STEM-TEC
SCIENCE · TECHNOLOGY · ENGINEERING · MATHEMATICS
TERTIARY EDUCATION CENTRE

STEM-TEC Centre's Highlights over 2014-2018

Overview

Science, Technology, Engineering, and Mathematics Tertiary Education Centre (STEM-TEC) is the first and only Centre in New Zealand that focuses on STEM education at tertiary level. The Centre was officially launched by Hon Steven Joyce in September 2014. Currently the Centre has 29 members from all faculties at AUT and 7 associate members from outside AUT. About a half of the Centre's activities are devoted to conducting high quality research in STEM education and the other half to scholarship of teaching and learning and links to schools and the community.

The annual budget/support from the DCT Faculty is $10,000. The website is www.stemtec.aut.ac.nz

At the launch of STEM-TEC, 17th September, 2014

Our mission statement: Increasing the number and improving the quality of STEM graduates for the New Zealand knowledge economy

We aim to achieve this by:

- Conducting high quality research in STEM education
- Implementing best pedagogical strategies in the teaching and learning of STEM subjects
- Ensuring equity and creating opportunity via social and community engagement

Research – Highlights and Impact

Grants ($320,000)

Members of the Centre received 15 grants in STEM education totalling $320,000: 10 internal grants from AUT valued $63,000 and 5 external grants valued $257,000 (New Zealand Council for Educational Research, Ministry of Business, Innovation and Employment (2), Ako Aotearoa National Centre for Tertiary Teaching Excellence, Microsoft New Zealand). Those grants supported projects on enhancing teaching and learning of STEM subjects, in particular contributing to increasing the pass and retention rates. Innovative learning and teaching approaches and resources developed in those projects lead to growth in successful graduates and to number of highly skilled employees in STEM related industry, service and research organisations for the economic benefit of New Zealand. Many of our members received grants in the traditional STEM subjects; these grants are not included here.

Publications (100+)

Members of the Centre produced more than 100 publications including 28 refereed journal articles, 32 papers in refereed conference proceedings, and 12 refereed book chapters, books and reports. Research based insights lead to improved learning and teaching approaches and student success and educator satisfaction, building a stronger graduate pipeline. Due to the nature of the publications in STEM education as a teaching-research nexus most of them have a direct impact on and implementation in the teaching practice. In particular, more productive and successful teachers and students retained in the system. The vast majority of those publications are produced by the following 5 members who are active in STEM education research: A/Prof Sergiy Klymchuk, A/Prof Tony Clear, A/Prof Jacqueline Whalley, Peter Maclaren, and Kerri Spooner. Many of our members publish extensively in the traditional STEM subjects; these publications are not included here.

PhD Students (3 including 2 to completion)

In 2018, Peter Maclaren completed his PhD. Kerry Spooner is making a good progress in her PhD on the topic “Identifying effective teaching practices to overcome student difficulties in the formulating mathematical models” and is expected to complete in 2019. In 2017, a PhD in STEM education (computer science education) was completed at the GeoInformatic Research Centre under supervision of two STEM-TEC members A/Prof Jacqueline Whalley and Anne Philpott. Many of our members supervise PhD students in the traditional STEM subjects; these PhDs are not included here.

Partners and Collaborators (22 including 15 international)

Microsoft New Zealand is the official partner of the Centre. The Centre has partnership/collaboration with 22 similar Centres – 7 in New Zealand and 15 international from 10 countries. Examples of extensive collaboration include: joint organising of conferences and seminars with the effective use of the resources for the benefits of stakeholders in New Zealand, exchange visits including sabbaticals, joint projects and publications, running community events. Those collaborative activities inform and influence STEM education policy and practice in the participating institutions and countries and increase the national and international reputation of AUT. As an example, one of the earlier joint national projects between AUT, University of Auckland, Manukau Institute of Technology and 4 secondary schools “Analysing the Transition from Secondary to Tertiary Education in Mathematics” (principal investigators A/Prof Sergiy Klymchuk, AUT and Prof Mike Thomas, UoA) has been widely disseminated throughout New Zealand and internationally. It has made a significant and sustained impact on smoothing the transition by informing and shaping educational policy in New Zealand. In particular, through a series of investigations and evaluations, it highlighted the differences between the mathematics curricula as intended by policy makers and as experienced by teachers and students.

