The Impact of Teacher Interest-Led Inquiry on the Student Learning Experience

Toby Russo
Victorian Department of Education
<russo.toby.t@edumail.vic.gov.au>

James Russo
Monash University
<james.russo@monash.edu>

Building on recent research into the importance of positive teacher emotions for student learning experiences, the current study involved five upper primary teachers at a Victorian government school developing integrated mathematics units built around topic areas of personal interest or passion. Respective students (n=88) elected to participate in one of five structured inquires developed by these teachers. Participation was associated with increases in students' intrinsic motivation to learn mathematics. Students attributed positive evaluations to the opportunity to learn mathematics in a context in which they were personally engaged. Possible future research directions are discussed.

Recently, there has been burgeoning research interest in understanding both the causes and consequences of positive emotions experienced by teachers, particularly in mathematics classrooms (Jacobs, Frenzel, & Stephens, 2017). One potential cause of positive teacher emotions might be in providing teachers with greater autonomy over the context through which they design learning experiences in core instructional areas, such as mathematics. The Teacher Interest-Led Inquiry (TILI) program is an approach to the teaching of mathematics focused on teachers developing an integrated unit of mathematical inquiry connected to an identified topic of personal interest or passion. The TILI program was implemented by a team of five teachers at a Victorian primary school with respective Year 5/6 students each participating in one of the five 'electives'. The TILI program incorporated teacher interests, an element of student choice and an inquiry-based pedagogical approach. The purpose of the current paper is to explore the impact of TILI on the student learning experience.

Background Literature

Banchi and Bell (2008) identify four levels of inquiry based learning: confirmation inquiry, structured inquiry, guided inquiry and open inquiry. Structured inquiry involves the teacher providing the topic, catalyst questions, and scaffolding the approach students are expected to take. Students analyse and interpret the data collected, and collate and synthesise their findings. A comprehensive meta-analysis comparing assisted discovery-based learning, incorporating structured inquiry, found that this pedagogical approach had more positive impacts on student learning outcomes when compared with explicit instruction and unassisted discovery-based learning – including within mathematics education (Alfieri, Brooks, & Aldrich, 2011). Moreover, inquiry-based learning more generally has been linked to a range of affective student outcomes, including positive attitudes towards academic subjects, self-efficacy, and intrinsic motivation (Saunders-Stewart, Gyles, & Shore, 2012). The program outlined in this study, TILI, is an example of a structured inquiry approach. Specifically, teachers determined the mathematical content to be learnt, an authentic context to support this learning, and provided structured investigations for students to explore.

The key idea behind TILI is to harness teacher passion for an authentic topic of interest (e.g. dance), described by Kunter, Frenzel, Nagy, Baumert, and Pekrun (2011) as "topic-related affective orientation" (p. 290). Research into the potential value of teaching mathematics thematically is not new (e.g., Handal & Bobis, 2004), however we could not

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identify any prior research specifically examining the benefits of building thematic units around topics of teacher interest and passion. We argue that the development and delivery of mathematical learning experiences around an area of interest can be expected to promote positive emotional responses for the teacher, in particular, high levels of enjoyment. Research indicates that teacher enjoyment can enhance the student learning experience, motivate teachers to improve instruction, and reduce teacher burnout (Frenzel et al., 2016). Moreover, teachers who are more enthusiastic about teaching mathematics have been shown to demonstrate higher quality instructional practice (Kunter et al., 2008).

With regards to its impact on students, teacher enjoyment of teaching mathematics has been demonstrated to be related to student enjoyment of learning mathematics, with this relationship mediated by the level of enthusiasm displayed by the teacher (Frenzel, Goetz, Ludtke, Pekrun, & Sutton, 2009). In order to explore the reciprocal relationship between teacher and student enjoyment, Frenzel et al. (2018) followed 69 middle and high school teachers and their students across several disciplines, including mathematics, for a six month period. It was revealed that teacher enjoyment at the beginning of the school year was positively associated with student perceptions of teachers' enthusiasm for teaching, as well as student enjoyment, halfway through the school year.

