How to make Mathematics relevant to first–year Engineering Students: Perceptions of Students on Student-produced Resources

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Many approaches to make mathematics relevant to first year engineering students have been described. These include teaching practical engineering applications, or close collaboration between engineering and mathematics teaching staff on unit design and teaching.

In this paper, we report on a novel approach where we gave higher year engineering and multi-media students the task to "make maths relevant" for first years. This approach is novel as we moved away from the traditional thinking that staff produce these resources to students, who have more recently undertaken first year mathematical study themselves but who can provide a more mature student perspective to the task than first year students, producing. Two higher year engineering students and three year multi-media students worked on this project over the Australian summer term and produced two animated videos showing where concepts taught in first year mathematics are applied by professional engineers. It is this student perspective on how to make maths relevant to first years that we are investigating further in this paper.

We analyse interviews with the higher year students as well as focus groups with first year students who had been shown the videos in class, with a focus on answering the following three research questions: 1) How would students demonstrate the relevance of mathematics in engineering; 2) What are first year students' views on the resources produced for them; and 3) Who should produce resources to demonstrate the relevance of mathematics?

There seemed to be some disagreement between first and final year students as to how the importance of mathematics should be demonstrated in a video. We therefore argue that it should ideally be a collaboration between higher year students and first year students, with advice from lecturers, to produce such resources.

Keywords: mathematics relevance, demonstration, first-year engineering, students as producers, inter-disciplinary collaboration, animated video

Subject classification code: 97M99, 97U80, 97C99

Introduction

First year mathematics study is often seen as irrelevant and distracting by engineering students who are more interested in applied engineering subjects. Many disengage for this reason and perform at lower levels in mathematics than they are capable of. This has consequences for students when they undertake higher year mathematics subjects given the hierarchical nature of mathematical study, where first year content is a prerequisite and it might be difficult to catch up on deficits accumulated throughout first year. Contributing to this issue is that mathematics is often taught in a "mathematical" way with a focus on mathematical concepts and understanding rather than applications. The applications are covered in later engineering studies.

In order to address first year engineering students' lack of understanding of the relevance of mathematics to their degree and later working life, we asked higher year engineering students to create multi-media artefacts to "make maths relevant". We teamed up these students with higher year multi-media students to assure a professional outcome. This pilot project, supported by summer term scholarships for students funded by the faculty, resulted in two animated videos showing how mathematics is used to plan and construct a building [1] and a car .[2] We set up a research study around this pilot for a deeper investigation into students as producers of maths relevance material for other students.

In this paper, we analyse interview data from the students who produced the resources, and focus group data from first year students for whom the videos had been produced. Through this qualitative research study, we gain insight into the student perspective on how they would demonstrate the relevance of mathematics to first years, how the first years perceive the videos, and we analyse the student view on who should produce resources to demonstrate the relevance of mathematics. We hope that this study will encourage others to research the contribution students can make to demonstrate the relevance of mathematics to engineering study.

Literature review

In this literature review, we first touch on the relevance of mathematics to engineering students and summarise how the relevance of mathematics has been demonstrated elsewhere. We then provide an overview of the literature on engaging students as co-producers of resources.

The relevance of mathematics to engineering students

Mathematicians "speak mathematics and not engineering", [3] which makes it at the same time more difficult and less important for them to relate the relevance of mathematical topics to engineering students. Pennell et al. [3] believe that students also face a similar problem in that they know there is a reason why they are taught the mathematics but they can't see this reason "until long after the courses have ended". To make matters worse, by the time the mathematics is needed they have forgotten much of it as it hasn't been used for a long time. Students can't see how the mathematics is relevant to their future engineering work and do not engage fully with the unit. The abstract nature of mathematics makes it challenging for the students to learn and for the lecturers to teach. While engineering educators have proposed changes to how mathematics should be taught to engineers, for example by having engineering lecturers teach the mathematics, by integrating mathematics and engineering better, or by changing the curriculum significantly, Cardella [4] suggests a move towards teaching "mathematical thinking". [5]

Two studies have investigated engineering students' perceptions of the relevance of mathematical studies in an Australian context. Coupland, Gardner and Carmody [6] find that higher year engineering students recognized the relevance of the mathematics for their engineering studies to a higher degree than students in first year. First year civil engineering students rated the relevance of mathematics lower than students from any other engineering discipline, while mechanical engineering students rated it highest. Flegg et al. [7] discover that when surveyed, students seemed to agree that mathematics is relevant to their future career and study, however in follow-up interviews it appeared that the understanding of the relevance of mathematics varied widely with some students seeing no relevance, in particular to their future workplace in the industry.

