

REMSTEP project activity report: Monash University Maths Videos

The Faculties of Education and Science at Monash University have collaborated to undertake three very different REMSTEP projects initiatives. This report focuses on the evaluation of 3 videos about the nature of contemporary mathematics and how to incorporate this in to secondary school mathematics education.

Project overview

- Project name: **Maths Videos**
- **Who was involved?**

Project leaders:

- Dr Rebecca Cooper
- Dr Norman Do

Project Coordinators:

- Joanne Burke
- Lisa Fazio
- Dr Matt Hall

Project contributors:

- Professor Deborah Corrigan
- Greg Lancaster
- Maggie Lowe Productions
- Dr Kelly-Anne Twist

- **What was done (in broad terms)?**

A series of 3 short videos about mathematics for pre-service (PSTs) and in-service teachers (ISTs) was produced accompanied by educational tasks to challenge the viewer's notions about mathematics in the classroom. The videos are designed to a) inspire PSTs and ISTs to think of mathematics as a beautiful, creative and relevant discipline b) provide them with ideas and activities for use in the classroom. The project was a collaboration between the Faculties of Education and Science.

Project rationale: what is the intention?

- **Is there a theoretical basis or model, or literature that informed the project?**

The rational underpinning this mathematics video project is the need for PSTs to broaden their awareness of contemporary mathematics and to use this to inform their teaching practice to make mathematics learning more meaningful. Research into mathematics education shows there is more to mathematics than an accumulation of rote facts and

algorithms (Cobb, 2000). Whilst procedural fluency is a goal of mathematics education, 'mathematics has its own value and beauty and it is intended that students will appreciate the elegance and power of mathematical thinking, [and] experience mathematics as enjoyable' (ACARA, 2009, p.5). The videos made in this project provide examples of where contemporary mathematical ideas are relevant in other disciplines and in real life contexts. The associated activities give PSTs and ISTs the opportunity to consider these connections to promote deep thinking and learning in the maths classroom (Frykholm & Glasson, 2005). In addition, Sullivan (2011) states that using students' familiarity with a social context when teaching mathematics can also lead to greater student engagement with the mathematics and a greater disposition to continue to learn mathematics.

- **What gaps do you see are addressed with this project?**

The vast majority of resources currently available for mathematics teachers are aimed at the mechanics of teaching or the mechanics of mathematics. The primary goal of this project was to produce content that showcases the nature and beauty of mathematics. The resources are aimed for teachers looking to appreciate the concepts, philosophy, and attitudes of mathematics. More concretely, they will provide them with inspiration for classroom activities that deal with the ideas, rather than the technical aspects, of mathematics.

Project activities

- **What was the nature of the activities – provide examples.**

The three videos have been produced for the engagement of PSTs and ISTs.

Each video begins with an introduction by a teacher educator, Rebecca Cooper, describing the educational purpose of the videos. Mathematics lecturer, Norman Do, then introduces the maths content with links to real life examples to be considered by the audience.

The videos are accompanied by questions designed to stimulate and challenge the PST and IST's thinking and current practices in maths education.

- **What was the nature of engagement of PSTs or teachers with contemporary science/mathematics practices?**

The three produced videos are: Video 1: Parabolas, Video 2: Fractals, Video 3: Knots. These topics are not necessarily part of the Australian Curriculum; however, they demonstrate how aspects of mathematics occur in a range of interesting, real life situations. It is our intention to have PSTs and ISTs consider mathematics through a different lense in an effort to broaden their approach to teaching maths to include more contemporary mathematical ideas.

- **What aspects of science/mathematics practice were represented to the PSTs?
How was this orchestrated?**

Maths lecturer Norm Do presented all three videos to a script, devised along with education lecturer Rebecca Cooper. Aside from communicating mathematical concepts clearly and imaginatively, the following requirements occurred:

1. Three segmented videos, between ten and twenty minutes in length.
2. The videos and accompanying questions challenge traditional maths education methods of teaching and traditional views of maths.
3. Whilst the videos and the accompanying resources are aimed at PST and IST maths teachers, the videos are presented in such a way that they can also be used as visual stimuli for students in maths classes.

- **In what sense do you regard this as innovative or significant?**

Our videos are innovative because they are made by a highly regarded mathematician who has a strong focus on student engagement and learning of mathematics. Further, they are innovative because they are intentionally shifting the focus of learning mathematics from being firmly centred on completing problems using algorithms and formula to being strongly focused on capturing the nature of mathematics and the possibilities it unveils.