This body of research might imply that teaching mathematics through a context or activity that a teacher is passionate about could impact student enjoyment of learning mathematics. The suggestion is that allowing teachers to connect the content of their lessons to an area of passion is likely to lead to teachers both enjoying these lessons, and presenting these lessons enthusiastically. Given the conceptual overlap between enjoyment and intrinsic motivation (Amabile, Hill, Hennessey, & Tighe, 1994), it can be postulated that experiencing mathematics taught in this manner might result in higher levels of intrinsic motivation to learn mathematics amongst students. Intrinsic motivation to learn mathematics is an important goal in and of itself, and has also been shown to be positively associated with mathematical performance (Güvendir, 2016; Thomson, De Bortoli, & Buckley, 2014).

In the spirit of a designed-based research approach, this research literature can be synthesised with the professional knowledge and context of the researchers to develop a local instruction theory (Gravemeijer & Cobb, 2006). Our theory is summarised in Figure 1.

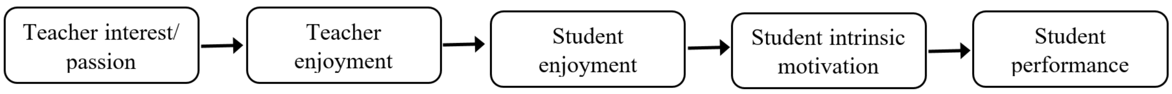

Figure 1. Local instruction theory informing development of the TILI program.

The purpose of the current paper is to explore the student experience of participating in TILI. The specific research questions that will be addressed are:

1. To what extent did participation in the TILI program improve the study school students' intrinsic motivation to learn mathematics?
2. What factors did study school students identify as being responsible for their positive experience of the TILI program?

Method

Participants

Participants were Year 5 and 6 (11 & 12y/o) students (n = 88) who attended a relatively socio-economically advantaged government-run primary school in Victoria, Australia (507 total student enrolments). The school's Index of Community Socio-Educational Advantage (ICSEA) was 1154, with 69% of students' families distributed in the top quartile of the Australian population on this measure.

Measures

Intrinsic motivation can be defined as the "desire to engage in behaviours for no reason other than sheer enjoyment, challenge, pleasure, or interest" (Lepper, Corpus, & Iyengar, 2005, p. 184). Intrinsic motivation to learn mathematics was operationalised through incorporating the measure included in the Programme for International Student Assessment (PISA) 2012 study (Thomson et al., 2014). Items were measured on 4-point likert scales, as per the PISA study. Students were asked, "Thinking about your views on maths: to what extent do you agree with the following statements: Strongly Agree (4), Agree (3), Disagree (2), Strongly Disagree (1)?". Items included: I enjoy reading about maths; I look forward to my maths lessons; I do maths because I enjoy it; and I am interested in the things I learn in maths. Scores on this instrument range from 4 to 16. Cronbach Alpha on the two administrations was acceptable-to-good (α=0.76 and 0.84).

Procedure

The first stage in development of the TILI program was for the five participating teachers to independently consider areas of interest or passion from which they might develop a unit of mathematical learning. Teachers brought their ideas together at a planning day. Led by one of the participating teachers (the first author), they workshopped their ideas and began to connect teaching and learning activities to their chosen themes (within the context of the curriculum). Teachers then worked independently to finalise a unit of work around their chosen theme. Themes included: basketball, dance, robotics, space and zoos.

Participating students were then invited to complete a pre-TILI questionnaire. In addition to the intrinsic motivation to learn mathematics measure, this questionnaire described each unit and gave students an opportunity to elect their preferred unit from the options provided by the teachers (86% of students participated in their first choice, 14% their second choice). The primary purpose of presenting TILI units as student electives pooled across five classes was to free-up teachers to choose their theme of interest independently of what they anticipated to be acceptable to students in their own classrooms. For example, a teacher may have been reluctant to choose dance as an integrated topic if they anticipated strong negative reactions from a group of students in their classroom.

