominant perspective suggests that they are sequential and cumulative, as an individual’s immediate attentional and affective response is sustained via repeated and self-regulated engagement with the content (Hidi & Renninger, 2006).

To support instruction that enhances students’ academic motivation and learning, Hidi and Renninger (2006) offer a four-phase model of interest development that integrates situational and individual levels of interest. The first phase, Triggered Situational Interest (triggered-SI), may be prompted by environmental aspects that temporarily alter students’ affective and cognitive processing. This phase is often externally supported, for example, by learning environments and pedagogical strategies that stimulate situational interest, such as science demonstrations; hands-on activities; and fun facts, anecdotes, and stories (Palmer, Dixon, & Archer, 2016). Phase two, Maintained Situational Interest (maintained-SI), is characterised by persistent and/or recurring situational interest that is sustained through active and meaningful learning experiences that enliven students' enjoyment of and connection to the content, such as inquiry-based learning (Jocz, Zhai, & Tan, 2014). Maintained-SI can be broken down further into feeling-related (maintained-SI-feeling) and value-related (maintained-SI-value) components (Linnenbrink-Garcia et al., 2010; Schiefele, 1991). While maintained-SI-feeling is characterised by an individual's affective experiences while engaging with content (e.g., excitement and enjoyment), maintained-SI-value is characterised by an individual's belief that the content itself is meaningful to their lives beyond the classroom (Linnenbrink-Garcia et al., 2010). Phases three and four, Emerging Individual Interest and Well-developed Individual Interest, respectively, refer to the development of an ultimately enduring disposition to actively seek reengagement with specific content over time. Each phase may be considered sequentially as a deepening of interest, and as mediators of subsequent interest development (Hidi & Renninger, 2006).

An individual's interest in content may arise from a variety of sources. One line of inquiry in science education has found that novelty, involvement, and meaningfulness are important antecedents of situational interest. Novel learning experiences are new, suspenseful, and/or surprising, and differ from what is normally experienced in a learning context (Jack & Lin, 2014). A novel activity or task may incorporate unfamiliar disciplinary content knowledge, practical work, or provide choice to promote student autonomy (Linnenbrink-Garcia, Patall, & Messersmith, 2013; Palmer et al., 2016). Students' active involvement in their learning may encompass cognitive and physical engagement or participation, and student interaction with the teacher and amongst peers (Jack & Lin, 2014). Such involvement may be achieved through the manipulation of materials or models in hands-on activities, or through carefully designed group work that promotes social or achievement interactions. Finally, the meaningfulness of the content, which refers to its relevance to students' existing pre-instructional knowledge and to their lives beyond the classroom (Jack & Lin, 2014), can generate student interest, and may be supported through teaching that relates to students' topic interests (Linnenbrink-Garcia et al., 2013; Palmer et al., 2016.)

Many educational approaches have been shown to enhance school students' interest in learning science. These include inquiry- and problem-based learning approaches, collaborative learning or cooperative group work, technology-enhanced instruction, hands-on learning activities, and field trips or science museum visits (Potvin & Hasni, 2014). While such approaches are well-researched in general science education, there appears to be a paucity of interest studies concerned with learning geologic concepts. At the time of the present study, the authors were unaware of any published scholarly papers conducted within this context. While this finding is unsurprising given the lack of research on students' affective experiences in geoscience education more broadly (see Mills et al., 2016), the importance of this research agenda is paramount given that school students find geology topics uninteresting (Dawson & Carson, 2013) and traditional teaching methods (i.e., transmission style pedagogies) have been shown to erode students' already low interest in learning in this discipline (e.g., Hetherington, 2010).

Associations between Interest and Student Learning

At present, there are competing perspectives about the association between student interest and learning. The most widely accepted viewpoint, as posited in the four-phase model of interest development, explicates that knowledge co-develops alongside both situational and individual interest through the aforementioned repeated engagement with content, which is likely to become increasingly self-regulated and independent of external supports (Hidi & Renninger, 2006). An alternative hypothesis positions knowledge as a cause of student (individual) interest, as positive feelings and value toward content result from concept mastery (Rotgans & Schmidt, 2017). While both fields of thought are supported by empirical evidence, in the current study, we subscribe to the first conceptualisation of interest and knowledge as co-developing alongside each other. This is because the latter idea remains in its infancy and is still being scrutinised by experts (see Hidi & Renninger, 2017).

Despite unanswered questions about the exact nature of the relationship between student interest and learning, there is clearly a positive association between the two. This is evident in longstanding educational research (see Schiefele et al., 1992 for a meta-analysis) and is being refined continually in emerging research. A recent study by Janson, Lüdtke and Schroeders (2016), for example, found that a nationally representative sample of German middle school students (n = 39,192) achieved higher in the disciplines that they were more interested in, and, in a given discipline, students who were more interested in the content achieved higher than their less interested peers. Similarly, in science education specifically, international data from the Programme of International Student Assessment (PISA) suggest there are associations between measures of student interest and academic performance (Krapp & Prenzel, 2011). Findings such as these attest further to the importance of developing students’ interest in science and geology, as they demonstrate a positive correlation between interest and learning-related outcomes such as academic performance and achievement.