We agree with Flegg et al. [7] that "it is in the interest of both mathematics and engineering academics to understand how students view the relevance of mathematics to engineering", particularly since it cannot be assumed that students will make the link between this particular study area and its relevance, without additional assistance.

Demonstrating the relevance of mathematics

A variety of approaches and suggestions on how to demonstrate the relevance of mathematics to engineering students can be found in the literature. Most of these relate to the curriculum, particularly demonstrating engineering applications of the mathematics learnt. An extensive literature review on the integrated engineering curricula which also includes papers on how to engage students better in their mathematical studies may be found in [8].

Pennell et al. [3] studied five units taken by mechanical engineering students over five semesters, starting with a differential equations unit in the first semester. Students revisit the same project in all of these units, with different emphasis. While in the past the differential equations unit focused on techniques for generating solution formulas, this new approach changed the focus towards an engineering point of view where the system being modelled is the object of interest and understanding how the system reacts is the goal. In the mathematics unit students now study how to model two systems by a differential equation and then learn analytical techniques to find solutions to these systems. A preliminary evaluation of student attitude towards the usefulness to them as engineers of differential equations and the mathematics course material in general indicates a significant increase in agreement from the start to the end of semester.

Wedelin and Adawi [9] describe their success with an inquiry-based course in mathematical modelling and problem solving, by pairing students to solve around 30 small problems that were realistic, interesting, and sufficiently challenging, and designed to connect theory with practice. This resulted in deeper learning, in students realizing for the first time "how mathematics can be part of their identity as engineers", and in high pass rates. [9] Further details on some of the problems used in this course may be found in [10]. We note that Wedelin and Adawi argue against intensive study of only a small number of problems of the type discussed in [3].

Coming from secondary education, but with as much relevance to tertiary education, Silk & Schunn [11] caution that while teaching mathematics in context (of robotics) may engage students, "further supports are required to effectively enable students' mastery of the more general mathematical ideas", raising doubt about the mathematical rigour and depth when the context takes over from the content. This is also reflected from a tertiary perspective in [12] where traditional mathematics prerequisites are replaced by an engineering mathematics application unit, taught by engineers. The viewpoints of mathematicians are not included, but Klingbeil and Bourne [12] point out that "a legitimate concern with increasing the accessibility of the curriculum is whether it waters down the calibre of engineering graduates".

Mustoe and Croft [13] suggest case studies to capture secondary students' interest to become engineering students, before these students have decided on a study focus. Mustoe and Croft highlight the difficulty in balancing the amount of detailed mathematical explanation that is included as well as the level of realism of the case study, in order to create effective case studies.

A fascinating but time consuming approach is described by Allen & Wilson [14]: A mathematics lecturer went "back to school" and completed an engineering undergraduate degree at his university. Following this experience, he changed his teaching style and started to use motivational examples in his mathematics class, from those he had worked through as a student in his higher year engineering classes. This, of course, showed students where the mathematics is leading in engineering. The lecturer has since added motivational examples for other majors that take his classes, for example biology, chemistry and computer science majors. As a consequence of this study, Allen & Wilson recommend teaching staff to "return to the classroom" as this results in better understanding of the curriculum between departments and improves collegiality. While a nice idea and very effective, due to the high workload required it is unfortunately not feasible for mathematics lecturers to undertake extensive engineering studies to gain the other perspective. Close collaboration between mathematics and engineering colleagues of the type described by Lowery et al. [15] may achieve a similar outcome.

Returning to the Australian context and to higher education, Flegg et al. [7] suggest that mathematics and engineering academics collaborate on the design of mathematics unit and embed the relevance in the curriculum, "to specifically target using mathematics as a tool for dealing with real-world problems". Coupland et al. [6] had earlier suggested an increase of the number of practical engineering applications in the teaching of mathematics to engineers.

Students as producers of resources for their peers

Involving students in course design has gained popularity across higher education in the last decade. McCulloch [16] discusses in detail the concept of students as consumers that has emerged from massification of higher education and pressures on funding, and then emphasises how the concept of the student as co-producer can overcome the shortcomings of the consumer model such as distance between the student and the educational process, failure to encourage deep learning, and compartmentalisation of the educational experience as a product rather than a process.