Organising International Research Conferences (3)

The Centre organised the First Australasian Symposium on Using Pen-Enabled Tablets in Teaching STEM Subjects in 2015 (convenor and chair A/Prof Sergiy Klymchuk, chair of programme committee Peter Maclaren). The major impacts are: more than 60 participants from Australia, New Zealand and USA attended the symposium sharing their research findings and impact on teaching. Following the success and using the experience of that inaugural symposium one of the participants Sylvia Urban organised the second Australasian symposium at the RMIT University, Australia in 2017.

Two international conferences on computer science education were organised by A/Prof Tony Clear and A/Prof Jacqueline Whalley (co-chairs): the Sixteenth Australasian Computing Education Conference in 2014 and Sixth Learning and Teaching in Computing and Engineering Conference in 2018. The major impacts are: increasing international profile of AUT and New Zealand as a centre for research in STEM education and financially successful hosting of both events. A/Prof Tony Clear also served as international working groups co-chair for the 2016 Innovation and Technology in Computer Science Education Conference in Arequipa Peru, and gave a keynote speech at the 15th Baltic Sea Conference on Computing Education Research, Koli, Finland, 2015. In November-December 2015 A/Prof Tony Clear spent a period on research and study leave with long term collaborators at the UPCERG research group at Uppsala University Sweden http://www.it.uu.se/research/group/upcerg where he presented seminars and workshops and ran focus groups with students on global collaboration.

Organising Research Seminars (40 including 17 by international speakers)

The Centre organised 40 research seminars and hosted 17 international visitors including 2 on sabbatical. The major impacts are: developing, enhancing and implementing best innovative pedagogical strategies in teaching and learning of STEM subjects as all research seminars were devoted to STEM education; joint national and international projects and publications; increasing national and international reputation of STEM-TEC and AUT. Below are a couple of links to recent high-profile international visitors:

https://stemtec.aut.ac.nz/news-and-events/march-2018/23-march-2018-seminar-by-professor-gabriele-kaiser,-university-of-hamburg-mathematical-modelling-competences-meaning,-teaching-and-assessment

https://stemtec.aut.ac.nz/news-and-events/february-2018/16-february-2018-seminar-by-pauline-hoyle,-associate-director-of-the-national-stem-learning-centre,-uk

Research Projects (15 including 8 research)

The Centre has run 15 projects: 8 research projects and 7 teaching/learning projects. They are presented on the page: https://stemtec.aut.ac.nz/themes-and-projects

Examples of recent research projects together with their national and international impacts are as follows:

1. Enhancing Generic Thinking Skills of Tertiary STEM Students through Puzzle-Based Learning (2016-2018). Research project, project leader A/Prof Sergiy Klymchuk, team 4 members or associate members of STEM-TEC from 2 universities, supported by a $10,000 grant from Ako Aotearoa National Centre for Tertiary Teaching Excellence.

   The major impacts are:

   - National: presentations at 5 national conferences of different communities (mathematicians, tertiary education researchers, learning/teaching developers, school mathematics teachers);

1 official report and 1 e-book – both available on Ako Aotearoa website; 2 local seminars. The resources developed are available for all New Zealand tertiary institutions; the findings are also widely disseminated via the Ako Aotearoa website, workshops, and communities of practice of STEM educators (professional associations like New Zealand Mathematical Society, New Zealand Association of Mathematics Teachers, and partner institutions). The findings show that students were very positive about the suggested pedagogical strategy by indicating enhancement of their problem-solving (91%) and generic thinking skills (92%). Convinced by the findings, many colleagues from different tertiary institutions and secondary schools have started using the suggested pedagogical strategy with their students.

- International: 1 article in an international research journal ranked A by the Australian ERA; presentations at 2 international research conferences in Germany and England; 7 invited research seminar presentations at universities in Norway, Singapore, England, Scotland, Ireland, Germany, Ukraine.