Motivational and Learning Affordances of Slowmation

Slowmation is a type of student-constructed stop motion animation that has been researched largely in initial science teacher education (e.g., Hoban & Nielsen, 2014; Kidman, 2016; Nielsen & Hoban, 2015; Paige, Bentley, & Dobson, 2016; Wishart, 2017), and to a lesser extent, in school science education (e.g., Brown, Murcia, & Hackling, 2013; Mills, Tomas, & Lewthwaite, under review). During the process of constructing a slowmation, learners create, manipulate, and photograph three-dimensional models of a scientific phenomenon, and display the photographs at approximately two frames per second to create a moving animation that explains the associated concepts and processes (Hoban, Loughran, & Nielsen, 2011). Slowmation has been shown to offer a range of affordances for knowledge reconstruction, as, during the construction process, information is translated between several modes of representation (i.e., written research notes, a storyboard, models, digital photographs, and final animation) (Hoban et al., 2011). This presents opportunities for learners to engage in scientific reasoning and argumentation about the accuracy of their representations alongside their peers (Hoban & Nielsen, 2014). While many studies document the affordances of slowmation for preservice teacher or student learning in science, a thorough examination of its influence on learners' affective or motivational experiences remains notably absent from the literature.

A number of existing studies report promising anecdotal findings. A recent study by Paige and colleagues (2016) examined, in part, preservice teachers' experiences of learning with slowmation. In this study, the participants reported that learning with slowmation enhanced their academic motivation, due to their enjoyment of learning science in a different and creative way.

Similarly, in an earlier study carried out by Hoban and Nielsen (2012), preservice teachers described their experiences learning science with slowmation as highly engaging and, notably, preferable to the conventional teaching methods they were accustomed to. Finally, research by Shephard, Hoban, and Dixon (2014) suggests that slowmation can also stimulate the interest of students with special needs, reporting that a group of primary school students with mild intellectual disabilities demonstrated great excitement and eagerness in manipulating and photographing the content of their slowmation animations.

Research Problem and Questions

Given that school students are seemingly disinterested in learning about geology, and experience difficulty coming to understanding abstract geological topics such as plate tectonics, the present study investigated the influence of a promising instructional approach on students' interest in learning science and geology. The research questions that guided the inquiry were: *To what extent does constructing a slowmation develop students' interest in learning science and geology?* and *How does students' interest develop through the construction process?* The next sections present an overview of the research design and methods of data generation and analysis that were employed to answer the research questions.

Research Design and Procedures

This study was conducted over a two-week period in April, 2015, in a co-educational urban school in South-East Queensland, Australia. The participants were 95 Year 9 students from four intact science classes, and their two teachers (both teachers taught two classes each). At the time of the study, the students were completing a mandated unit of work from the *Earth and Space Sciences* sub-strand of the *Foundation to Year 10 Australian Curriculum: Science* (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2017a). The unit of work, entitled *Changing Earth*, was common to all Queensland state (public) schools, and explored a range of geological concepts and processes. As part of the unit, students learn about different tectonic plate boundaries as a foundation for understanding natural hazards, such as earthquakes and volcanoes. This was the topic chosen for investigation in the current study because the processes that operate at tectonic plate boundaries can be readily modelled. Through their participation in the study, two classes of students worked in small groups to construct a slowmation about a type of tectonic plate boundary (n = 52) (students chose their own groups and these were amended by the teacher, if deemed necessary), and two classes of students experienced the state mandated program of instruction, which we will refer to henceforth as 'teaching as usual' (*n* = 43). The classes were assigned a condition such that each teacher taught both pedagogical approaches.

The slowmation construction process employed in the current study was adapted from studies conducted in preservice teacher education contexts, and spanned four 70-minute science lessons. First, students used the Internet to research answers to the following questions: (1) What are tectonic plates? (2) What causes tectonic plates to move? (3) How do tectonic plates interact at your chosen type of tectonic plate boundary? (4) What landforms occur at your chosen type of tectonic plate boundary? and (5) How are these landforms created and how long does the process take? Then, students created a storyboard for their slowmation. The storyboard showed how students would use the available craft materials (e.g., coloured paper, modeling clay, sponges, pipe cleaners, paddle-pop sticks, markers, and labels) to create a representation of a tectonic plate boundary, and how the materials would be manipulated between each still photograph to show the relevant geological processes. Next, students constructed, manipulated, and photographed their representations with the support of an iPad application called *MyCreate*™.

The application allowed them to display their photographs at two frames per second to create a moving animation, and to narrate a scientific explanation of their work. Finally, students viewed each other's slowmations so that they could learn collectively about all types of tectonic plate boundaries.

Teaching as usual was the school's enactment of the *Australian Curriculum: Science*; namely, the learning activities in the mandated *Changing Earth* unit that were relevant to plate tectonics. The unit was predominantly teacher-led, and included activities such as viewing a PowerPoint™ presentation about plate tectonics and answering questions; drawing and annotating diagrams of tectonic plate boundaries; and watching short online videos or engaging with interactive learning objects online. Some of the activities were adapted, as necessary, to span four 70-minute science lessons, and to ensure that all classes involved in the study learnt the same underlying science content (Table 1).