Bovill, Cook-Sather and Felten [17] provide the theoretical background to argue for the inclusion of students as partners in the production of course material, and give examples of successful collaborations where students were co-creators of teaching approaches, of course design, and of curricula. Benefits to students described are a deeper understanding of learning, increased sense of engagement, motivation and enthusiasm, and a more understanding relationship between staff and students. Elsewhere, [18] Bovill examines case studies from three countries that involved students in the co-production of curricula for first year courses in the areas of geography (Ireland), education (USA) and environmental justice (UK). She particularly focuses on staff views of the level and type of student participation, approaches to achieve participation, and outcomes for students and staff. As a consequence of their involvement in the curriculum creation, students showed higher levels of self-directed learning, confidence and motivation and a deeper understanding of curriculum design and learning processes, and they exceeded staff expectations. For staff, the experience was described as "risky" and "nerve-wracking", but also "transformatory". Bovill also discussed the design of projects to co-create curricula, with considerations given to the types of students who should participate, how many students, and if they should be paid.

Many more studies can be found that involved students in the production of particular types of multi-media resources in a range of disciplines [19], for example student-produced podcasts in engineering and education, [20] genetics, [21] information technology, [22] and accounting. [23]

Dunne and Zandstra [24] report on the first year of the University of Exeter's Students as Change Agents project which saw students engaged in research into the improvement of learning and teaching, with action taken to implement change based on the research outcomes. Their report also provides a theoretical framework for the involvement of students as change agents and highlights case studies from a number of disciplines.

Until recently, little literature could be found on the involvement of students as co-producers in tertiary mathematics education. [25] Since then, studies have started to emerge with students as partners in the co-creation of (or improvement of existing) mathematical content material for their peers. Duah and Croft in [25], and Croft, Duah and Loch in [26] report on the benefits to themselves that mathematics students see when producing learning material for other mathematics students, identify what students can contribute, and discuss barriers to lecturer acceptance of student created material. Students who participated in the co-production of material for the next cohort of students had developed transferrable skills, improved their own study habits, and for the first time had undertaken a deep learning process necessary to be able to teach the content to others. Croft et al. conclude that lecturers and students should collaborate on the production of material. This ensures acceptance by other lecturers, provides guidance to students on how to explain mathematics most effectively, but also provides the unique perspective from a student who has recently studied the material they are working on.

Hernandez-Martinez [27] takes a socio-cultural framework to investigate how a mathematics and an engineering student have collaborated on the production of teaching and assessment tasks on mathematical modelling and learnt from each other, highlighting "learning across the boundaries of mathematics and engineering", and meeting "in a common ground, a Third Space". Taking a mathematics discipline view, Cooper [28] discusses case studies from universities in the UK where students are partners, in the four roles of students as researchers, students as educators, students as ambassadors and students as managers.

The literature summarized in this section describes educators learning how to include the student perspective into curriculum and teaching material. We have not found literature on the involvement of higher year students to demonstrate the relevance of mathematics to first years – this is the focus of the present paper.

The maths relevance project

The maths relevance project was initiated at Swinburne University of Technology after realising engineering students in first year were not able to remember mathematical concepts covered in high school, and later on in second year did not seem to recall how to apply mathematical concepts they had learnt in first year. It appeared that the cause for this was a perception that the mathematical topics they studied in their first university mathematics units were not needed for their engineering degrees, which had resulted in low engagement with the material. Anecdotal evidence also indicated that some students were aiming to just pass first year mathematics units rather than fully engage with the unit and try to do well.

The first year first semester engineering mathematics unit at Swinburne University of Technology follows a standard first year Australian curriculum, covering vectors, a revision of algebra, functions and graphs, differentiation and integration. It is taught by the Mathematics Department. After noting how internship students and staff were successfully collaborating to produce material to enhance a second year mathematics unit at Loughborough University, [25, 26, 29] it was decided to take an innovative approach by involving final year engineering students in making mathematics relevant to first years. The faculty funded three six week summer term scholarships which were awarded to two final year engineering students – one civil engineer and one mechanical engineer – with the third scholarship shared by three final year multi-media students who had worked in a team before. They were guided by the authors, a mathematics and an engineering academic, and the faculty engagement and retention coordinator, who facilitated regular meetings to discuss and report on progress.