Students participated in their TILI group over a five week period: three sessions per week for a total of 15 sessions. At the completion of the unit, students completed a post-TILI program questionnaire, which revisited their intrinsic motivation to learn mathematics, framed in the context of their learning during the TILI group. The questionnaire also contained some qualitative items. All grade 5 and 6 students participated in TILI (n=115), with 88 students completing both the pre and post questionnaires due to a range of practical, school-related issues (e.g., student absenteeism, extra-curricula commitments).

Data was analysed using mixed methods. Quantitative data was analysed using SPSS Statistics (v25).[1] Qualitative student questionnaire data was analysed thematically.

Results

Overall Impact of TILI on intrinsic motivation to learn mathematics

A mixed-design analysis of variance was undertaken, with intrinsic motivation to learn mathematics before and after the TILI program included as the within-subjects factor, and gender included as a between-subject factor. There was a significant difference between pre-TILI (M=9.50, SD=2.66) and post-TILI (M=10.39, SD=2.43) student levels of intrinsic motivation to learn mathematics; $F(1, 86) = 11.01$, $p < 0.01$. The effect size for this analysis was medium (partial $\eta 2 = 0.113$). Gender was not associated with changes in intrinsic motivation $F(1, 86) = 0.056$, $p > 0.05$. Participating in TILI positively impacted student intrinsic motivation to learn mathematics equally for males and females (see Figure 2).

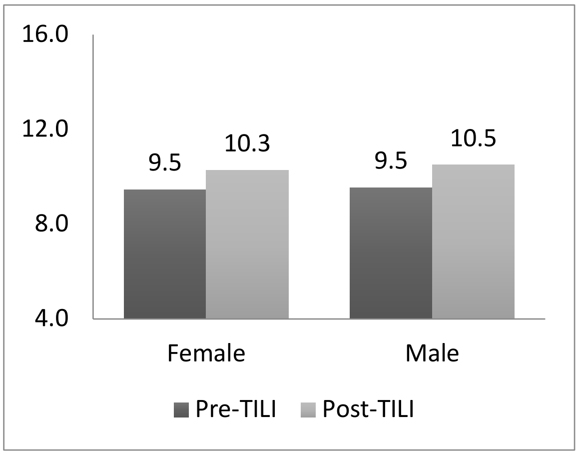

Figure 2. Pre and Post TILI Program intrinsic motivation to learn mathematics by gender.

A breakdown of student responses to individual items from the intrinsic motivation to learn mathematics scale indicates a positive impact on student attitudes across all items (see Table 1). The greatest impact of the TILI program was on whether students look forward to maths lessons; with 72% of post-TILI students providing a positive response to this question (agreed or strongly agreed), up from 50% of the pre-TILI group. Notably only 2 respondents post-TILI ‘strongly disagreed’ with this question, down from 9 pre-TILI.

Part of the motivation of the TILI program were teacher perceptions of negative student attitudes towards mathematics, with teachers extrapolating from Attitudes to School Survey data as well as anecdotal evidence (e.g., groans and negative comments from students at the beginning of mathematics lessons). Indeed, levels of intrinsic motivation to learn mathematics were similar for the upper primary participants from the current study to that of middle-secondary students in Australia participating in the PISA study. For example, 45% of 15 year old Australian students (Year 9, 10 & 11) agreed or strongly agreed with the statement “I look forward to my mathematics lessons” (Thomson et al., 2014), compared with 50% of students in the current study pre-TILI. By contrast, the equivalent percentage for Year 1 and 2 students from a Victorian school in the Russo (2017) study was 92%.

[1] Results of the evaluation of the assumptions of normality, independence, linearity, homogeneity of variance, sphericity and homogeneity of intercorrelations were satisfactory for all analyses.

Consequently, it seems that, at least prior to TILI, the current cohort of students held attitudes towards mathematics more similar to students in middle secondary school than early primary school. It is worth noting that this decline in intrinsic motivation to learn mathematics as students progress in their schooling is consistent with prior research (Lepper et al., 2005).

