25.09.2017

UTS pathway projects develop a formula for better maths engagement

1. Abstract

The pathway projects, launched by the Mathematics and Science Study Centre (MSSC) at UTS, addressed the urgent need for more student engagement in mathematics. Many first year science, technology, engineering and mathematics (STEM) students were unable to cope with the transition process and mathematics demand at tertiary level due to a lack of engagement in the mathematics space at school.

Through tutoring initiatives and accompanying research demonstrating improved confidence and performance among first year STEM students, the project successfully increased student wellbeing and retention. Moreover, opportunities for student development in mathematics are now presented as part of the enrolment process.

2. Problem

Many students are opting out of higher levels of mathematics and despite lacking the mathematical skills required to succeed at tertiary level, students are offered higher degree places in STEM as the threshold for mathematics pre-requisites has been lowered. As a result, student retention has become an issue, and as an unintended consequence of this development, universities now have to do the heavy lifting in the transition to ensure students cope in their first year mathematics course.

According to Jason Stanley, Curriculum Developer at the School of Mathematical and Physical Sciences, much of the issue stems from students' lack of confidence and negative associations with mathematics. Many students experience injustice and discrimination especially in mathematics, and are unable to develop a positive relationship with the subject. As a result, students are less likely to choose higher-level mathematics and thus face frustration and difficulties in the transition process from school to university, with many dropping out in the first year.

3. Beneficiaries

The initiative particularly targets first year STEM students who come from a variety of backgrounds, including high school graduates, mature age students and trade professionals looking to improve their mathematics ability. In particular, the project has been beneficial for students whose disposition reflected a lack of belonging in the mathematical space.
In addition, Stanley has also directed efforts towards primary school and secondary school students to intervene at an early stage and demonstrate the benefits of supporting students across all age groups. He firmly believes that early intervention is important for a holistic pathway approach to ensure no student falls through the cracks and gets left behind.

4. Approach to impact

In order to identify the gaps in mathematical knowledge and support required, Stanley was contracted to a team, led by Dr Mary Coupland, which launched two pathway projects at UTS from 2012 until 2014.

In collaboration with the School of Mathematical and Physical Sciences, the project tried to identify whether it was possible to run an intervention which addresses the needs of first year mathematics courses provides them tutoring which is concurrent with their first year studies. Simultaneously, the projects supplied both qualitative, survey analysis and quantitative, pre-test results data to gain a better understanding of the ability and expectations among students and the faculty.

As part of the projects, Stanley engaged students with a variety of experiences and at different stages of progression; schools students included primary school early years to late secondary school, and tertiary students included first year undergraduates through to postgraduate students. Early intervention is at the heart of Stanley's philosophy. As such, including school students was an important part of this work because it aimed to identify areas of the school curriculum, which need to be addressed if an intervention is to be effective. According to Stanley, who formerly served as school educator, Stage 5 of the NSW school curriculum plays a much more important role than Stage 6 in the mathematical foundation, and it is much more difficult to resolve gaps in Stage 6 alone.

The project also reached out to members of the public through evening courses, and attendees included teachers retraining as mathematics teachers, mature students hoping to improve their math skills, and school age children. A common theme among the participants at all levels was a desire to improve their performance in mathematics. Stanley's goal for the project was to collect evidence of improved performance in mathematics across all demographics through efficient and scholarly intervention.

To gather this evidence, Stanley spent time with students, both in a classroom format as well as on a one-on-one basis, and essentially provided mathematics tutoring. However, his holistic approach to teaching, which is a snug fit within the Australian Professional Standards for Teachers, focused on the students' wellbeing as much as on their academic needs, enabled him to simultaneously audit students' learning processes, gain an insight into their past experiences at school and with mathematics in particular, and understand the impact of these experiences on their current situation.

This approach to the interaction with the participants was based around the idea that students learn by doing. The projects used interview and discussion techniques to explore the meta-information surrounding mathematics, which allowed students to compare their general learning experiences with those specific to mathematics. Moreover, the practical approach also enabled students to explore different learning environments and compare them with the classroom experience.

As such, Stanley was able to measure the students' confidence levels after spending time in the project and developing their mathematics.

5. What has changed as a result of this work?

5.1. The Outcomes

While post-participation test results generally confirmed the students' improved performance, the additional data collection also showed improvement in the processing of mathematical ideas overall. Furthermore, the survey responses indicated that students felt more able to complete mathematics in a tertiary setting.

Most importantly, retention among the students who were engaged with the project improved, and students felt more confident in choosing mathematical subjects as they felt more prepared for the course.

These findings in first-year undergraduate students were further supported by the results of the other school-based initiatives, which have helped to improve the current systems to better support incoming students with mathematical needs.

As a result of Stanley's participation in the pathway projects, and the evidence he could present through his research, the faculty is now better placed to explore options in the transition space as it applies to mathematics. Based on the work he has undertaken, UTS developed the "Mathematics Study Support Centre - Website", to allow students to engage in blended learning. The foundation for this site is based on the findings from the short-courses and tutoring interventions.

In addition, opportunities for student development are now presented as part of the enrolment process. This is a significant change as students are now informed about these opportunities and have access to tools and support which target their needs as learners in mathematics. The implementation of these pathway opportunities, and the subsequent uptake by students, is firm evidence of a positive change for students of mathematical sciences.

Finally, a new project with a national in scope, “MathsInside”, has a “pathways” component which evolved from these initiatives. This aspect of the project is not just a pathway to UTS university mathematics, but a pathway to any university program incorporating mathematics (STEM).