The students produced two animated videos, one for each of the two engineering disciplines. [1, 2] The civil engineering video shows how mathematics is applied in the construction of a high-rise building and touches on the topics of trigonometry, algebra, vectors, differentiation and integration. The narrator guides the viewer through a list of tasks that all involve one or more of these mathematical areas (see frames from the video in Figure 1, for example). The mechanical engineering video shows how mathematics is applied to improve a vehicle, touching on vectors, algebra, matrices, differentiation and integration. The narrator, again, guides the viewer through the steps to improve a "clunky" vehicle towards a racing car.

[Figure 1 goes here]

The videos have been shown to promote mathematics at the university, for example on Open Day, and they have also been shown in first year mathematics lectures. In this paper, we analyse views of some of these first year students on the videos, and contrast these to the perceptions of the final year students who had produced the videos.

Methods

We take a case study approach with descriptive and explorative focus to investigate the perceptions of students creating resources to demonstrate the relevance of mathematics, and of students who these resources were created for. A case study approach is suitable as we are interested in "*process rather than outcomes, in context rather than a specific variable, in discovery rather than confirmation*", [30] and since such an investigation has not been undertaken before.

Data were collected through two interviews with the engineering students, one with the multi-media students and one with all five students present, during and at the conclusion of the production stage of the project. In addition, we included a final report written by the engineers in our analysis. [31] We have already reported elsewhere on the engineering students' views of the collaboration that ensued [19] and lessons we have learnt from this project. [32] We have renamed the two engineers **C**hris (civil) and **M**ax (mechanical), but do not distinguish between the three multi-media students.

In order to gauge the impact the two videos have on a cohort of engineering students' understanding of the relevance of mathematics, we also collected data through two focus groups with two participants each with volunteering students from the first year engineering mathematics lecture where the videos had been shown. The students came from a range of backgrounds: One of the students had transitioned into university via a vocational pathway

(TAFE) and had practical experience through an apprenticeship (**T**ony). Another had taken a gap year between finishing high school and commencing university study (**G**ary). The third had a design background and work experience in that area before enrolling in a product design engineering degree but had failed the mathematics unit in his first attempt and was therefore repeating and already in his second year for other units (**R**ory). The fourth had come straight from high school (**H**anna). All student names have been altered to preserve student anonymity.

All interviews and focus groups were audio-recorded and professionally transcribed. We undertook a thematic analysis of the data to answer the following research questions, each posed from the perspective of students:

1. How would students demonstrate the relevance of mathematics in engineering?
2. What are first year students' views on the resources produced for them?
3. Who should produce resources to demonstrate the relevance of mathematics?

Results

In this section we have arranged student views in response to the three research questions. We have kept the student groups separate as each group provides a unique perspective in this study.

1. ***How would students demonstrate the relevance of mathematics in engineering?***

The Engineering Students

The engineers described their resources as follows:

> A simple animation, hopefully demonstrates the relevance of maths not in a complicated way, in a relatable method. It's going to be focused on different disciplines of engineering and above all going to be fun and engaging.

They were aware that if they made the animation too simple they would not achieve student engagement, while a too technical approach would be overwhelming to the new students as they described in their report. [31] They declared their "ultimate goal […] to increase student engagement" by showing the relevance to increase student awareness of what they're learning,

> Because if you're aware of what you're learning and you can see the link to where it's going to go further down the track, for example, car design or building design, they might […] go that looks familiar, we saw that in the video. So okay, it's whether they sit there and go I want to learn it because I saw the video or if they say okay, that rings a bell, that looks familiar, even that starts the trigger. They think about building a building but they don't think about what goes into it. And so to show a couple of examples that aren't in a complicated way, they're in a simple, visual way, they can look at that and go that's interesting, I want to learn more about that, I might want to go in that kind of direction. So that'll be the interest, and the engagement, we've thought about that, will follow on from the interest.

The students had searched through their first year mathematics notes for topics they had covered, mainly to refresh what they had done as first years and to help make the connection to the mathematics that had become relevant later. They also talked to mathematics lecturers to ensure they were "happy to incorporate these things in […] classes" and to include the right topics.