An explanatory mixed methods intervention design (Creswell, 2015) was chosen to develop a deeper understanding of the research problem than a quantitative or qualitative research approach might afford individually. Specifically, data pertaining to students' interest in learning science and geology were generated from the quantitative analyses of an interest survey, the *Student Interest in Learning Science (SILS) Survey*, and from the qualitative analyses of semi-structured student interviews. This pragmatic approach combined the strength of both types of data, in that the quantitative data allowed the identification of trends, while the qualitative data facilitated a deeper and nuanced understanding of students' experiences (Creswell, 2014). By integrating these data, a more complete picture of the research problem was gained.

Table 1
The learning sequence enacted in the 'teaching as usual' classes

Topic	Lesson	Timing	Students' actions
Heat and convection	1	70 min	• Viewed an interactive website about Earth's structure and answered comprehension questions. • Drew annotated diagrams comparing Earth's layers. • Conducted an experiment to model how convection may cause the movement of tectonic plates. • Drew annotated diagrams to explain the findings of the experiment.
Divergent boundaries	2	70 min	• Viewed a PowerPoint™ presentation that explained types of divergent plate boundary. • Modeled the process of seafloor spreading through a hands-on activity and answered questions. • Drew annotated diagrams to explain the processes that occur at divergent plate boundaries.
Convergent boundaries	3	70 min	• Viewed a PowerPoint™ presentation and videos that explained types of convergent plate boundaries. • Viewed an interactive website and answered questions. • Drew an annotated diagram to explain the processes that occur at convergent plate boundaries.
Transform boundaries and summary	4	70 min	• Viewed an interactive website that explained transform plate boundaries and answered questions. • Viewed an interactive website that compares all types of tectonic plate boundaries and completed a summary table.

It is noted in the literature that there are a range of methods for measuring interest and its development (Krapp & Prenzel, 2011; Renninger & Hidi, 2011); however, self-report measures such as surveys and student interviews are used widely by researchers and are deemed appropriate for measuring all stages of interest development (e.g., Palmer et al., 2016, 2017). In the current study, data on students' interest in learning science and geology were generated immediately before and after their participation in the study using the SILS survey, and immediately after their participation in the study at interview. This approach enabled an examination of how the slowmation construction process effected students' interest development in comparison to teaching as usual. Data on students' situational interest was not generated in-the-moment to prevent constant interruption to the classroom activities, and to students' thoughts and feelings during the lessons (see also Palmer et al., 2016).

Quantitative data source and analysis

The SILS survey is a Likert-style questionnaire that examines students' individual and situational interest in learning science. The survey is an amalgamation of subscales from the *PISA 2006 Student Questionnaire* (Organisation for Economic Co-operation and Development [OECD], 2005) and the *Situational Interest Survey* (Linnenbrink-Garcia et al., 2010). The survey was administered to students immediately before and after the four 70-minute science lessons, and responses were analysed to identify any statistical shifts in students' interest that could be attributed to the slowmation construction task or to the teaching as usual classroom activities.

The SILS survey consists of 19 items within four subscales that examine students' individual interest in learning science (Subscale 1); individual interest in learning geology (Item 1f); triggered-SI (Subscale 2); maintained-SI-feeling (Subscale 3); and maintained-SI-value (Subscale 4) (Table 2). Subscale 1 of the survey was taken directly from the *PISA 2006 Student Questionnaire* (OECD, 2005). The items that belong to this subscale appear as they do in the PISA student questionnaire, as they examine students' individual interest in learning science and geology topics. These items were scored using a four-point scale ranging from 1 (*no interest*) to 4 (*high interest*). Subscales 2, 3, and 4 of the survey were adapted from the *Situational Interest Survey* (Linnenbrink-Garcia et al., 2010). Items 2a to 2d measure triggered-SI; Items 3a to 3d measure maintained-SI-feeling; and Items 4a to 4d measure maintained-SI-value. These subscales were adapted slightly from the original survey instrument to make the items specific to the context of the current study. First, these subscales were prefaced with the proposition, *Think about your experiences learning science this term while answering the questions below*. Second, wording in the original survey items that asked students to consider their interest in mathematics was removed and replaced with science. For example, Item 2a was changed from *This year, my* *mathematics teacher is exciting*, to *My science teacher is exciting*. Third, the survey was adapted from a five-point Likert-style scale ranging from 1 (*not true at all*) to 5 (*very true*) to a four-point scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). This was done to achieve consistency between all subscales, and was modeled on the internationally accepted format used by PISA and other attitudinal research in educational settings (e.g., Tomas, Girgenti, & Jackson, 2017; Tomas, Ritchie, & Tones, 2011).

To confirm the factor structure of the SILS survey was valid, protocols established by Tomas et al. (2011) were followed. First, a principal component analysis was conducted using SPSS 23™. Results suggested four subscales within this instrument that are consistent with how interest development is theorised in the literature: (1) individual interest, (2) triggered-SI, (3) maintained-SI-feeling, (4) maintained-SI-value. A confirmatory factor analysis was then conducted using AMOS 25™. Fit indices were produced to assess model fit: the Tucker Lewis fit index, comparative fit index, root mean square error of approximation, and the root mean square residual (see Tabachnick & Fidell, 2007). These indices demonstrated a satisfactory fit between the four-factor model of interest development adopted in the current study and the data (Table 3).

