MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

UNIVERSITY OF AGDER

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Annual Report for 2018

1. Abstract

MatRIC organised a rich programme of activity that embraced international, national and local (University of Agder) higher education mathematics teachers and students. During 2018 there have been significant advances locally, within the University of Agder, nationally across other higher education institution in Norway, and Internationally through engagement in international conferences and networks. Significant progress has been made in addressing all action points in the plan agreed with the mid-term evaluation panel. MatRIC's actions have been directed towards two key priorities: developing MatRIC;s networks to achieve transformation and improvement of students' learning experiences in mathematics and dissemination, sharing MatRIC's vision so that this transformation permeates the whole country.

This report draws attention to, for example, another successful annual conference in which the first day day addressed the teaching and learning of calculus, including contributions from prominent international and national researchers and teachers. The second day took a broader view to address the important issue of student engagement and partnership. The programme in day two included international guests in addition to reports from other Norwegian Centres for Excellence. MatRIC also hosted a major research conference that focuses on didactic research in university mathematics with over sixty reports of research from Europe, North Africa and the United States.

MatRIC has been successful in becoming more tightly woven into the fabric of Norwegian Higher Education, thus enabling MatRIC to be more effective in influencing and shaping both policy and practice. This report tells of collaboration with Universities Norway, especially with the STEM and Economics and Administration Subject groups – in particular the work of Morten Brekke and Thomas Gjesteland in the development of the revised framework for engineering education. As part of its goal to promote active learning in mathematics MatRIC is working closely with the Norwegian Mathematics Council, currently developing an instrument to explore the incidence of 'active learning' approaches in mathematics education in Norwegian higher education institutions.

This report also includes actions locally at the University of Agder, such as developing the quality of learning assistants and improving the performance of students on the mathematics for economics course. These actions have achieved successful outcomes in the development of students' competencies and identity as mathematics learning assistants, in addition to facilitating a university wide effort to develop student learning assistant. There has also been considerable success in developing the research culture and community within MatRIC, the research group has been enlarged, strengthened and drawn more closely together through strategic appointments, workshops and seminars.

Attention to learning outcomes is on-going and we look forward to the publication of PhD dissertation this year that will describe in-depth explorations of students' learning. We also look forward to the development of a new strand of quantitative research to provide evidence of patterns of effect on students' learning outcomes arising from MatRIC's interventions.

2. Results compared to the application and plans

The year 2018 started with determination to build on the successful outcome of the mid-term evaluation. The evaluation panel had agreed a revised action plan and in addition challenged MatRIC with several recommendations for the Centre's development and activities. The year began (January 4-5) with a joint

meeting of MatRIC's Advisory Board and Management Board in which the Evaluation Panel's report and MatRIC's Action Plans were discussed at length.

The panel made 5 recommendations in addition to the agreed Action Plan.

1. Integrating actions strategically: For 2018 we focus first in this report on integrated actions that have strategic importance for MatRIC. There follows a detailed table of individual actions mapped against the objectives of the agreed action plan for Phase 2.

2. Putting 'smaller classes' in the action plan: This recommendation was discussed and considered beyond MatRIC's remit and resource.

3. National relationships: MatRIC's role in the national higher education community has been strengthened during 2018 as reported below.

4. Measuring the impact of MatRIC actions: Researchers have been appointed to explore the issue of the impact of actions that MatRIC initiates and supports. More information about this follows.

5. Connection between MatRIC's research and MatRIC's actions: MatRIC's research group, and research activity have been a focus of attention throughout 2018. MatRIC's research activity is set out briefly in the following.

One observation of the evaluation panel was that MatRIC would benefit from a more-distributed management, to which we responded by appointing a co-Director who took up the role in May 2018. To further broaden the MatRIC's leadership, it was agreed to double the allocation of time given to MatRIC's activities by one of the existing coordinators. There have been several beneficial outcomes from this revision of MatRIC's leadership including: shared responsibility and executive decision making, leadership distributed over tasks, a stronger presence of MatRIC on both UiA campuses, greater capacity to represent MatRIC on external bodies, an injection of fresh ideas, imagination and energy.

Activities/projects have been conducted and the effects and results of these.

Table 1, Appendix, provides a summary of MatRIC's actions during 2018 cross-referenced to the action plan agreed as part of the interim evaluation that took place in 2017.

This report begins with a theme-wise account of MatRIC's achievements. Each theme is composed of accounts of several individual goal directed activities. The account cuts across individual objectives reflecting the coherence and composite nature of MatRIC's mission.

Key themes:

Community building

Our goal is that Mathematics teachers in Norwegian higher education institutions will engage in our community of inquiry in order to transform and improve students' learning experiences in mathematics. We seek to motivate theoretically and empirically informed innovation in teaching and learning and, as such, MatRIC is a national resource for achieving excellence in mathematics education. Our aim is to develop MatRIC's positive impact so that the community we build is of sufficient value to ensure sustainability beyond the funding period.