The engineers described that the initial idea had been to produce short segments that could then be combined into a longer video, and where the short segments could be shown in class whenever a topic was covered. However, the multi-media students had advised against this and suggested two longer videos, due to time constraints and since it "would be too clunky" and there would not be any "overall flow". After watching videos on YouTube, it was decided that the most effective way to include all their topic ideas would be to produce an animation, including "some quirky things from time to time, throughout it, that have a light hearted nature" and not try to be too serious. The animation gave them the chance to move away from the constraints of the real world, which meant they were not "restricted by building a story around an object; we built the objects around the story." The multi-media students guided them with the logical order of the videos and helped develop storyboards and scripts.

In their research on existing resources to demonstrate the relevance of mathematics, the engineers had found mostly text-based documents such as PDF files, also explaining the relevance of mathematics with "no pictures, nothing, it was just text on this applies here, this applies here". On the other hand, "all the videos, […] they were really just focusing on […] academics sitting there and just talking through things." One of the engineers related to his personal experiences and said that he'd seen "old lecturers […] give off really disengaging topics". While the engineers acknowledged that they had found slides with good ideas, they pointed at a lack of "some actual engaging way to do it". They had particularly not found any approach that had a humorous side. They were, however, inspired by Minutephysics, [33] a collection of short animations on YouTube explaining physical concepts.

The engineers explained that their resources were different from others as they wanted to show "the role of mathematics but not in a teaching way, but in more of a concept way". They also believed that they were going to be more engaging for students as they produced resources they, as students, found engaging. They took the approach of giving a clear goal to the viewer (to design a building or improve a vehicle), that had to be achieved using engineering concepts which require strong mathematical skills. In addition, the students had made sure there was particular relevance to what the first years at Swinburne are studying as one of the students said that he "purposely placed a couple of things in there that they will see identical in their textbooks".

The engineers were mindful that not all topics they had studied in first year mathematics had been of direct relevance to them later on, but showed a level of maturity often missing in first years when they said that "it's not learning the actual formula; it's learning how to think through it."

The Multi-media Students

The multi-media students described the videos as follows:

> A short animation that takes you through a bit of a maths journey […] and kind of shows how mathematical concepts are used within practical applications. So demonstrating mathematical applications.

The videos place the viewer as an engineer, with the narrator providing "that knowledge so they kind of feel like they've become an engineer by starting this course rather than attempting to be an engineer." While the videos are "not actually teaching them any maths –

it’s just saying You need to know this maths and you will be an awesome engineer”, they were meant to strike a balance between being informative and entertaining.

Before commencing this project, the multi-media students had produced a successful video on the student experience and had initially anticipated that they would again create a video “of the engineering students showing various areas of Swinburne and what they had to offer – to current students and potential students”. However, after discussing with the engineers and understanding what the engineers wanted to show, they “figured that animation was the best way to clearly and succinctly show all these mathematical concepts in the most straight forward way that would be easily accessible by first year students, so […] the impact of the animation sinks in the message a bit more effectively than a promotional video.” While they had experience with a range of multi-media formats such as animation, video and flyers they “focussed on the one most effective method.” Commenting on the collaboration with the engineering students, they said that “just like they helped us with what to say like math wise – we had to help them with how to say it”.

Asked what other direction they could have gone into, the students said they could “have shown one person stay and all the maths they used in that day – something like that.” They also said an earlier idea had been the production of a video interview with “someone that’s working on the cars downstairs [the university racing car team] or someone that’s got on IBL [industry based learning] on what they are doing and how mathematics is helping them with this. In their research they said they did not find “many videoed animations targeted towards first year maths students”. Most resources they found had been “content lecture[s]”. In their animation, they were able to put “the theoretical world and the visual world in one which was great”.

Asked how they thought the first years would react to the videos, the students said

> I think they will smile at it because it’s cute; it’s kind of fun – it’s probably not what they would expect from a maths lecture. Like I mean as multimedia students we see videos and funny things all the time, but I imagine that in maths lectures that it’s generally not a fun video time.

2. ***What are first year students’ views on the resources produced for them?***

We asked the first year students what they thought of the videos that had been produced, if they were demonstrating the relevance of mathematics to first years and how they could be improved.