Table 3
Confirmatory factor analysis indices of fit test results

Index	Pretest	Posttest
Tucker-Lewis index (TLI)	.971	.961
Comparative fit index (CFI)	.977	.969
Root mean square error of approximation (RMSEA)	.038	.054
Root mean square residual (RMR)	.042	.046

Table 2

Subscales and items of the SILS survey, and their corresponding response options

Subscale	Items	Response Options (Score)			
1. Individual interest	1a. Topics in physics 1b. Topics in chemistry 1c. The biology of plants 1d. Human biology 1e. Topics in astronomy 1f. Topics in geology 1g. Ways scientists design experiments	No interest (1)	Low interest (2)	Medium interest (3)	High interest (4)
2. Triggered-SI	2a. My science teacher is exciting 2b. When we do science, my teacher does things that grab my attention 2c. My science class is often entertaining 2d. My science class is so exciting it's easy to pay attention	Strongly disagree (1)	Disagree (2)	Agree (3)	Strongly agree (4)
3. Maintained-SI-feeling	3a. What we are learning in science is fascinating to me 3b. I am excited about what we are learning in science 3c. I like what we are learning in science 3d. I find the science we do in class interesting	Strongly disagree (1)	Disagree (2)	Agree (3)	Strongly agree (4)
4. Maintained-SI-value	4a. What we are studying in science is useful for me to know 4b. The things that we are studying in science are important to me 4c. What we are learning in science can be applied to real life 4d. We are learning valuable things in science	Strongly disagree (1)	Disagree (2)	Agree (3)	Strongly agree (4)

The SILS survey was found to be a reliable instrument to measure students' individual and situational interest in the current study. As shown in Table 4, the internal consistency of each subscale at pre- and post-intervention was high, as Cronbach's α was >.70 (de Vaus, 2014), and corresponded favorably to the international benchmarks of PISA and Linnenbrink-Garcia et al.'s (2010) study of the *Situational Interest Survey* across a number of educational contexts.

Table 4

A comparison of Cronbach's α for the original and adapted subscales used in the SILS survey

	Subscales	Number of Items	Cronbach's α Reliability			
			Pre (*n*=95)	Post (*n* = 95)	PISA 2006 (*n*=500)	SIS* (*n*=236)
1	Individual interest	7	.74	.82	.87	-
2	Triggered-SI	4	.76	.85	-	.86
3	Maintained-SI-feeling	4	.90	.95	-	.92
4	Maintained-SI-value	4	.86	.90	-	.88

Note: The measures of internal consistency (Cronbach's α) presented for each subscale are from this study and either the 2006 round of PISA testing or Linnenbrink-Garcia et al.'s (2010) validation of the *Situational Interest Survey* (*SIS).

In order to investigate the extent to which the slowmation construction process developed students' interest in learning science and geology, quantitative analyses of the SILS survey data generated pre- and post-intervention were performed. Changes in mean scores for each of the four subscales were analysed using SPSS. Multivariate and univariate statistics were used to explore the development of students' interest as they constructed a slowmation or experienced teaching as usual. Multivariate analyses of variance (MANOVA) were performed to identify any significant interaction effects between the four dependent variables in the SILS survey (i.e., individual interest in learning science, triggered-SI, maintained-SI-feeling, and maintained-SI-value), two independent variables (i.e., time and condition), and two co-variables (i.e., class teacher and gender) that would warrant further statistical investigation. While all possible combinations of variables were explored, only the significant effects and interactions of relevance to the research questions are presented in this article. Univariate analyses of variance

(ANOVA) were performed as follow-up tests on each dependent variable, and *t*-tests were conducted in order to investigate further the significant interactions identified by the univariate tests, and their impact on students' SILS survey scores.

Qualitative data source and analysis

While the quantitative component of this study provides data regarding the development of students' interest in learning science and geology, it does not uncover the aspects of the slowmation construction process that might have contributed to their interest development. As such, semi-structured student interviews were the source of qualitative data used to gain further insight into students' interest development. Interviews were conducted in the week following the completion of the study with a random sample of students who constructed a slowmation and consented to participate in an audio-recorded interview during class time (n = 17). Our questions probed students' experiences of constructing a slowmation. A fixed interview protocol was not used, as we wanted to pursue courses of fruitful dialogue and allow students opportunities to elaborate on their learning experiences. Example questions students were asked at interview include, *Can you tell me about your experience creating a slowmation about plate tectonics?* and *What was the most memorable part of your experience?* Students who experienced teaching as usual were not interviewed, as this data was not needed to answer the research questions.

The student interviews were audio-recorded and transcribed, using pseudonyms for students' names. Once transcribed, an initial exploratory analysis was carried out, whereby the transcripts were read several times in their entirety to discern what was important in the data and what was not. Short segments of text were then coded in a manner representative of their meaning (Saldaña, 2013), with specific attention given to students' descriptions of their affective experiences toward the learning environment or subject matter. This coding was a cyclical process, wherein the focus of the analyses was iteratively sharpened, and codes were eventually grouped together as more parsimonious themes (Saldaña, 2013).