- **What changed curriculum / classroom practices are envisaged, flowing from the project? By what means were these changes supported?**

We would be hoping that teachers practice would become less about the mechanics and algorithms of mathematics and more about the nature, uses and beauty of mathematics. We would envisage more exploration, creativity and discussion to take place and for less time to be spent on completing exercises from a text book. These changes are supported through the selection of topics that do not link directly to specific aspects of the maths curriculum and focus on the nature of mathematics, where the links can be allowed to emerge rather than compelled.

- **What opportunities were there for science/mathematics students (undergrad or HDR) to reconceptualise their perceptions of school science or mathematics learning and teaching?**

We ran a workshop where these videos were shown to PST and IST maths teachers. The PST and IST maths teachers were given the opportunity to consider the ways they might make use of these videos to support their own teaching and learning as well as the teaching and learning of their students. The interactions with the videos as well as the interactions with each other provided an opportunity for the reconceptualisation of mathematics learning and teaching.

Results

Experience of participants

- **What was the experience of PSTs or science and mathematics students, school students, teachers, scientists, teacher educators?**

In order to evaluate the PSTs' and ISTs' experience of the videos and activities, data was collected at a workshop and through a follow-up online survey. At the workshop, PSTs and ISTs viewed the video on fractals and wrote responses to the accompanying questions. Facilitated by a teacher educator, group discussions about the responses were shared. Discussions were audiotaped, and an independent research assistant identified common themes. When the 3 videos were completed, workshop participants were sent a link to all 3 videos and questions and asked to complete a survey.

- **What evidence is available to identify the experience? (surveys, notes, video, etc?)**

The workshop focussed on one video, Fractals. There were three linked themes that resonated through the oral and written responses to the discussion questions:

1. ISTs (n=8) and PSTs (n=11) saw the value of using **fractals as an interesting "hook"** to engage students but they were not sure how to move beyond initiating interest.

PST(1) - "I would use this because it's an interesting/engaging way to show/introduce fractals"

PST(2) - "I have not, but will! Easy to introduce, very tangible. Good example of how simple ideas can become complex quickly."

PST(3) - "Yes, to teach about applying maths in the real world."

PST(4) - "I think one thing that this does is it expands what students think mathematics is about. Somehow people can get lost thinking it's only about this much when really there's a lot more going on. No one can ever say they know all mathematics that's for sure."

2. Initially, PSTs and ISTs did not see **links between the fractal videos and the curriculum** and wanted these made more explicit. The Fractals and Coastlines Paradox segment provided a more visual and 'hands on' example of fractals and seemed to shift ISTs perceptions of the relevance of fractals. After watching all four segments of the Fractals video, some ISTs and PSTs were able to identify related mathematical concepts: algorithmic thinking, Cartesian planes, conjecture test-prove "and" arithmetic, algebra, co-ordinate geometry and concepts of iteration.

IST(1) - "The problem is that [years] 11 and 12 are so packed full of content already,"

IST(2) - "If it is just going to be extended area of a problem then is there any value to doing it?"

PST(1) – “Students will have a deeper understanding of where the maths theory came about.”

PST(2) - “Math’s can be experimental: one thing that I thought the students could take from this was math’s actually involves experimentation and it is always sort of growing and changing which is really not something that is evident at all in the curriculum.”

3. ISTs & PSTs expressed concern that they **did not have sufficient understanding of fractals and were unsure whether students would understand or see their relevance**. This may have led to the conclusion that this would only be suitable for students strong in maths and motivated to rise to the challenge of this material. At this point teachers opened up about feeling unprepared to teach fractals as they did not have enough background knowledge themselves.

PST(1) - “Because the maths is perceived as being so complex you spend so much time doing the maths that you think “right, whenever I do that I write ‘f goes to h, or f goes to infinity’. That [video] is actually explaining this. And when I saw it, I thought “Ah, that’s what it meant the whole time!” >lots of agreement from others

PST(2) – “would prefer the topic to be explained/develop further. It seems to leave much up in the air – and as I do not know about it myself – I could not answer any questions from students.”

The survey responses provided the following insight:

1. After watching all 3 videos, all PSTs (n=4) and ISTs (n=4) agreed that they have learned some interesting mathematical concepts; they felt they had learned about current mathematical practices and that they had gained ideas for how to bring contemporary mathematical practices into the school curriculum. They all agreed that the ideas could be linked to the Australian Curriculum and that the ideas presented are useful for maths teachers’ education.

2. Most (7/8) thought that the videos had changed their perception of mathematicians in a positive way. The 4 ISTs felt that the videos had gained an understanding of how to communicate mathematical ideas to students. The videos also encouraged thinking and discussion about the nature of mathematics and how it can be connected to real contexts.

