2019 DMISRS Symposium

Day One – Monday 8 July

Opening Address by Prof. Lis Lange

Prof. Lis Lange opened the 2019 DMISRS symposium by praising the collaboration that is central to the DMISRS project. She noted that collaboration at scale is rare in policy, implementation and research, and it is therefore critical for institutions to work together.

Prof. Lange noted that the root cause of poor academic literacy begins before students enrol at university, but this does not mean that we can shirk responsibility for this problem. Instead "*we need to teach the students we have*". It is important to look at the things that make our students fail in order to make teaching and learning more effective and satisfying. Poor teaching leads to student fear and anxiety by making the subject inaccessible and not guiding students toward understanding the subject.

She described the inheritances that we are still contending with in the mathematics field: the subject is feared by students and it remains male-dominated and white-dominated. She stressed the importance of turning the spotlight on ourselves: where did we go wrong? What can we do better?

The Status of STEM and the DMISRS Project by Mr Robert Prince

Mr Prince welcomed colleagues to the 2019 DMISRS symposium, and revisited the purpose of the project in impacting the mathematics landscape at universities.

He stressed the importance of ensuring that learning environments are aligned between four interconnected perspectives. These perspectives ssuggest that learning environments should be: *learner centred* by connecting learners' own knowledge

with their current academic tasks; *knowledge centred* by working with students' current knowledge and considering particular curricula designs; *assessment centred* by providing relevant feedback and giving students the opportunity for revision; and *community centred* by encouraging social norms outside of the classroom that value learning and high standards.

Mr Prince further highlighted the collaborative effort that underpins the DMISRS project, saying that the more people that come together under the project, the bigger the contribution of skills and knowledge to the mathematical landscape can be. Furthermore, challenges are easier to tackle when working together.

The project's Theory of Change was presented, describing the proposed pathway that links the DMISRS project activities (i.e. analysis of diagnostic information and research into curriculum-integrated student support) to the long-term objectives of positively transforming students' success in mathematics and reducing university attrition.

Mr Prince closed his presentation by describing the project's funded activities, timelines and plans for 2019.

Courses that Impede Graduation: A Case Study by Prof Suellen Shay

Prof. Suellen Shay presented the work done by her and her colleagues concerning the UCT-based CIG Project. As the high-risk courses that are addressed by the project are associated with complex challenges, they require collaboration by multiple parties. The CIG project thus involves: UCT faculties, CETAP, IPD, CILT, and ADP.

Prof. Shay emphasized the urgent need to address these courses as they can stand in the way of students' graduation and success rates, thus negatively impacting the lives

of thousands of students. Department relationships are not always collaborative, or even communicative, resulting in service courses not adequately serving the students. As these courses are foundational, students cannot move on to more advanced courses.

The CIG project aims to address high failure rates, and close the gap between black and white students' performance, by focusing on black students' experiences in high-risk courses. The project aims to develop a deeper understanding of the following questions: for whom is this curriculum working? Who is at risk? Why are they at-risk? Prof. Shay noted that curricula remain unchanged year after year and we are not making the necessary positive changes that can impact students and their success rates.

The CIG Project worked with faculties to identify priority high-risk courses and then provided them with analysed data on student performance, engagement, and qualitative feedback to understand the predictors of students' academic outcomes. While, historically, students' risk profiles were thought of as bi-modal, the project team's research found a tri-modal distribution. Moreover, academic literacy was found to be more important among students who fail these courses than quantitative concepts.

Prof. Shay concluded by stressing the importance of flexibility among high-risk curricula, and the need to constantly review our assumptions about who our students are, and what they need to pass, so that our structure is responsive to the current context of students.

Audience Questions:

UCT has the highest performing students so the curriculum structure may not work with other students from other institutions, as groups of students are being excluded (e.g. students who cannot pay for NBTs). Can UCT share their curriculum content? How can on tailor courses for students when there are limited resources to do so?