Research Findings

In this section, we present evidence to support three claims that correspond to the research questions. First, we assert that students who constructed a slowmation demonstrated a significant increase in their triggered-SI, maintained-SI-feeling, and individual interest in learning science and geology, while students who experienced regular classroom instruction demonstrated lower levels of interest by the end of the study. Second, we claim that the construction process enhanced students' interest as it afforded opportunities for students to work and learn in active, hands-on, and collective ways; to exercise creativity; and to engage with technology. Finally, we suggest that students' heightened individual interest in learning science and geology emerged from the early attentional and affective phases of their interest development (i.e., their triggered-SI and maintained-SI-feeling), rather than through a meaningful connection to the geological subject matter (i.e., maintained-SI-value). Before substantiating these claims, we report on the quantitative analysis of students' responses to the SILS survey, followed by the major findings arising from the student interviews.

Students' interest in learning science and geology

A repeated measures MANOVA was conducted to examine students' interest development over the course of the study. The dependent variables were students' mean scores on the four interest subscales, and the independent variables were time (from pre- to post-intervention) and condition (slowmation or teaching as usual). Mean scores and standard deviations for each dependent variable by condition are presented in Table 5. The mean scores for both the slowmation and teaching as usual classes corresponded to low-moderate levels of interest at the start of the study.

Table 5
Summary of the descriptive statistics for the SILS survey subscales

Variable	Condition	Pre-intervention	Post-intervention
		Mean (SD)	Mean (SD)
Individual interest	Slowmation	2.56 (0.48)	2.77 (0.54)
	Teaching as usual	2.48 (0.62)	2.43 (0.69)
Triggered-SI	Slowmation	2.82 (0.51)	3.06 (0.57)
	Teaching as usual	2.77 (0.55)	2.62 (0.71)
Maintained-SI-feeling	Slowmation	2.59 (0.60)	2.89 (0.51)
	Teaching as usual	2.61 (0.84)	2.42 (0.91)
Maintained-SI-value	Slowmation	2.68 (0.60)	2.73 (0.60)
	Teaching as usual	2.59 (0.76)	2.49 (0.80)

A significant interaction effect for time*condition was observed, Wilks's $\Lambda = 0.80$, $F(4, 89) = 5.42$, $p = .001$, partial $\eta^2 = .20$, which suggests that there was a difference in students' SILS survey scores for students who constructed a slowmation and students who experienced teaching as usual, over the course of the study. A series of ANOVAs were conducted to explore this interaction for each interest subscale further. There were significant time*condition interaction effects for individual interest, $F(1, 92) = 8.41$, $p < .05$, triggered-SI, $F(1, 92) = 15.46$, $p < .001$, and maintained-SI-feeling, $F(1, 92) = 13.90$, $p < .001$. There was no significant time*condition interaction effect for maintained-SI-value.

A series of paired samples *t*-tests were carried out to explore the univariate time*condition interactions (Table 6). For the individual interest in learning science subscale, there was a significant increase in the scores for the slowmation condition, $t(51) = -3.48$, $p = .001$. No significant change was observed for the comparison group. For the triggered-SI subscale, the intervention group's scores significantly increased, $t(51) = -3.24$, $p < .05$, whereas the comparison group's scores significantly decreased, $t(42) = 2.38$, $p < .05$. This trend was also observed for the maintained-SI-feeling subscale, with the intervention group's scores increasing, t(51) = -2.83, *p* <.05, and comparison group's scores decreasing, t(42) = 2.46, *p* <.05. Neither groups' maintained-SI-value scores changed significantly from pre- to post-intervention.

Table 6
Results of the paired samples t-tests, which examined changes in students' interest from pretest to posttest

Variable	Condition	ΔMean	*t*-Value	df	Sig.	Cohen's *d*
Individual interest	Intervention	0.25	-3.48	51	.001*	.49
	Comparison	-0.05	0.79	42	.440	.12
Triggered-SI	Intervention	0.24	-3.24	51	.002*	.46
	Comparison	-0.15	2.38	42	.022*	.39
Maintained-SI-feeling	Intervention	0.29	-2.83	51	.007*	.40
	Comparison	-0.19	2.46	42	.018*	.37
Maintained-SI-value	Intervention	0.05	-0.58	51	.568	.08
	Comparison	-0.10	1.06	42	.294	.17

*Significant at the p < .05 level (two-tailed).

To confirm that the changes in students' SILS survey scores from pre- to post-intervention could not be attributed to other factors, a supplementary MANOVA that included classroom teacher and gender as additional independent variables was conducted. The critical four-way time*condition*gender*teacher interaction was not significant, nor were the three-way time*condition*gender and time*condition*teacher interactions. This means that the study was implemented consistently among the classroom teachers, and that boys and girls responded similarly to the SILS survey. The time*condition interaction remained significant in the supplementary statistical tests, so the results of the original analyses were retained.

A separate repeated measures ANOVA was conducted to investigate whether students' individual interest in geology topics (i.e., Item 1f) changed from pre- to post-intervention. A significant interaction effect was observed for time*condition, $F(1, 92) = 2.30$, $p < .05$, partial $\eta^2 = 0.63$. Follow-up paired samples *t*-tests were conducted to investigate the critical time*condition interaction. As shown in Table 7, the analyses revealed that the intervention group's reported interest in learning about geology topics increased significantly from pre- to post-intervention, t(51) = -3.86, *p* <.001. A moderate effect size of 0.53, as measured by Cohen's d, was observed (Tabachnick & Fidell, 2007).