During 2018;

- MatRIC organized an annual conference that attracted nearly 100 participants, a workshop for computer aided assessment in mathematics and a workshop aimed at school teacher education – instructors and students about the use of the computer software GeoGebra in communicating and exploring mathematical concepts. (Information about MatRIC events can be found at https://www.matric.no/).
- MatRIC joined forces with the Centre for Excellence, Centre for Computing in Science Education in organizing a workshop on programming and visualization in mathematics.
- MatRIC's teaching-induction course (2017-2018 cohort) concluded successfully and planning started for a new cohort (2019.220), this time in collaboration with the German centre khdm,

Centre for Higher Mathematics Education (khdm: Kompetenzzentrums Hochschuldidaktik Mathematik, see https://www.khdm.de/en/).

- MatRIC hosted the biennial conference of INDRUM, International Network for Didactic Research in University Mathematics (https://indrum2018.sciencesconf.org/).
- MatRIC also supported and had a significant presence at international conferences - The international conference on E-Assessment in Mathematical Sciences is a three-day academic conference organised by Newcastle University https://eams.ncl.ac.uk/. Also POEM, a conference for researches working in early childhood mathematics education held at UiA (POEM is relevant for MatRIC because MatRIC is concerned with the mathematics taught to all students at university, including those preparing to be teachers of very young children. https://www.uia.no/en/conferences-and-seminars/poem-2018) .

Conferences provide a very important arena for communicating MatRIC's vision and goals, for sharing ideas about improving students' learning experiences in mathematics, and for inviting high profile mathematics educators from around the world to inform about important developments taking place outside Norway. Events MatRIC has organised this year have focused sharply on highly topical issues for the higher education mathematics community – programming and use of digital technologies, student partnership in education, teaching and learning calculus to first year undergraduates.

A challenge we address in MatRIC is to extend participation in events beyond the faithful interested, to attract higher education mathematics instructors who have not yet been reached by MatRIC's message. In 2019 we established a 'Contact Group' to help meet this challenge. MatRIC's Director and Morten Brekke, who has been asked to convene the Contact Group visited several higher education campuses throughout Norway (Tromsø. Narvik, Ålesund, Bergen, Haugesund, Stavanger) to promote and recruit members for this group and combine with contacts already firmly established at NTNU Trondheim and Gjøvik, USN, UiO, OsloMet, NMBU. The Contact Group had its first meeting at Gardermoen in October 2018 and is now an important of MatRIC's community. The Contact Group is of value to MatRIC in the development of MatRIC's strategy and plans, in providing two-way communication between MatRiC and mathematics teachers on campuses around Norway, and as a point for reflective and constructive criticism of MatRIC's activity.

MatRIC as a national resource and influence

The mid-term evaluation panel challenged MatRIC to be more influential at institutional and national policy levels. During 2018 MatRIC has engaged actively at national level with The Norwegian Mathematical Council (NMR), 'Universities Norway' (UHR), in particular the subject groups for STEM subjects (MNT fag gruppe) and Economics (Ø-A fag gruppe). During 2018 MatRIC has been presented at meetings of each of these groups.

MatRIC was represented at …
UHR-MNT Subject Group meeting at UiB in Bergen, April 26-27.
The Norwegian Mathematical Council (NMR) meeting in Oslo September 20.
UHR MNT Subject Group meeting at USN in Kongsberg, November 1-2.
UHR Economics and Administration Subject Group meeting at UiA, November 12-13.

Professor David Bressoud (a leading mathematician and mathematics educator from the USA) was keynote speaker at MatRIC's annual conference, he also addressed members of NMR. This address at NMR provided the catalyst for further collaboration between MatRIC and NMR. The two organisations are going to work together to promote active learning approaches. As the first stage in this work, we have set up a joint working group to create an instrument to survey (active) learning approaches in mathematics implemented in Norwegian higher education institutions. Work on this production, led by MatRIC is now well-established. MatRIC has observer status at NMR meetings.

We are very pleased that Mette Mo Jakobsen, "Sekretær for UHR-MNT (hovedansvarlig), innovasjon og entreprenørskap; and Sekretariat for UHR-Økonomi og administrasjon (hovedansvarlig)" is part of MatRIC's contact group. One outcome from the first MatRIC Contact Group meeting was setting up a small working group, in conjunction with UHR-MNT, to develop mathematics learning outcomes for the recently introduced revised framework for engineering education. MatRIC is leading this working group. We were pleased that Professor Burkhard Alpers (a member of MatRIC's International Advisory Board) a leader of

the Mathematics Working Group of the European Society for Engineering Education came to address the first meeting of the NMR-MNT/MatRIC working group that met at Gardermoen in the beginning of January 2019. MatRIC's expertise in this area has been recognised by the invitation to Morten Brekke, a key member of MatRIC, to deliver the keynote address at the bi-ennial SEFI (European Society for Engineering Education) Mathematics Working Group conference in Coimbra, Portugal.