The Diagnostic Information from the NSC and NBT: Teaching and Learning by Dr Pragashni Padayachee

Dr Padayachee began her presentation by asking: how do we cater to the large amount of diversity in our classes? Instead of focusing on students' differing backgrounds, experience with mathematics, etc., she proposed looking at what students have in common: they are Generation Z. According to Dr Padayachee, current students are very familiar with the internet, mobile systems, and social networks. Thus, "*to exclude technology from teaching is to separate students' learning from their realities*". This is a hyper-cognitive generation, comfortable with cross-referencing multiple sources. Do our classrooms take this into account? Dr Padayachee argued that blended learning should integrate face-to-face methods with online resources, so that students can learn independently and at their own pace. This would help to extend our reach and maximise in-classroom time for valuable discussion and problem-solving.

Dr Padayachee emphasised that this is the best time to teach mathematics as there are so many high-quality resources available from all over the world to help support students and maximise time spent together in the classroom. To illustrate this point, Dr Padayachee described the blended learning techniques that she has recently implemented in her own classrooms, including:

- Interactive worksheets;
- CalcView app;
- Flip classrooms;
- WebAssign; and
- Whiteboard tutorials.

She concluded her presentation by suggesting that we first get to know students' performance and knowledge gaps, and then present new concepts and techniques that are the most suited to their competencies. By doing so, we can avoid the complexities of teaching a diverse range of students by focusing on the academic challenges that they have in common, and provide self-paced resources to support them.

Relevance of AL to Students of Mathematics: Patterns and Performance by Ms Sanet Steyn

Ms Sanet Steyn focused her presentation on the relationship between student performance and the academic literacy (AL) skills assessed by the NBTs (distinction--making, extrapolation, metaphorical expressions, understanding vocabulary, cohesion, communicative function, discourse relation, grammar/syntax, and text genre).

She argued that we tend to mistakenly assume that students understand the language of material delivery. However, language is a potential academic hurdle for students as it facilitates their ability to understand both new and existing concepts. It may also act as a proxy for other related skills (e.g. language sequencing and number sequencing). Consequently, language is important to consider when preparing and scaffolding content, as well as designing assessments.

Ms Steyn presented the research done on the relationship between AL skills and performance, demonstrating that there are some NBT subdomains that are consistently problematic (i.e. vocabulary and text genre). However, this research is not showing the full story as we see both students who pass and fail having similar problems with these subdomains. It is thus important for us to conduct further research into these relationships, and develop an understanding as to why the subdomains' weighting shift according to NBT score ranges.

The Academic and Quantitative Literacy Diagnostic Information of the Current First Year Mathematics Students by Benita Nel

Ms Nel further expanded on Ms Steyn's presentation, with a shift from AL skills to quantitative literacy (QL) skills. She defined quantitative literacy and explained its value in helping to identify misconceptions among students. She presented the QL subdomains that students struggle with in the Science/Mathematics faculty, as well as the relative importance of each sub-domain to NBT performance.

Panel Discussion: Mathematics for Science

Facilitator: Jakes Maritz [NMU]

Panellists: Muntuwenkosi Chili [MUT]; Ingrid Rewitzky [US]; Syamala Krishnannair [Unizulu]

The panellists introduced the first-year mathematics courses at their universities, the challenges faced by their students and the ways in which they support their first-year students.

First, Ms Chili spoke about improving her first-year students' performance through improved interactions with students, fairer assessments, increased opportunities for practice, and lecturer encouragement.

Mr Krishnannair explained challenges faced by MUT students, including: a school background with poor teaching practices, class sizes, student protests, poorly resourced backgrounds, and work load. Students are supported by various interventions, including in-person tutorials, online tutorials, and online material distribution.

Ms Rewitsky presented a conceptual framework that she and her colleagues use to understand mathematical profiency using legitimation code theory. She further explained how she has used this framework to understand skill-building and knowledge creation, in order to build deeper knowledge among students.

Audience Questions:

What is mathematics for science? Is the maths that we are doing fit for purpose? Are we developing specifically scientific competencies? How do we develop a more positive culture around mathematics? How do we bring scale, ratio and proportion into a first-year maths course?

Panel Discussion: Mathematics for Engineering

Facilitator: Anita Campbell [UCT]

Panellists: Howard Pearce [UCT]; Mark Jacobs [CPUT]; Noor Ally [DUT]

Mr Pearce began the panellists' presentations by highlighting the poor transition from school to university among students (academic, attendance, paying attention, using textbooks, etc.), as well as the transition from mathematics to engineering. He presented an approach to foster the relationship between engineering and mathematics by considering the interplay between students' learning objectives and: the *course purpose* (e.g. are the mathematics well-aligned to engineering?); *assessments* (e.g. are the assessments appropriately directing student efforts?); and *topics and the learning environment* (e.g. are topics and the environment designed to assist students in meeting their objectives?).