Table 7
Results of the paired samples t-tests, which examined changes in students' interest in learning about geology topics only, from pre- to post-intervention

	Pretest mean (SD)	Posttest mean (SD)	*t*-Value	df	Sig.	Cohen's *d*
Intervention	2.38 (0.72)	2.83 (0.79)	-3.86	51	.000*	.53
Comparison	2.30 (0.80)	2.30 (0.91)	0.00	42	1.00	.00

*Significant at the *p* < .001 level (two-tailed).

While these results indicate that constructing a slowmation enhanced students' interest in learning science and geology, qualitative analysis of student interview data identified a number of aspects of the construction process (presented below) that may have contributed to these changes.

Aspects of the slowmation construction process that students attributed to their enhanced interest

In seeking to understand how constructing a slowmation enhanced students' interest, four themes were drawn from the analysis of the interview transcripts: *Active, hands-on learning*, *Exercising creativity*, *Working collectively,* and *Engaging with technology* (Table 8). These themes are significant because they serve to deepen our understanding of the significant improvements in students' interest identified by the SILS survey, by illuminating aspects of the construction process that captured their interest. Findings relating to each of these themes are presented below.

Table 8
Aspects of the slowmation construction process that students perceived to capture their interest

Aspect	Sample Quotation	Frequency (*n* = 17)
Active, hands-on learning	Making the clay models and watching how the clay models worked was better than reading off a textbook. (Student 15)	17
Exercising creativity	I think it really let everyone stretch their creative muscles and let us do something that we wouldn't normally do. (Student 7)	4
Working collectively	It was really fun and it was good watching everyone else's *[slowmation]*. (Student 6)	2
Engaging with technology	It was interesting I guess. I think the most memorable part was the *[MyCreate]* program and trying it out and seeing if it works and how to properly use it. (Student 5)	2

Active, hands-on learning. This represented the most salient theme to emerge from the data and was identified by all students at interview (*n* = 17). Students' comments suggest that constructing a slowmation was different to how they typically learnt science, which appeared to have an impact on their attentional and affective experience while learning geology. This is exemplified by one student's comment at interview: "It was really fun doing something different" (Student 9). When prompted to elaborate upon statements like this further, most students contrasted their experience constructing a slowmation with their perceptions of their usual experience of learning science. Specifically, students appreciated the active learning opportunities afforded by creating slowmation, rather than "reading from textbooks" (Student 4) or "writing on a worksheet" (Student 5). The following excerpts from interviews with students encapsulate this viewpoint:

> It's *[slowmation]* better than doing normal stuff in class and it helps you understand it *[the science content]* more. (Student 3).

> Instead of reading from textbooks and stuff, it *[slowmation]* was more ... interesting for me to make stuff, and *[it]* taught me more. (Student 4)

> It's *[slowmation]* a more enjoyable way to do it *[learn science]*. Instead of writing on a worksheet for 70 minutes, it's taking pictures of the bits and pieces you've created. (Student 5)

For one student, constructing models called for active learning and the application of knowledge: “You had to learn stuff and apply it. You weren’t just writing it down, you had to make stuff” (Student 11).

The physical construction, manipulation, and photographing of the models was a particularly memorable affective experience for students, who articulated that “making” the slowmation was their favourite part of the construction process. Student 10, for instance, described “making the models for the animation”, “making the slides *[still photographs]*”, and “seeing it all come together” as the most memorable parts of his learning experience. Another student, who described making a slowmation as “fun”, indicated that this was “because [*her*] group was physically making it” (Student 14). Students differed in their perceptions about why this was their favourite part of the construction process; however, most indicted that they enjoyed the hands-on nature of these activities, as indicated by the following excerpts:

> “I enjoyed making the props *[models]* for the slowmation because it was hands-on.” (Student 15)
>
> “It helped me *[learn]* more because I prefer hands-on *[activities]* instead of just talking and writing.” (Student 6)
>
> “It was really fun. I could learn more when I was interacting with everything.” (Student 17)

It seems that the student-centered nature of the construction task resonated with these students, as they were positioned as active participants in the learning process, physically interacting with the craft materials provided to them to represent what would otherwise be abstract geological concepts and processes.

Exercising creativity. For a smaller number of students (*n* = 4), the creativity afforded by the slowmation construction process sparked their interest. As one student explained at interview, “*[we]* got to do something more creative than just writing something” (Student 12). Student 2, who described the construction process as “fun and interesting and very creative”, identified the inclusion of photography in learning science as a particularly creative aspect, while another student identified that the open-endedness of the task "let everyone stretch their creative muscles" (Student 7):

Researcher:	Can you tell me about your experience making a slowmation about plate tectonics?
Student 7:	I really enjoyed it. It was fun. It's something I would really like to do again.
Researcher:	Was there something specific that you thought was fun about the *[construction]* process?
Student 7:	I think it was the planning ... and ... how creative you could be with it. It was really limitless what you could do. I like the freedom of it. I think it really let everyone stretch their creative muscles and let us do something we wouldn't normally do.