Table 1

Pre and Post TILI Program intrinsic motivation to learn mathematics by item

	I look forward to my maths lessons	I do maths because I enjoy it	I am interested in the things I learn in maths	I enjoy reading about maths
Pre-TILI				
Strongly agree	10%	11%	10%	3%
Agree	40%	27%	50%	19%
Disagree	40%	44%	32%	56%
Strongly disagree	10%	17%	8%	22%
Post TILI				
Strongly agree	16%	14%	17%	6%
Agree	56%	39%	56%	27%
Disagree	26%	38%	23%	41%
Strongly disagree	2%	10%	5%	26%

TILI Compared to Other Learning Approaches

In addition to the TILI program, this student cohort had exposure to varied approaches to mathematical learning. The approaches can be broadly defined as:

- Fluid groupings, with students organised by readiness-to-learn levels across different number concepts (three hours per week, except during the TILI program).
- TILI Program, which ran for five weeks for approximately three hours per week (replacing fluid groupings in the timetable).
- In class mathematics learning, with students exploring applied mathematical concepts in mixed groups in their own classrooms (two hours per week throughout the year; continued throughout the TILI program).

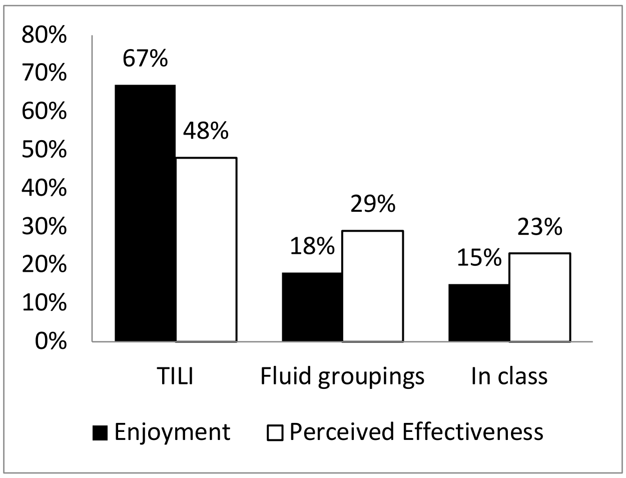

Figure 3. Enjoyment and perceived effectiveness of different learning approaches.

Following the TILI program, participants were asked which approach they enjoyed the most as well as which was most effective for their learning. Two thirds of students indicated that they enjoyed the TILI program more than other learning approaches, while almost half (48%) found the TILI program to be most effective for their learning (see Figure 3).

Student Reflections on the TILI Program

As part of the post-program questionnaire students were asked what they most enjoyed about their TILI maths unit and why. Six distinct themes emerged from a thematic analysis of student response data: *learning context, connecting mathematics, choice, social, novelty, and skill/ knowledge development.*[2] Table 2 collates the number of student responses categorised to each of these themes. The three most frequently occurring themes are elaborated on below, with exemplary student quotes provided.

Table 2
Summary of the analysis of student responses describing why they enjoyed TILI

Theme	Number of respondents	Percentage of respondents
Learning Context	57	69%
Connecting Mathematics	19	23%
Choice	10	12%
Social	8	10%
Novelty	6	7%
Skills/Knowledge Development	6	7%
Generic Positive	3	4%

Note: n=83; 5 students did not respond to this question. Some responses were coded to more than one theme.

In response to this question, most students (69%) explicitly mentioned the context in which the learning took place and/or specific learning activities undertaken within the unit of work. For example, one student (S1) enjoyed "designing the (zoo) enclosure and finding out how big it had to be and making it unique" while another (S2) enjoyed "making dance routines with different angles". It is worth noting that responses coded to this category were often brief and highly concrete, for example, "I got to use robots" (S3), or "Playing basketball" (S4).

Approximately one-quarter of students (23%) explained their enjoyment by emphasising the value in connecting mathematical learning to their personal interests. Students highlighted the impact of these connections on both their level of engagement and learning. For example "I enjoyed doing a subject while doing another subject, it made it more fun and (led to) more understanding" (S5) and "You got to have fun and learn about maths and your interest at the same time" (S6). On occasion, students discussed connecting mathematics in the context of making mathematical learning more authentic: "It was more fun because we got to have a chance to use the maths we learn in a real life activity" (S7) and "I liked doing maths problems based on real data and my own interests" (S8). For some students, negative attitudes towards mathematics were counterbalanced by positive attitudes towards the learning context: "You could have fun doing maths because it was hidden by your passion" (S9), and "I love dance, so incorporating (it) into something I don't exactly like makes maths fun" (S10).