Mr Jacobs described his students as predominantly sitting at the basic level on the NBTs, saying that he and his colleagues are aware of the level that these students start at and they therefore know what can be expected of them. Mr Jacobs spoke of the issues in bringing together mathematics and engineering, such as: what mathematics fundamentals/principles should we teach? How much math is necessary? Who is best qualified to teach mathematics in engineering? Are we developing a disciplinary, critical form of thinking among students that is relevant? He then went on to provide possible solutions to these problems, such as project-based learning, teamwork, and broadening students' resource-base by including online resources.

Mr Ally argued that technology is an enabler of the learning process and that we cannot ignore the role of ICT in education. He argued that there is an urgency to introduce online learning in order to reach more students and increase access to assistance. Mr Ally stressed that every online model should be assessment-driven and pedagogic. The model should include pedagogically-focused diagnostic tests (that provides prompt feedback), online formative assessments, supporting material (e.g. lesson notes, e-books), and online assessments and tutorials.

Audience Questions:

How can you choose certain techniques or topics for engineering, without teaching students the complete underlying mathematical foundations? Is it appropriate for engineers to teach mathematics? How much modelling is done in these courses?

Panel Discussion: Mathematics for Commerce

Facilitator: Gilbert Makanda [CUT]

Panellists: Sonica Froneman [NWU]; Edward Inyangala? Sol Plaatjie]; Phumezile Kama [TUT])

Commented [CS1]: Someone else from Sol Plaaitjies took part, not Edward. Didn't catch the name though.

Ms Froneman provided a detailed description of the topics covered by NWU's 12-week first-year mathematics course. She also emphasised how she and her colleagues try and lessen the amount of mathematical content by considering context, and teaching the most relevant and applied concepts.

Mr Kama described the challenges faced by his service department at TUT. The department provides elementary quantitative and qualitative techniques, with the bulk of the first year being statistics focused. According to Mr Kama, there is a high failure rate that necessitates analyses in order to understand what is going wrong. Challenges faced by the department include a lack of expertise in all subjects, a lack of support and infrastructure to get course content online (with connectivity being the biggest issue), student motivation, and limited space for tutorials.

Sol Plaaitjies: presented introductory courses offered to students but has no experience in teaching mathematics for commerce.

Audience Questions:

What constitutes 'mathematics for commerce'? How do professional bodies influence course content?

Day Two – Tuesday 9 July

Mathematics for Computer Science: A case study by Claire Blackman

Ms Blackman presented her experience with designing and implementing a new blended learning mathematics course that was tailored for computer science students.

The UCT Computer Science department needed to implement an additional new course in discrete mathematics in order for students to register with the British Computer Society. Blended learning is increasingly encouraged by the faculty, and so it was decided that the new course would use a combination of online lecture videos, an interactive textbook and quizzes, and in-person lectures (that were recorded) in order to pilot the content. Students were supported by tutorials and office hours. The interactive textbook was open-source and modifiable using students' feedback, which was well-received by the students.

Ms Blackman said that it was important to support and encourage students' time management skills, as they needed to get used to the idea of demarcating time to go through the online content every week. This was supported by providing students with weekly checklists that included lists of tasks and learning outcomes.

In its first year, the course's pass rate was 89%, and its average course satisfaction rating was 4.65/5. Ms Blackman closed her presentation by explaining how lessons from the course's first year are being incorporated into future plans.

Audience Questions:

How many students come into the CompSci major who are not computer literate? Are there any interventions for these students? Do students need mainstream mathematics for image processing? Do you have second year discrete maths? Is the course serving the purpose, and if so, why is there a need to make the course more difficult? Can students carry on with mathematics in second year? Does your department value discrete maths? What are the entry requirements for the maths course? Do the online quizzes require mathematical input and does it count toward the course mark? How different is this course to MAM1000W? How did you navigate around the mandated contact hours with the students?