- The project served as a pilot for the following large research project: "Investigating the Impact of Non-routine Problem Solving on Creativity, Engagement and Intuition of STEM Tertiary Students" (2018-2019, project leader A/Prof Sergiy Klymchuk, team 10 members or associate members of STEM-TEC from 4 tertiary institutions, supported by a $198,205 grant from the New Zealand Council for Educational Research). Currently the methodology of measuring the impact of creative problem solving in STEM subjects has been developed and is at the implementation stage. This ongoing large project received wide national and international recognition via our partners/collaborators and advisory board members including Sir Vaughan Jones KNZM FRS FRSNZ FAA, the New Zealand mathematician recipient of a Fields Medal - the Nobel prize equivalent for mathematics. The project is in line with the Vision Mātauranga that encourages a spirit of creativity and innovation as "the place where creative thinkers focus on key issues, problems and creative possibilities". It also enhances students' C skills creativity, curiosity, collaboration, and critical thinking, as well as their employability since those skills are a workplace requirement.

  Below is a link to the Ako Aotearoa project report:

  https://akoaotearoa.ac.nz/enhancing-generic-thinking-skills-of-tertiary-stem-students-through-puzzle-based-learning?mc_cid=c098b984bd&mc_eid=eb3b2f243a

2. Enhancing the Teaching of STEM Subjects Using Digital Pen-enabled Tablet Technologies (2014-2018). Research project, PhD thesis of Peter Maclaren supervised by 3 STEM-TEC members A/Prof Sergiy Klymchuk (primary), A/Prof Tony Clear (secondary), A/Prof David Wilson (third).

   The major impacts are:

   - Publishing 5 articles in international research journals ranked A or B by the Australian ERA; presentations at 2 international and several local conferences/seminars; promoting the use of pen-enabled tablet PCs in teaching STEM subjects by sharing findings from the research (e.g. the vast majority of STEM students prefer pen-enabled tablet PCs as the presentation mode in a classroom), demonstrating useful features of the new technology and how they can enhance the existing pedagogy. As a direct result 40+ staff from AUT started using pen-enabled tablet PCs in teaching for the benefit of the students. Peter's PhD thesis is available on the STEM-TEC website providing a free access internationally to this valuable resource:

     https://stemtec.aut.ac.nz/__data/assets/pdf_file/0009/197298/Enhancing-the-Teaching-of-Mathematically-Intensive-STEM-Disciplines.pdf

3. Computing for the Social Good (2015-present). Research project, project leaders A/Prof Tony Clear and A/Prof Jacqueline Whalley, supported by a Fulbright award and sabbatical from Xavier University in Cincinnati, USA. The major impacts are:

   - A collaborative international project with Dr Michael Goldweber, visiting fellow, Department of Mathematics and Computer Science, Xavier University, Cincinnati, USA. Dr Goldweber spent his sabbatical at AUT in 2015. The project had a significant impact on staff and students in computer science by increasing awareness of the social impact of computing. Dr. Goldweber ran several workshops and seminars at Universities in the North and South Islands, involving over 200 academic staff and students and published several joint papers.

4. Effective Teaching of Mathematical Modelling and Applications to STEM Students (2014-present). Research project, PhD candidate Kerri Spooner supervised by 2 STEM-TEC members A/Prof Sergiy Klymchuk (primary) and A/Prof Roy Nates (secondary).

   The major impacts are:

   - Publishing 1 article in an international research journal ranked B by the Australian ERA; 1 refereed book chapter; 3 refereed papers in international conference proceedings; presentations at several national conferences and seminars; disseminating best pedagogical strategies learned from the International Community of Teachers of Mathematical Modelling and Applications (ICTMA) among New Zealand tertiary lecturers and secondary teachers (e.g. via Auckland Mathematical Association); being the New Zealand representative and selecting teams for the International Mathematical Modelling Challenge in 2017 and 2018.

Scholarship of Teaching and Learning – Highlights and Impact

Teaching and Learning Projects.

As expected, our members are particularly enthusiastic and diligent in their teaching of STEM subjects. Only in one year, the following 7 projects involving 15 members of the Centre were successful in receiving Learning and Teaching Development Fund 2014 grants from the AUT Centre for Learning and Teaching totalling more than $40,000:

1) Virtual Robot Development – project leader A/Prof Loulin Huang.

2) Developing Digital Resources of Puzzles, Paradoxes, Provocations and Sophisms in STEM Subjects and Investigating their Impact on Enhancing STEM Students' Critical Thinking and Analytical Abilities – project leader A/Prof Sergiy Klymchuk.

3) Enhancing the Teaching of STEM Subjects Using Digital Technologies – project leader Peter Maclaren.

4) Effective Strategies for Teaching Statistics to Non-Specialists – project leader Dr Sarah Marshall.