The First Year Students

Both students in the first focus group agreed that the videos did demonstrate the relevance of mathematics, with Gary commenting “Before the videos, yeah I understood that maths is a part of everything and there is probably reason we’re being taught what we’re being taught, but after watching the videos it makes you think “right okay vectors really do play a role in how and when you design something”. Tony who had already been exposed to applications said “I think the videos would help because then you would get an idea of what you were getting into.” Hanna “thought the videos were good” as they showed where mathematics is applied, but at the same time found them overwhelming because of the amount of mathematics that was shown. She said that the videos “showed you’re going to learn this but you don’t know this yet, you realise how much you really don’t know”, and that there was too much happening in the videos. Rory agreed and suggested to focus on one concept and explain it properly, with a “revelation at the end”. Tony suggested to include “simpler mathematics” that the viewer can understand and “can get more involved” in. The pace of the videos was seen as too fast, as the students wanted to follow the mathematics rather than see it come into view only briefly.

All four students agreed that seeing the videos at the start of semester would not have impacted on the effort they put into their own mathematical studies as they already were motivated or are already spending a lot of time on mathematical study. Gary said that he “would have been blown away that’s for sure”.

In the first focus group the students asked for more real life scenarios, e.g. showing how mathematics applies to the new 10 storey building that had just been completed on campus (Gary), or how one of the landmark bridges in Melbourne stays up (Tony). These students also suggested that the mechanical engineering video could have been more focused, for example on “one little component and just showed how much maths goes into the most basic of components for a vehicle” (Gary). On the other hand, the lack of realism in the car animation had Gary intrigued to explore further how one would improve a car. He said “You have a good laugh that it’s turned into a race car but after the video I was actually wondering – well if you did have a vehicle like that and you wanted to make a better vehicle, what would the actual outcome be”. He also commented that

> It made me think and me being me and probably if I had really thought about it I would go home and try and calculate all this stuff to myself which would be a really long process, but yeah if it was more realistic it might show a bit more relevance”

On the other hand, Tony thought that the civil engineering video showed sufficient realism when he said that “the first one was good in that it was realistic.”

Although much emphasis had been placed on adding humorous elements into the animations, it appears that the approach “we’re engineers, well of course we can do this” was seen as arrogant.

Finally, Rory asked if it was “appropriate to make a video into a scare campaign? Like ‘this is how hard maths is going to be – do you get this? If you don’t get it maybe you should pay more attention?’”

Having talked to both producing and consuming students, we also see that there is a fine line between showing a realistic scenario and being limited by real world constraints, [13] but also between the level of light-heartedness that should be applied. However, what we appear to have observed is that the students did engage with the videos, that they did explain the relevance of mathematics, and that this is what we were after in the first place.

3. *Who should produce resources to demonstrate the relevance of mathematics?*

We asked the final year engineering students and the final year multi-media students in their respective interviews and the first year students in their focus groups who they thought should be producing material to demonstrate the relevance of mathematics to first years. All three groups had strong views on this, with the main point they agreed in that it should be students in charge and not staff.

The Engineering Students

The engineering students emphasised that their animations were "created for students, by students", and explained that this was important as

> we've been in their shoes, we know exactly what it's like to be there and because of that reason, we feel that we'll probably have more of an insight – better insight into exactly how we would make this video effective.

They thought that the key was to be still thinking like a student while for staff it had been a longer time since they last attended lectures.

Although the students think they should be producing such material, they did realise that seeking advice and feedback from teaching staff is valuable. For example, they had asked a staff member teaching first year mathematics which mathematical topics students traditionally struggle with most, enjoy, or find easy. They appreciated that this teacher perspective "helped direct where we were going" as "we are students, we think like students. So we're fallible, of course we are, we're going to miss things, something we didn't enjoy as much we're not going to focus on." In fact, the students further supported staff input:

> so to have the teachers overseeing the maths content, but using the students to think of the examples and the ideas and how you can make that relevant, I think that's the ideal combo.

This was also supported by their comments regarding the first author's checking of the mathematics and mathematical notation for the animations. The students had written down the mathematics the way they were used to, doing the calculations to come to a solution but omitting words explaining the steps such as "solve" or "differentiate" as they had not focused on the communication aspect "to explain it to someone else". They acknowledged that a lecturer could have input towards the mathematics or give the students mathematical topics to work off. In further support of students producing resources, the students pointed out that they felt that their summer project was exciting and they were highly motivated, whereas workload would be an issue since "if you had a lecturer […] do it, that'd be taking away from other time that they'd be putting towards other things".