The Psychological Well-being of our Students by Banetsi Mphunga

Mr Mphunga introduced UCT's holistic wellness offering to students, which includes medical, psychological and psychosocial services. The provision of these services is aimed at supporting students so that they remain within the institution and graduate successfully. Mr Mphunga described his role as the UCT mathematics department's resident psychologist, describing the most common academic issues students suffer with. He says that these are typically faculty-based, such as the difficulty and intensity of the course, as well as the transition from high school to university. Adjustment is difficult in terms of language, academic difficulty, workload, external expectations and pressures, as well as separation from families.

Audience Questions:

Is there a sense of higher levels of anxiety in the science faculties? How do you connect with all students, including those not used to westernized practices? Are you aligned with the department/faculty or a wellness centre?

Panel Discussion: Extended Mathematics Programmes

Facilitator: Washiela Fish

Panellists: Ruan Moolman [UCT]; Jonathan Swanepoel [UWC]; Jerry Madzimure [VUT]

Mr Moolman began the panellists' presentations by describing UCT's extended mathematics programme which consists of two courses. Each course is predominated by diverse service course students studying toward different degrees. According to Mr Moolman, service courses are associated with low interest and motivation among students. In order to address this, Mr Moolman researched ways in which to motivate his students. He found that perceived usefulness is critical; students need to understand and believe that mathematics is important and useful for their careers. To do so, they need to be able to think practically about what they learn and how to apply it to their different careers. Mr Moolman applied these principles to his teaching, beginning with the development of an understanding of *who* he is teaching (students' majors, backgrounds, expectations, etc.). He explained the ways in which he would relate mathematical concepts to career-related situations (e.g. by using degree-

related problems in assignments), and how he would show students how concepts build on one another, year to year. Mr Moolman concluded his presentation by sharing qualitative feedback from his students which included positive perceptions of maths applicability, value and improved comprehension of previously abstract concepts.

Mr Swanepoel presented a constructivist approach to teaching mathematics in response to diverse groups of students. The aim of this approach is to understand how students construct knowledge through tests and peer interactions, and provide opportunities for student reflection and positive peer learning. He began by describing ideal graduate attributes, and how these attributes are used to build the extended programme. He also went on to describe the prevailing academic culture that holds students back from achieving these attributes, such as academic isolation, competitiveness, and poor mathematical vocabulary. According to Mr Swanepoel, in order to facilitate effective learning, students need to study regularly, regularly attend contact sessions, prepare for lectures, and meaningfully engaging with their peers. The extended programme should support this by applying guiding principles to the learning environment, such as facilitating cooperation and ensuring that learning is student-centred. Lastly, Mr Swanepoel described the problems encountered by the extended programme, including poor attendance, poor administrative support, and a profound lack of student resources (e.g. food and transport).

Mr Madzimure described the various support interventions available to extended programme students, such as motivational talks, consultations, extra revision classes, tutorials, and a dedicated mathematics centre. According to Mr Madzimure, students' confidence and group work are both critical aspects of the learning environment. He described a lack of student motivation as a significant challenge, as these students are typically the most unprepared and often have to further extend their degree. Other challenges include: a lack of available venues, students who seek help in the eleventh hour, a lack of a comprehensive diagnostic test to identify at-risk students, irregular attendance, students who do not prepare for tutorials, and poor retention of prior material. Mr Madzimure and his colleagues have tried to address these problems by setting ground rules (e.g. arriving to tutorials prepared and compulsory attendance at lectures and tutorials). Going forward, the university is going to build another centre for engineering and science students, however space remains a problem.

Panel facilitator, Ms Fish, closed the panel presentation with the following points:

- Extended programmes address challenges experienced by previously disadvantaged students, as well as the shortcomings of previous interventions tried at universities all over the country.
- Different universities implement different models; it would be good to understand what is and what is not working, as well as who it is working for.
- It is important to consider where students are going after the programme, and how we can better prepare them.

Audience Questions:

How do we prepare students for a lack of jobs or how to create jobs? Is Mr Swanepoel's assessment strategy aligned with the university's assessment strategy? Do you try and establish prior mathematics knowledge at the beginning of the year? Why not address the issues served by extended programmes through curriculum reform?

Panel Discussion: The Way Forward

The facilitators of all panels came together to discuss the way forward with the rest of the audience. The following points were raised by the panellists and by the audience members.