PST(1) – “I think these videos are a good inspiration to look for both more ‘artful’ representations of maths, and more authentic examples of how maths is used in the world outside of school.”

PST(2) – “I think they give the larger context of mathematics. I found the knots video most relevant as it clearly connects to the Biology curriculum (DNA) and the picture-hanging puzzle connects to the Year 9 math curriculum for algebra. I found the Surfaces video most difficult to understand. Whilst I followed the general idea, I think the concepts of no volume but infinite surface area are too difficult for me to conceptualise let alone teach to students. The parabolas video was also very useful...”

Project outputs

- **What resources were produced and what is their quality (and where can they be found)?**

The videos and questions can be found at Monash Science Education Research Group website: <http://monash.edu/scienceeducation/category/resources/>

- ReMSTEP Maths – Knots
- ReMSTEP Maths – Fractals
- ReMSTEP Maths - Parabolas

- **What understandings or models have resulted, concerning how to engage PSTs with contemporary science and mathematics practice?**

These videos are visually engaging and they explore mathematics through the lenses of history, arts, sciences and as a human endeavour. The videos challenge PSTs to look beyond the mechanics of mathematics and to consider how this added dimension could affect the learners in their classroom.

Project outcomes: What were the outcomes for the different players?

- **Is there evidence of a cultural shift in the way education and science faculty staff inter-relate as a result of this project?**

Initially there was concern by individuals about collaborating with the other faculty, particularly in regards to different approaches and opinions held towards education. The faculty staff however, found the experience to be positive. The regular face-to-face meetings aided this where relationships of trust and good communication developed. Acknowledgement of the strengths each individual brought to the project was also important; the educational aims were quite distinct and needed for the mathematician to put together something that may appeal to educators and secondary students.

The team deliberately avoided working with specific topics of the secondary mathematics curriculum. We tried to engage with topics and ideas that were broad and inspirational. They were meant to show the work of mathematicians rather than exemplify the curriculum.

Staff from both faculties agreed that this project has certainly opened doors to further communication and collaboration between the Faculties in the future.

Maths Educator – “I learnt of the value in expanding the way we, as scientists, think about education.”

Teacher Educator – “Wow! Where to start!! I learnt a lot of maths (definitely about the applications of fractals and certainly about knots and what they can be applied to). ... I’ve learnt a great deal about the willingness of mathematics academics to consider their students learning in what they do, with respect the number of examples they feel they need, the clarity with which they explain concepts and their general desire to share maths...with a hint of fun!”

- **What have research scientists or mathematicians gained by participating in the REMSTEP project? Have their views about teaching and learning science and mathematics changed as a result of the project?**

There have already been some extremely positive outcomes that have arisen as a result of this collaboration. In particular, the teacher educator has now been involved in another project in the School of Mathematical Sciences. The aim of the new project is to promote discussion on teaching practice in tertiary mathematics education. The role played by the teacher educator is one of provocateur where she has posed questions and offered suggestions to get mathematics educators thinking about learning and teaching in mathematics but also about meta cognition, scaffolding, linking learning to assessment and giving learning purpose. Her presence there has already and will continue to make positive change to mathematics educators' teaching practice. We hope to have interesting educational research outcomes from this collaborative project.

- **What have science or mathematics undergraduate or HDR students gained by participating in the project? Is there evidence of a shift in science or mathematics students' perception of teaching as a worthwhile career path?**

NA. Science and mathematics students were not involved in this project.

- **What evidence is there of improved learning and engagement of PSTs, or of teachers, as a result of the project? What did PSTs learn about the nature of science, or how to incorporate science/mathematics practices into the curriculum?**

PSTs' thinking was pushed and their notions of the nature of mathematics and the purpose of mathematics education was stretched.

PST(1) – "I think these videos are a good inspiration to look for both more 'artful' representations of maths, and more authentic examples of how maths is used in the world outside of school."

PST(2) – "It shows another way to engage students so that PSTs don't just fall back on the way they were taught maths."

In response to what school students would think of this approach to maths:

PST(1) – "It shows students that maths relates to the real world around them. Makes it more interesting, rather than dry and boring. It helps them understand about applications of maths."

PST(2) – "Oh! Maths is very interesting. Good to know where graphic designing & pixels of pictures come from – I did not know that there is maths behind these."