Asked if first year engineering students, the consumers of the material, should be involved, their first reaction was that "a first year engineering student wouldn't have a clue about that", as first years "cannot see the whole big picture of their course yet" and would "kind of look at it as just a maths question. Wouldn't have enough know-how". They, however, had now been able to appreciate how what they had studied in first year fitted "into this broad umbrella of engineering." Chris said that "there's certain things that I wish people would've told me in first year", and that he tried to portray these in his video to help students put the mathematics in context. They had identified topics and examples from their own first year studies rather than use textbook examples, "and then refined them a little bit more for this video". In discussion with each other, ideas evolved and one of the engineers then suggested that

> You could look into further having a first year student with a third and a fourth year student to get that mindset from three years prior to you, now. Like if we sat down and talked with a first year student, what do you think about coming into this, what do you expect to get out of it? That might've been – we didn't actually think of that, but it might have been a good idea.

They acknowledged that while less time had passed since they completed first year compared to any of the teaching staff, not everything was still fresh in their minds “because it was so frickin long ago, you know, it’s hard to remember that” and it might be useful to listen to a first year student on the first day or two of the project.

The Multi-media Students

One of the multi-media students took a pragmatic point of view from their discipline in suggesting that students should be producing these resources as “then they’ve also got something for their folios as well when they finish”. Another followed along the engineering students’ view by saying “I feel like the students – for this kind of project I think students should definitely be the ones who are creating because this is for first year students and we know what it’s like being in a lecture hall like recently.” They believed that they themselves would not have been able to produce an animation of this quality when they were in second year as they’d learnt enormously through a major project they had just completed, indicating that final year multi-media students are required as “maturity takes its role.”

The First Year Students

Gary and Tony believed that resources should be produced by a combination of “students and teachers – like working together to build it”. They added that collaboration between students and teaching staff would mean “sort of working on the same level it’s almost like they’re not scary – you can ask them questions; you can work with them; you can do all sorts of stuff.” On the other hand in the second focus group only one student commented and suggested it should be students.

Discussion and Conclusion

We note that the final year students were well aware of the importance to balance simplicity and technical content to achieve student engagement, but did decide to move away from the constraints of reality by opting for animation. As Mustoe and Croft [13] had pointed out, striking the right balance is difficult. While the first years asked for a more realistic scenario for the car example, they did seem to engage with the animations by considering how the problems would be solved in real life.

The final year students had decided to show the mathematical concepts, rather than teach the mathematics. The first years didn’t like this approach as they wanted to have the mathematics explained properly and understand it. Not being able to follow all steps made the animations seem overwhelming. An introductory statement before students watch the video may be needed to reassure them that they do not need to try to follow the mathematics in the video.

The animations intentionally took a humorous angle with students balancing being informative and entertaining, and they placed the viewer into the position of the engineer. This humour was interpreted as arrogant by first years who seemed to feel strongly about preconceptions of the engineering profession.

From all the above, we conclude that first years should be involved in the production of these resources, at least as advisors to the production team as their views do differ from the views of the final year students. The professional videos that were produced in this project are evidence that higher year students are capable of producing high quality resources, however we would strongly encourage the inclusion of advice from teaching staff on the presentation and correctness of the content. This is similar to the findings in [26]. The final year students have a point when they highlight that they can relate better to a first year's thinking than staff due to the smaller age gap, and since they still have the student perspective.

A key point that was vital to achieving the high quality of the produced videos was the interdisciplinary nature of the collaboration, as we have indicated before. [19] The multimedia students summarised this very fittingly when they said that the engineers knew what to say, while they knew how to say it. Watching the interdisciplinary collaboration between engineers and multimedia students evolve [19] was very rewarding for us as we could see that the students were benefiting from this project. They started to learn from each other, to show mutual respect towards the skills each was able to bring to the project, and we saw friendships emerge.

The focus of this stage of the research was to investigate student production of multi-media resources to make first year students understand why they need to learn the mathematics, and as part of that to compare the views of producing and consuming students. We acknowledge that one of the limitations of this study is that our focus groups consisted of only four students who had volunteered to participate. However, these students covered various backgrounds, and shared their views openly.

We agree with Flegg et al. [7] who argue "that it is important to emphasize the relevance at every opportunity". The thoughtful integration of the resources into the first year curriculum, maybe as part of the upcoming redevelopment of the first engineering mathematics unit into blended learning mode, will be the focus for the next stage of our research, as will be to identify how else we can demonstrate the relevance of mathematics.