On student skill-building:

- High school mathematics is critical for building foundations for future applied mathematics; basic topics need to be learned as early as possible. We have few graduate students because of this problem; they lack the basic concepts needed to achieve excellence.
- Context is key when teaching mathematics to students. Tailoring service courses so that they are fit-for-purpose may prevent students from learning high-level competencies that provide a manner of thinking that is useful in all disciplines. Instead, we should be creative in the way we deliver content using context as a key mechanism for student comprehension.
- Teaching students *how* to learn may be particularly helpful in improving understanding and retention of concepts, as well as positive learning behaviours (e.g. time management). Metacognitive skills should thus also be targeted by institutions.

On learning objectives:

- We should be teaching mathematics that facilitate job-seeking and employment.
- Regarding students from disadvantaged backgrounds, should we not also focus on excellence as opposed to just catching up? Developing interest is just one part, they also need to be competitive and able to demonstrate excellence despite their backgrounds.
- It is important to get students to postgraduate level so that we have future teachers. In doing so, institutions should cultivate a culture of interest and passion for mathematics among students.

On technology:

- Whatever we teach will not be adequate for everyone as classes are too diverse with varying levels of competency, interest and motivation. A possible solution is using technology more to plug these gaps by guiding students to helpful resources.
- Students engage in online forms of learning anyway – we need to facilitate this process so that they are exposed to high quality materials.
- It would be very advantageous if experts could collaborate and share blended learning resources through forums that showcase what is working. This should include student voices that will help with student buy-in and peer motivation.

On teachers:

- It is important to consider the wellness of lecturers and the stressors and pressures that they face; what support is available to our teachers? We should focus on developing coping skills and foster supportiveness among staff.
- How should teachers deal with negative feedback from students? It is important to consider what the underlying justification for their feelings are and whether there is validity to their points. If so, these are opportunities for self-reflection; negative feedback can be turned into positive changes to your teaching methods.

Group Discussion: Toward Solutions

Mr Prince began this discussion by reiterating the theme of the symposium and its major questions: what does Mathematics in practice look like? Is it a valid notion? How can the DMISRS project help remedy the problem of high drop-out rates in STEM programmes?

He also highlighted key project-related points:

- The symposium affords one the opportunity to come together with colleagues and rethink one's perceptions and assumptions about students and learning.
- The blended learning approach is worth considering and if it works, invested in.
- The importance of monitoring and evaluation of the DMISRS project, as well as the need for cooperation amongst academics in the drafting of progress reports and surveys.

Mr Prince then opened the floor to the audience. The following points were raised about the DMISRS symposium and future project activities:

- Various members of the group expressed a willingness to participate in collaborative workshops focusing on critical thinking skills, metacognitive skills, and discussions around the construction and changing of curricula.
- Presentations need to include a greater focus on solutions, including practical application.
- There is a need for a greater understanding of students' learning styles, and the development of their critical thinking and metacognitive skills.
- While institutions are collecting data on students, this data is not freely available to academics. Furthermore, it would be useful to collect data on academics' institutional experiences.
- There is a need to address blended learning in DMISRS workshops, and possibly create online spaces (e.g. WhatsApp group) to facilitate collaboration among group members, and to share teaching methods and challenges in implementing them.
- There should be greater discussion between traditional university staff and UoT staff, regarding similarities and differences in teaching style and content.

- Research into and the sharing of best practices would be useful to better facilitate responses to unique challenges.
- It was suggested that relevant research questions be proposed and a literature review conducted and shared. One topic that was suggested concerned generational trends among students: how are students today different from the past, and how might they change in the future? In this case, the literature review could highlight changes in teaching style, learning style, and information retention.

Group Discussion: 2020 DMISRS Symposium

In discussing the 2020 DMISRS Symposium, a broad theme concerning 'curriculum and its implications' was proposed. Two key suggestions were posed by the group:

Invite academics from the other STEM departments to contribute to discussions about curriculum changes, challenges they face, and the effectiveness of solutions that they have implemented.

Include workshops that could provide "*hands-on experience of materials*" that could be shared with colleagues. These semi-structured workshops could facilitate focused discussions on readings, teaching practices, and allow for greater networking among members. However, this would need to be carefully planned so as to avoid the symposium becoming fragmented or disjointed.