5) Screencasts: The Development of AUT's Online Mathematics and Statistics Resources – project leader Dr Robin Hankin.

6) Rewarding Sustainability with Green Teaching Badges II – project leader Dr William Liu.

7) A Diagnostic Testing Framework for Threshold Concepts in Software Engineering – project leader Dr Roopak Sinha.

In addition, all research projects described in the Research section above also relate to the scholarship of teaching and learning due to the nature and area of the research topics/themes. The projects have

a big impact by enhancing the quality of teaching and learning of STEM disciplines at AUT via innovative pedagogical approaches, in particular improving their grades and satisfaction.

Student Olympiads, Competitions, Contests

The Centre was involved in organising, promoting and sponsoring several local and international student competitions in STEM subjects: International NASA Space Apps Challenge, International Mathematical Modelling Challenge, AUT Programming Contest, Programming Challenge for Girls, GirlTech Event, and AUT Kickstart Event. Those extra-curricular events, which are beyond the 'business-as-usual' have a significant impact on the participants by enhancing their C skills - creativity, curiosity, critical thinking, collaboration, communication – that are highly valued by employers. The most active members involved in organising/running such events are: Prof Sergei Gulyaev, Dr Jordan Alexander, Kerri Spooner, A/Prof Sergiy Klymchuk, Dr Sarah Marshal, Anne Philpott. Below are a couple of links to such competitions:

https://stemtec.aut.ac.nz/news-and-events/april-2015/11-12-april-international-nasa-space-apps-challenge

https://stemtec.aut.ac.nz/news-and-events/september-2015/2-september-2015-programming-challenge-for-girls-pc4g

STEMpreneurs Club

In 2015, the Centre established the AUT STEMpreneurs Club. The founders are A/Prof Sergiy Klymchuk and Brody Radford. The aim of this venture is to enhance entrepreneurial culture at AUT by running regular STEMpreneurs Guest Speaker Series - getting students and staff in the same room with influential entrepreneurs, STEM graduates, and technology leaders, sharing knowledge and making connections on the path to becoming job creators. To date we have successfully run 19 sessions inspiring students to become 'job makers' rather than 'job takers' and inspiring staff to commercialise their research. The sessions influenced 400+ people (both students and staff) who attended them and are on our e-mail list. The informal feedback from the participants is overwhelmingly positive. Below are a couple of links to such events:

https://stemtec.aut.ac.nz/news-and-events/september-2015/23-september-2015-stempreneurs-guest-speaker-series-presents-mark-thomas,-founder-of-right-hemisphere

https://stemtec.aut.ac.nz/news-and-events/may-2016/4-may-2016-stempreneurs-speaker-series-presents-professor-stephen-henry,-ceo-kode-biotech

Resources on Centre's Website

Members of the Centre developed and/or carefully collected 30+ innovative supplementary resources for engaging students and enhancing teaching and learning of STEM subjects. The resources help increase motivation and retention rate of STEM tertiary students not only at AUT but also around New Zealand. One of the original resources – the *Counterexamples in Calculus* book by A/Prof Sergiy Klymchuk, a recipient of an Outstanding Academic Title in the USA – has been sold in thousands copies worldwide and is now freely available on our website for New Zealand students. Below are a couple of links to such resources:

https://stemtec.aut.ac.nz/__data/assets/pdf_file/0003/57639/Counterexamples-in-Calculus-MAA-e-book.pdf

https://emedia.rmit.edu.au/triz/node/1

Links to Schools and the Community – Highlights and Impact

Examples of our active involvement with New Zealand secondary schools and the wider community are below.