Working collectively. The social nature of the slowmation construction process, which students carried out in pairs or groups of three, was identified by two students as a source of interest as they recalled their learning experiences at interview. For Student 1, constructing a slowmation enabled her to work with different students in her class; an opportunity to collaborate socially: "It was a good time to make new friends. I got to talk to them *[the other group members]* ... and learn who they are". Student 6, on the other hand, appreciated the opportunity to watch his peer's slowmations about other types of tectonic plate boundaries: "… it was good watching everyone' else's [*slowmation*]". While this student did not elaborate on this sentiment, it may be that he enjoyed seeing the final product of everyone's work, or learning about different tectonic plate boundaries.

Engaging with technology. For two students, the technology-enhanced nature of the slowmation construction process (i.e., using the *MyCreate*™ application to create the stop-motion animation effect) ignited their interest in learning. At interview, Student 5 explained, "It *[the slowmation construction process]* was interesting, I guess. I wanted to know how to make that sort of thing *[a stop-motion animation]* for a while, because I've seen a few on YouTube™".

The most memorable part of the construction process for this student was "... the *[MyCreate™]* program and trying it out". Likewise, for Student 13, the most memorable part of the study was "learning about the animation techniques". This student enjoyed using the application to the extent that he completed additional work on his slowmation outside of class time: "I did some ... at home, too" (Student 13).

Discussion

In light of well-documented concerns about school students' disinterest and difficulty in learning about geology, and given that there are strong links between interest and learning, this study examined the extent to which students' participation in the construction of a slowmation developed their interest towards learning science and geology. In seeking answers to the research questions articulated earlier in this article, data on students' interest development were generated from students' responses to the SILS survey, pre- and post-intervention, and interviews with students about aspects of the project that they attributed to developing their interest.

The quantitative analyses of the SILS survey data provided evidence to support the claim that students who constructed a slowmation demonstrated a statistically significant increase in their triggered-SI, maintained-SI-feeling, and individual interest in learning science and geology. Moderate effect sizes were observed in each case, the largest being students' individual interest in learning geology (d = 0.59), which represents the greatest improvement from pre- to post-intervention. No change was observed in students' maintained-SI-value in our study. It is to be noted that maintained-SI-value concerns students' perceptions of the relevance and importance, of, in this case, the geological content that they were learning. Given that the *importance* of learning about plate tectonics (e.g., links to natural hazards such as volcanoes and earthquakes, and the implications for people's lives) was not examined in the unit of work in either the intervention or teaching as usual classes, it is perhaps unsurprising that students did not develop an explicit interest in the relevance of the science that they were learning.

For students who experienced teaching as usual, analyses of the SILS survey data revealed lower levels of interest by the end of the study, including statistically significant decreases in their triggered-SI and maintained-SI-feeling. This finding seemingly supports existing concerns within the literature about how geology is traditionally taught, and the implications for students' declining interest (Hetherington, 2010). Our findings suggest that the regular program of instruction may have deteriorated further students' already low interest in learning geology, and speaks to the need for further research about how to engage students in learning about Earth's physical systems, including fundamental geological processes like plate tectonics.

Qualitative analysis of student interviews provided evidence to support and explain the findings from the SILS survey drawn from the slowmation intervention groups, by illuminating their perceptions of the most enjoyable aspects. Although students seemed to experience difficulty articulating their views during interviews, and their responses to the interview questions were limited at times, the themes distilled from this data are important because they make an original contribution to the literature with regards to the motivational affordances of slowmation. The most salient theme to emerge from the data was the active, hands-on learning associated with constructing a slowmation, which was identified by all 17 students in the intervention group who were interviewed. While students reported that they were accustomed to reading, listening to the teacher, and writing in science, the slowmation construction process afforded opportunities to be active participants in the learning process, as they physically constructed, manipulated, and photographed two or three-dimensional models of their chosen tectonic plate boundaries. Three other aspects of the project that engaged students' interest were exercising creativity, working collectively, and engaging with technology. While these aspects were identified by much smaller numbers of students, they nonetheless identify how a representational task like constructing a slowmation can engage diverse learners with a range of interests in learning about science and geology, and are important given the lack of empirical research about the motivational affordances of slowmation for student learning. Students reported that they enjoyed exercising their creativity while learning alongside their peers (cf. Paige et al., 2016), while two students identified an interest in using stop-motion animation technology. For Student 5, this was a pre-existing interest in the technology arising from watching *YouTube*™ videos. This particular finding is of significance and may suggest that, unlike most of the other students, Student 5 found the construction process meaningful in a way that exceeded an immediate attentional and affective reaction. Collectively, the findings that arose from the analysis of the interview data suggest that students engaged positively with the slowmation construction process because they enjoyed learning science differently.

While these findings alone are significant in the context of identifying effective instructional approaches that develop students' interest in learning about science and geology, they also speak to the importance of the early attentional and affective phases of interest development in mediating subsequent phases of interest development for middle school students. A somewhat unexpected finding in the current study provides evidence to support our third claim that students' heightened individual interest in learning science and geology emerged from the early attentional and affective phases of their interest development (i.e., their triggered-SI and maintained-SI-feeling), rather than through a meaningful connection to the geological subject matter (i.e., maintained-SI-value). It was found that students' mean response scores from pre- to post-intervention for triggered-SI and maintained-SI-feeling increased significantly alongside their scores for individual interest in learning science and geology; however, students' scores for maintained-SI-feeling did not change. According to the four-phase model of interest development (Hidi & Renninger, 2006), it could be argued that the slowmation construction process developed students' interest across Phases 1 and 2 of the model, as their attentional and affective interest was stimulated and maintained throughout the duration of the project. This is also supported by students' comments at interview, as when examining closely students' recollections of the slowmation construction process, it seems that they were largely immediate attentional and affective responses, characteristic of the initial phases of interest development. Typical comments at interview, for instance, described the construction process as "fun and interesting and very creative" (Student 2). This is in contrast to their perceptions of the actual geological subject matter as being relevant and important or meaningful to their lives outside the classroom. This did not arise as a perceived source of student interest in the current study, and did not appear to influence students' individual interest.