5.2. Impact

According to Stanley, education is the emancipating power which allows students to have a better range of choices and enhance their own situation. The impact his project aimed to have was a simple message for students: It does not matter where you are from, how old you are, in which postcode you reside, or the school you attended – the only thing that matters is that you are here in class and that you want to succeed in mathematics. He firmly believes that this willingness to learn and try is more than half the battle in achieving higher education goals.

On a small scale and within the space of UTS, the project has certainly achieved its purpose which is evident in the increased confidence and ability among the participants. In addition, the project was able to demonstrate that early intervention is not only useful but necessary to ensure that no student falls behind in their mathematical skill development, which also means that the transition to university will become a more positive experience with access to the required support.

With the outreach beyond UTS and further implementation around the country, it is very possible to make a more large-scale difference in the lives of aspiring STEM students and allow more students nationwide to succeed in their first year.

6. What has helped you accomplish this work?

6.1. Personal enabling factors

Stanley credits the success of the project to his many years of work within the school sector. Prior to dedicating his time to these pathway projects, he served as a former school educator at senior executive level where the curriculum was either traditionally sequenced or accelerated. Teaching senior mathematics and administering programs across a variety of demographics informed his experience of the teaching and learning requisites. Most importantly, it formed the foundation for projects that would address the gaps and shortcomings of this system.

Through his postgraduate education, Stanley has also been specialising in academic care as well as education, meaning that the students' wellbeing lies at the forefront of any teaching and learning interaction.

6.2. External enabling factors

Much of Stanley's work with the general public was on a pro-bono basis while the work specifically targeting university students was through HEP funded grants provided by the UTS Equity and Diversity Unit.

In addition, staff members provided important insight into mathematics education at tertiary level which helped Stanley better understand the transition and curriculum needs. UTS as an institution also supported the pathway projects, and aided in the development of support tools for STEM students.

7. Challenges

The reporting demands of the project drew on the experience of the team lead and members of UTS Equity and Diversity Unit. However, capacity and resources were the key challenges for the project. Stanley worked alone on the website, tuition and data collection for much of the project, assistance from a larger team interested in educational improvement in mathematics would have enabled a wider outreach and greater impact. He is hopeful that such projects will continue to expand and attract more support from staff and funders alike.

Stanley also believes that a wider, more structured study would help shape the curriculum more appropriately at all educational levels, referring back to his emphasis on early intervention.

8. Associated research

Abdulwahed, M., Jaworski, B., & Crawford, A. (2012). Innovative approaches to teaching mathematics in higher education: a review and critique.

Clark, M., & Lovric, M. (2008). Suggestion for a theoretical model for secondary-tertiary transition in mathematics. *Mathematics Education Research Journal*, *20*(2), 25-37.

Croft, A. C., Harrison, M. C., & Robinson, C. L. (2009). Recruitment and retention of students–an integrated and holistic vision of mathematics support. *International Journal of Mathematical Education in Science and Technology*, *40*(1), 109-125.

Rylands, L. J., & Coady, C. (2009). Performance of students with weak mathematics in first-year mathematics and science. *International Journal of Mathematical Education in Science and Technology*, *40*(6), 741-753.

Whannell, R., & Allen, W. (2014). The motivation and identity challenges for PhD holders in the transition to science and mathematics teaching in secondary education: A pilot study. *Australian Journal of Teacher Education, 39*(12).

9. References

Biggs, J. (1991). Introduction and overview. In J. Biggs (Ed.), *Teaching for learning: The view from cognitive psychology*. Hawthorn, Australia: Australian Council for Educational Research.
Davis, R. B. (1984). *Learning mathematics: The cognitive science approach to mathematics education.* London: Croom Helm.
Dewey, J. (1966). *Democracy and Education: An Introduction to the Philosophy of Education*. New York, London: The Free Press [first published 1916].
Evans, G. (1991). Student control over learning. In J. Biggs (Ed.), *Teaching for learning: The view from cognitive psychology* (pp. 51-70). Hawthorn, Australia: Australian Council for Educational Research.
Kilpatrick, J. (1986). Reflection and recursion. In M. Carss (Ed.), *Proceedings of the 5th international congress on mathematical education*. Boston: Birkhauser.
Lerman, S. (1994). Articulating theories of mathematics learning. In P. Ernest (Ed.), *Constructing mathematical knowledge: Epistemology and mathematics education* (pp. 41-49). London: Falmer Press.
McComb, B. (1989). Self-regulated learning and academic achievement: A phenomenological view. In B. Zimmerman & D. Schunk (Eds.), *Self-regulated learning and academic achievement: Theory, research, and practice* (pp. 51-82). New York: Springer-Verlag.
Schunk, D. (1989). Social cognitive theory and self-regulated learning. In B. Zimmerman & D. Schunk (Eds.), *Self-regulated learning and academic achievement: Theory, research, and practice* (pp. 83-110). New York: Springer-Verlag.
Skemp, R. (1986). *The psychology of learning mathematics* (2nd ed.). Harmondsworth, U.K.: Penguin Books.
Zimmerman, B., & Schunk, D. (Eds.). (1989). *Self-regulated learning and academic achievement: Theory, research, and practice*. New York: Springer-Verlag.

https://mssc.uts.edu.au
https://mathsinside.uts.edu.au
http://newsroom.uts.edu.au/news/2014/09/maths-and-minkes-developing-formula-better-maths-engagement

10. Additional indicator information