1. In 2015 and 2016 STEM-TEC Centre jointly with CoLab organised and ran 12 full-day workshops: in 2015 it was "New Horizons: STEM Meet-ups for South Auckland Youth" and in 2016 it was "STEMpreneurial Bugs for South Auckland Youth". The projects were supported by 2 grants totalling $50,000 from the New Zealand Ministry of Business, Innovation and Employment initiative "Unlocking Curious Minds". Both projects aimed to engage students from South Auckland schools with science and technology using hands-on activities. Taking into account the demographics of South Auckland, the projects influenced many Maori and Pasifika students who represented about 90% of all participants (around 500 in all 12 workshops). The workshops had a big impact on the participants – all students and their teachers gave very favourable feedback on the evaluation forms. One more measure of the project as a dollar return is based on the method from the 2016 impact evaluation report prepared for Ako Aotearoa National Centre for Tertiary Teaching Excellence by the Business and Economic Research Limited (BERL). The method and some statistics from the report were presented by Rhonda Thomson, Ako Aotearoa National Project Funds Manager at the Northern and Central Hubs Colloquium on 7 November 2016. Based on the contribution of STEM graduates estimated in the report, if only 2% (10 out of the 500 participants who attended our workshops) would choose and complete a STEM related tertiary qualification when otherwise they might not have, then the New Zealand GDP would increase by $100,000 per annum. This is a 400% Return on Investment in our project per annum for the MBIE. The following members, among other presenters, ran the workshops: Prof Sergei Gulyaev, A/Prof David Wilson, Dr Robin Hankin, A/Prof Sergiy Klymchuk, Dr Sarah Marshall, Chris Whittington, Dr Roopak Sinha, Dr Willem van Straten, Dr Jordan Alexander, Dr Jesse Pirini, Dr Sangeeta Karmokar, Wendy Emson, Dr John Perrott. Below are a couple of links to the workshops:

   https://stemtec.aut.ac.nz/news-and-events/august-2015/29-august-2015-workshop-numbers-dont-lie-or-do-they-maths-and-stats-for-high-school-students-from-south-auckland

   https://stemtec.aut.ac.nz/news-and-events/october-2016/15-october-2016-workshop-radical-engineering-building-stuff-And-then-pulling-it-apart-for-school-students-from-south-auckland

2. Six members of the STEM-TEC Centre (Dr Jordan Alexander, Dr Robin Hankin, A/Prof Sergiy Klymchuk, Dr Sarah Marshall, Dr Mahsa Mohaghegh and Chris Whittington) were part of the AUT team at the Super STEM Fair held at the MOTAT museum in 2018 engaging visitors with science and technology hands-on activities. The Fair was a big success with 2000+ visitors most of whom attended the AUT site. The impact include promotion and publicity of STEM subjects in general and at AUT in particular, new enrolments in STEM disciplines and better understanding and appreciation of science and technology by New Zealand students and their parents. The link is below:

   https://stemtec.aut.ac.nz/news-and-events/april-2018/8-april-2018-representing-aut-at-the-super-stem-fair-at-motat-museum

3. Three members of STEM-TEC Dr Murray Black, Dr Jordan Alexander and Chris Wittington regular give a series of workshops on statistics, physics and astronomy, and 3D printing at the annual Rotary National Science & Technology Forum held in Auckland every January. This is a programme for outstanding all round science, maths and technology students in Year 12 who will be returning to Year 13 and are planning to study the sciences or technology at tertiary level. By the end of the Forum students have a better understanding of the tertiary courses they wish to follow and a fuller appreciation of the place of science and technology in the wider community. It also provides an

opportunity for high-achieving students to spent time with similar minded people and the experiences gained invariably result in overall personal growth and renewed motivation to succeed.

4. Organising and running professional development courses “Critical Mathematics Education” for senior school mathematics teachers and giving regular presentations at the Auckland Mathematical Association of mathematics teachers including plenary (A/Prof Sergiy Klymchuk). The impact is: improving a dialog between secondary and tertiary educators in mathematics and smoothing the transition from school to university mathematics in New Zealand.

Awards/Publicity

Examples of Center recognition include:

- DCT Faculty Award of $5,000 for Academic Excellence in Learning and Teaching to the Founding Director A/Prof Sergiy Klymchuk in 2014 (Leadership Category).

- DCT Faculty Award of $5,000 to the STEM-TEC Centre for excellence in research into the scholarship of teaching and learning in 2015.

- Commendation from the Academic Quality Agency for New Zealand Universities in the 2016 AUT Academic Audit Report: “The Panel notes the University’s commitment to STEM subject development. The University’s Science, Technology, Engineering and Mathematics Tertiary Education Centre (STEM-TEC) is intended to increase the number of STEM graduates and to improve teaching in these areas”.

- Eight national media publications about the Centre that increased the profile of AUT and STEM-TEC, including The New Zealand Herald, Maori and Chinese TV, radio Newstalk ZB, and 4 online magazines.

For more information, please visit the STEM-TEC website www.stemtec.aut.ac.nz

Associate Professor Sergiy Klymchuk
Founding Director of STEM-TEC

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