As mentioned earlier, students were given an opportunity to choose which TILI group they would like to participate in. This aspect of choice was explicitly mentioned by 12% of students as a factor relating to their enjoyment. An indicative comment by a student was that they enjoyed "the freedom to choose a topic you wanted to learn about" (S11). Another stated "I enjoyed the choice involved because normally you do what you're told" (S12).

[2] Note also that some students (n=4) provided negative comments about the program, whilst a small number of students (n=3) made generic positive comments that were not further classifiable.

Discussion and Conclusions

The current study examined how participating in an integrated unit of mathematical work developed by a teacher with a strong interest in the context through which the mathematics is being explored impacted the student learning experience. Our local instruction theory assumed that creating and delivering interest-based units of work would allow teachers to experience greater enjoyment when teaching mathematics, by allowing teachers to introduce mathematical content through a topic area in which they were highly passionate.

With regards to the first research question, there was evidence that participating in TILI improved student participants' intrinsic motivation to learn mathematics. Both male and female students experienced similar improvements, with a particularly notable increase in the percentage of students who looked forward to their mathematics lessons post-TILI (50% to 72%). In addition, two-thirds of students most enjoyed learning mathematics through the TILI program, when compared with the two other approaches (i.e., fluid groups and in-class mathematics learning). These findings are consistent with prior research suggesting that student enjoyment of learning mathematics is related to teacher enjoyment of teaching mathematics, when this teacher enjoyment manifests as outwardly expressed enthusiasm towards the subject (Frenzel et al., 2009; Frenzel et al., 2018).

The second research question examined what in particular students enjoyed about participating in the TILI program. Three notable themes to emerge were: students enjoying the learning context, including specific learning activities; students valuing the opportunity to connect mathematics to an area of personal interest or passion; and the importance of allowing students to choose which TILI unit to participate in.

It is notable that the central themes that emerged explaining why students enjoyed the TILI program reflected our working hypothesis as to why we thought teachers might benefit from involvement in TILI in the first instance. We proposed that providing teachers with the autonomy and freedom to plan a mathematics unit around a topic of interest would enhance their enjoyment of teaching mathematics. Interestingly, rather than noting that they benefited from the teacher displaying more positive emotions, students perceived that participating in TILI directly conferred these benefits to them. This may reflect the fact that there was overlap in teacher and student interest in particular topics (e.g., basketball, dance, robotics). It is likely also a consequence of student choice and inquiry-based learning being additional mechanisms explicitly built into the TILI program, both of which have been associated with improved student intrinsic motivation (Patall, Cooper, & Robinson, 2008; Saunders-Stewart et al., 2012). This is not to say that students did not perceive that they benefitted from having a teacher who was teaching mathematics with greater enthusiasm and passion, as we did not probe this issue directly in the post-TILI questionnaire. It is worth noting that the impact of the TILI program on the experience of teachers, including interactions between the level of teacher passion displayed and changes in student intrinsic motivation to learn mathematics, will be explored in a subsequent paper.

To further tease out other possible mechanisms for TILI's positive impact, future research might consider two additional aspects. First, it could examine the importance of shared interest in the topic between teacher and students through systematically accounting for how interested students were in the teacher's chosen topic. Secondly, it could account for the role of student choice in the model through examining whether, for example, doing TILI with your classroom teacher generated smaller gains in intrinsic motivation to learn mathematics than choosing a preferred TILI unit from a suite of alternatives.

Finally, we will conclude this paper with an anecdote that further supports the potential of this type of approach to learning mathematics. A Year 6 student was interviewed by their prospective secondary school principal as part of a transition program and relayed his response to the question: “What would you want your learning to look like in Year 7?”. The student’s response: “I wish we could learn maths like we did in the basketball unit. The teacher made this so fun and interesting; and we learnt a lot!”

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