- **What has been learnt about the efficacy of incorporating contemporary science/mathematics practices in the school curriculum? What evidence is there of improved learning and engagement of school students, as a result of the project?**

From the perspective of the mathematics and teacher educators, there are many opportunities to incorporate contemporary mathematics in the school curriculum. However, a reoccurring theme in the feedback from in-service maths teachers is the pressure they feel in 'getting through' an already crowded curriculum. There is definite interest from teachers in the ideas that were conveyed.

It is too early to evaluate the success of the project on improving school student engagement.

- **What principles can be taken from the project concerning processes for bringing contemporary science and mathematics research and development practices into teacher education?**

1. Interest and beauty are important, but: Beyond using contemporary ideas as promoting interest, teachers were unsure of how to build upon this in the classroom.

Recommendation: Pre-service teacher maths education could consider placing greater emphasis on working with and from student interest and provide ideas about how to make links to the curriculum and how to utilise student interest to build lessons and units.

2. Confidence and Knowledge: Teachers expressed concern that they did not have sufficient understanding of contemporary mathematical ideas and were unsure whether students would understand or see their relevance.

Yet, the teachers did not dwell on maths content but rather focused on soft skills suggesting, maths is important at school as it develops communication skills, logical thinking, creativity, numeracy.

Teachers were particularly animated about linking maths to creativity, problem-solving and inquiry.

Recommendation: Pre-service teacher maths education could consider placing greater emphasis on working with situations that make greater use of contemporary mathematics and deal with problems that are more realistic and provide students with greater opportunity for creativity and exploration. Perhaps some links between maths and science could be capitalised upon?

3. Contemporary mathematics vs. the curriculum: Initially, teachers did not see links between the mathematical ideas in the videos and the curriculum and wanted these made more explicit. However, after watching the whole video, some teachers were able to identify key maths areas.

Recommendation: Teachers need concrete examples just as much as students do and we believe that these videos are a step towards offering pre- and in-service teachers more concrete examples to support their learning as well as their students'.

Concluding discussion

Challenges

- **What was the nature of challenges to successful implementation?**

1. Initially the generation of ideas and the direction of the project developed smoothly as the project team met regularly each month. Face to face contact was important for this to occur. The project lost momentum after a few months when team members' attentions were redirected by other more pressing projects. This was made more difficult by the different physical locations of staff on campus as incidental meetings were less likely.

2. The actual recording process was far more difficult and time-consuming than we had expected. While speaking to a lecture theatre full of students is rather natural for me, looking down the barrel of a camera changes everything!

- **What changes were made, from which we can learn?**

1. Persistence in making time to meet was important to keep the project going and to ensure everyone was heading in the same direction. In the second year, monthly meetings were held over coffee. This environment allowed time for the staff members to develop relationships and a shared vision for the project outcomes. Discussions about mathematics, teaching, learning and education often went beyond the project and beliefs and values on these areas were shared and developed.

2. We were very fortunate that Maggie Lowe (video producer) who was so understanding and helpful during the process.

Mathematics educator – "I think that by the end, I was becoming more comfortable, although I think I have a newfound respect for actors!"

Impact

- **What is the short/medium term impact of the project (ongoing processes, commitments, existence of resources, over a 1-3 year projection)?**

The videos and questions for educators are free and publically available on the Monash Science Education Research Group webpage.

In the short term, the Maths Association of Victoria (MAV) are excited about their potential and are keen to promote the videos to secondary mathematics teachers. The resources would be useful to challenge PST and IST thinking and professional discussion about the nature of mathematics and how this is conveyed in the secondary mathematics classroom.

There is a possibility (and it has been requested by teachers in the focus groups) that more videos be added to the collection in the future. There has also been interest for the team to present the ideas on the speaking circuit.

- **What are the longer-term implications?**

The videos and questions for educators are free and publically available on the Monash Science Education Research Group webpage.

Sustainability

- **What has been learnt about processes for incorporating contemporary science and mathematics practices in teacher education?**

PSTs were excited by the videos and the discussions the questions generated. However, there are competing priorities in teacher education programs. Further critical discussions are needed with teacher educators about the importance of incorporating this perspective of mathematics into the mathematics methods units.

- **In what sense is the project sustainable?**

The project is sustainable as the videos and questions require no further funding input and are publically available on the website. Teacher educators from different universities are able to use the resources in their units as a whole program or in flexible delivery.

Scalability

- **What is the possibility of the project processes and outcomes being reproduced at scale?**

There are no limitations on the videos and questions catering for a larger number of PSTs or ISTs, regardless of their location. The questions make reference to the Australian and Victorian curriculum, but are relevant beyond these in educating mathematics teachers.

References:

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