The importance of the early attentional and affective phases of situational interest, and their apparent direct relationship to individual interest in the current study, supports and extends other emerging research on student interest in science education. Palmer and his colleagues (2017), for example, recently examined interest development in science preservice teacher education, and demonstrated that a rich variety of stimulating experiences, encompassing demonstrations, hands-on activities, fun facts, and science games, were perceived by preservice teachers as bringing about both situational and (emerging) individual interest in science. Likewise, Rotgans and Schmidt (2017) demonstrated that elementary school students' repeated engagement with problem-based learning scenarios in science, which triggered their interest in learning, contributed to the growth of their individual interest in the specific science content. The current study contributes to this growing body of literature and emphasises the importance of triggered-SI and maintained-SI-feeling in developing individual interest, and challenges long-held assumptions that students need a meaningful connection to the subject matter itself in order to develop an individual or topic interest.

The sources of students' situational interest in this study appear to be consistent with previous research findings. Given that students in the current study recalled their interest and enjoyment learning science in an active, hands-on and collective manner, the *novelty* and *student involvement* aspects of the slowmation construction processes are likely to have contributed substantially to their interest development (see also Jack & Lin, 2014; Palmer et al., 2016). More specifically, students' feelings of novelty appeared to stem from their participation in a learning experience that they would not usually encounter in a classroom setting (e.g., *It was really fun doing something different* [Student 9]) and from the student choice and autonomy (e.g., *I really enjoyed it ... It was really limitless what you could do* [Student 7]). Students' feelings of involvement appeared to stem from the hands-on, practical nature of the construction process (e.g., *I enjoyed making the props for the slowmation because it was hands-on* [Student 15]) and from the social component (e.g., *It was really fun watching everyone else's [slowmation]* [Student 6]). These findings demonstrate the value of slowmation for engaging students in learning science and geology, and offer a greater understanding about the motivational affordances of slowmation than what is currently offered in the literature. As such, we offer empirical data to support anecdotal evidence from early studies about preservice teachers' positive experiences learning science through this type of instruction (e.g. Hoban & Nielsen, 2012; Paige et al., 2016).

While there were significant improvements in students' interest over the course of the study that can be attributed to aspects of the slowmation construction process, it is notable that students' mean scores on the SILS survey at the conclusion of the study represent only low-moderate levels of interest in learning about science and geology. This means that despite participating in what students' perceived to be an engaging instructional approach, their interest in learning about science and geology remained modest. It is essential, therefore, that students are provided with repeated opportunities to engage in science learning experiences that trigger and maintain their interest, as suggested in the four-phase model of interested development (Hidi & Renninger, 2006), and that future research gives consideration to the longitudinal development of student interest in science disciplines like geology where low student interest is of concern.

Although the immediate focus of the current study was not on the association between students' interest and learning, this notion emerged repeatedly during the student interviews, and is worthy of discussion. At interview, many students articulated the belief that "... it *[slowmation]* helps you understand it *[the science content]* more" (Student 3). When invited to explain this sentiment further at interview, Student 12 explained that, "If I learn something and it's boring, it just goes out of my brain; but if it's fun, I think about what I learnt". While this may seem unsurprising given that the rationale for the current study is underpinned by the well-evidenced relationship between student interest and learning, comments like this provide information about the exact nature of this relationship, which has not been explicated well in widely used models of interest development, including Hidi and Renninger's (2006) four-phase model. Many students in the current study strongly associated the initial stages of interest development (i.e., triggered-SI and maintained-SI-feeling) with their learning (e.g., *It was more ... interesting for me to make stuff, and [it] taught me more* [Student 4]), which suggests that activating students' early stages of interest development was sufficient for substantial learning to occur (see Mills et al., under review for data pertaining to the student learning outcomes of the present study). This is in contrast to the viewpoint that later stages of interest development (i.e., maintained-SI-value, emerging individual interest, and well-development individual interest) are more closely associated with learning, due to greater positive dispositions towards, and self-regulatory engagement with, the content. It seems that further research about the specific nature of the interplay between interest and learning is needed, as long-held assumptions are being challenged by new findings such as these.

Concluding Remarks

The research findings herein present empirical evidence about the relationship between situational and individual interest, and their development during the slowmation construction process. This is important in the context of the current study, as it extends to middle school students' interest in learning geology, which is a sorely underrepresented discipline in science education research. While further research about the relationship between early and subsequent stages of interest development is needed, the findings of the current study suggest that the use of innovative and student-centered instructional methods like slowmation can lead to the generation and development of students' positive dispositions towards learning science and geology, and by extension, the possibility of greater learning related outcomes in these disciplines.

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