The second iteration of the maths relevance project is currently underway, with a new group of three engineering students from robotics/mechatronics and biomedical engineering degrees working with three multimedia students on the creation of more resources to demonstrate the relevance of mathematics. These students have again all received scholarships. For the long-term viability of the continuation of this project, and of others that involve students as producers of resources, we will need to identify ways of including the student work into course project work and therefore make the production part of standard university business. This might then allow us to create a bank of resources, covering the mathematical topics taught in first year and their relevance to all engineering disciplines at Swinburne University.

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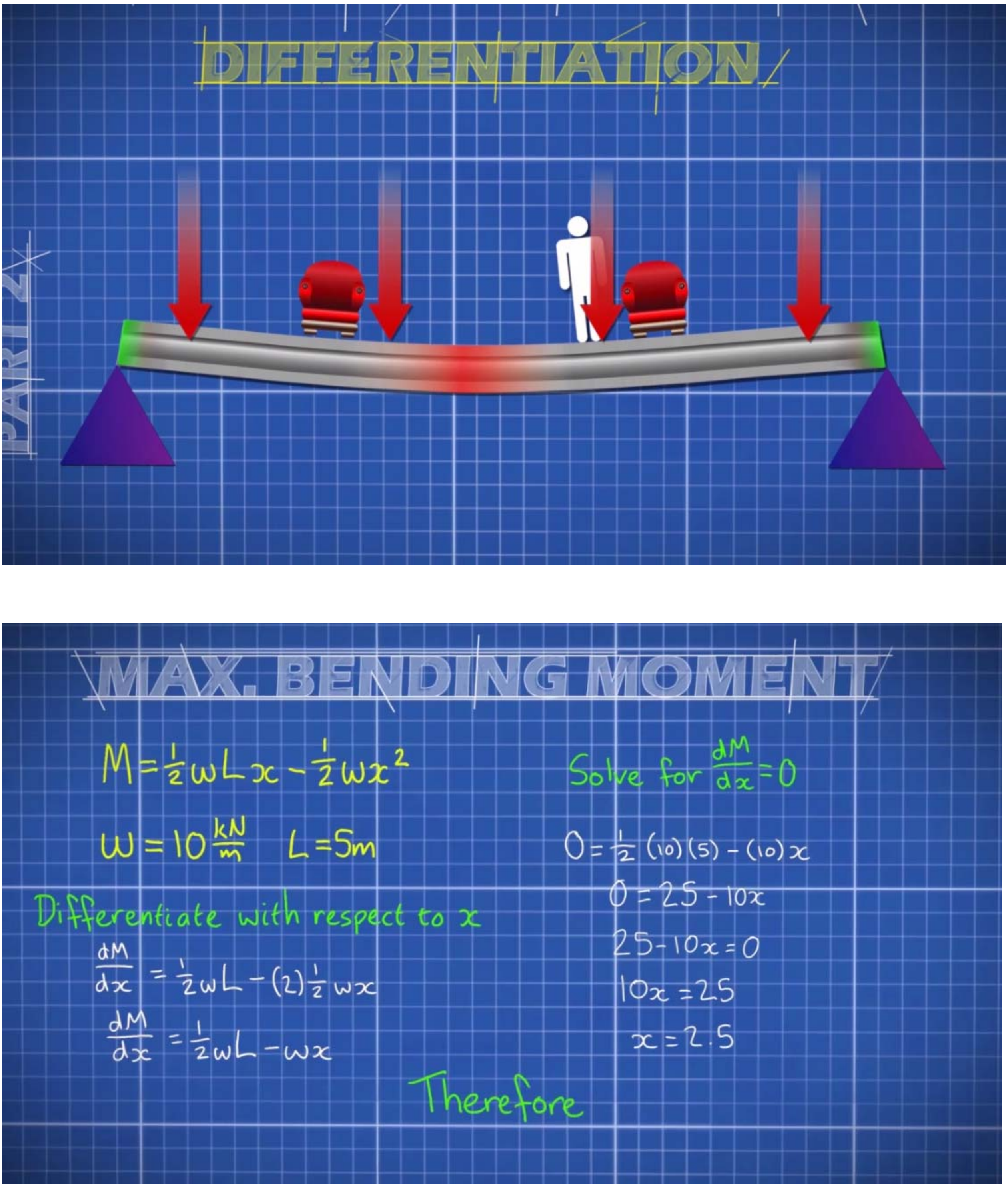

Figure 1: Two frames from the civil engineering video, showing how differentiation is used to determine the maximum bending moment.