As discussed further below, one of MatRIC's successes within UiA has been the redesign of the mathematics curriculum within the economics and administration study programmes. MatRIC's achievements, led by MatRIC PhD fellow Ida Landgärds were presented at the UHR economics and administration subject group meeting that took place in Kristiansand in November. The presentation proved to be a great showcase for MatRIC and we are now working to create a MatRIC network for mathematics teachers in economics programmes.

We are still working on finding the right focus for MatRIC in teacher education programmes. However, MatRIC has not neglected teacher education, for example the teacher education workshop and MatRIC's Open Lecture. Mathematics teacher education is already supported by very strong networks and it is important that MatRIC's effort is complementary and does not duplicate that which already exists. In 2018 MatRIC's Management Board was extended to include the Dean of Teacher Education at UiA, and the Advisory Board was extended to include the Director of the Norwegian Centre for Mathematics Education. We will now bring key players together (February 2019) to work out MatRIC's position and potential contribution.

Contributions to national developments
Frode Rønning prepared a response to 'Leidutvalgtet' on behalf of MatRIC.
Simon Goodchild prepared a response for MatRIC to the school curriculum development group.

Students as partners in education

Student partnership is high in MatRIC's priorities. There are areas in which MatRIC can have a direct effect, such as the education of student learning assistants, and areas in which MatRIC seeks to exert a strong and informed influence, through sharing and dissemination.

MatRIC launched a programme for the education of student learning assistants in 2017 and this has been continued into 2018. The programme has three features, recruitment, education and mentoring on task.

- Recruitment is carried out in collaboration between MatRIC's Project Manager and mathematics instructors, supported by colleagues in UiA's Examination Office. Student learning assistants are recruited to support course instructors or work in one of MatRIC's Drop-in Mathematics Support Centres.
- MatRIC provided a two-day training camp, just prior to semester one, for students recruited to the role of learning assistant. The two-day camp included sessions on mathematics didactics, pedagogy and communication skills, and introductions to course goals and objectives. Presentations were made by Mathematics Education Researchers teacher educators, the leader of UiA's Centre for Teaching and Learning and mathematics course instructors. Following the success of this inititive, MatRIC engaged in discussions with UiA's Centre for Teaching and Learning to collaborate on a university wide programme for developing competencies of learning assistants. A pilot session was implemented in January 2019, and this will be a significant development in the August camp.
- Mentoring on task, MatRIC emphasises and supports mathematics instructors to meet with student learning assistants assigned to their courses. In these meetings instructors discuss with students issues that have arisen through mentoring, and prepares the learning assistants for the mathematics content to be addressed in the near future.

Two summer interns were employed to work with MatRIC PhD fellow Ida Landgärds in the preparation of a pre-mathematics course for students on the economics programme.

In order to raise the profile and quality of discussion about student partnership the MatRIC Conference in 2018 was organised as two discrete programmes on consecutive days. The first day focused on teaching

and learning mathematics, the second day was dedicated to exploring student partnership engagement in education. The programme for this day included mathematics educators from the UK (Loughborough and Nottingham Universities) and an educational consultant from the UK, Abbi Flint who has been an advocate of and engaged in student partnership development for many years. The second day of the conference also included presentations from MatRIC and two other SFUs, bioCEED and CEMPE to tell about their activity to promote student partnership and engagement. Registration for the conference allowed participation in either day, it was pleasing that the mathematics community attracted by the programme of day one stayed on to the second day, and a significant number of other participants joined in the second day.

Research and development in and of education

The development of the MatRIC's research group has been sustained during 2018. A key event was a very successful workshop/seminar held at the University of Athens (UoA) in which the MatRIC research fellows and supervisors engaged with the mathematics education research group at UoA. The workshop included presentations of theoretical perspectives applied to researching university mathematics education in addition to research fellows presenting their work for critical discussion within working groups.

MatRIC's post-doctoral researcher Olov Viirman reached the end of his three-year contract in July 2018. We made two attempts to find a replacement without success. We then decided to shift the focus and invite applications from researchers within the Department of Mathematical Sciences at UiA. This proved successful and we appointed two colleagues, one experienced in qualitative research, the other a statistician who will help us to develop quantitative methods – aligned with proposals from the mid-term evaluation panel. In addition, a new PhD fellow was recruited to the MatRIC team, he took up his position in January 2019, he will focus on quantitative research.

Discussions with the Management and Advisory Board at the beginning of 2018 were based upon implementing the advice from the mid-term evaluation. The combined Boards recommended that MatRIC should consider developing the 'small research grant' action by opening the possibility for larger grants. These were announced in the spring 2018 and two grants of about 250 000 NOK were awarded. One to a research group led from Høgskulen på Vestlandet, which will investigate Norwegian preservice teachers' understandings about how digital technologies could be used in mathematics teaching and learning. The other grant was awarded to a group at NMBU who will explore student-active, inquiry-based teaching approaches that promote students' mathematical reasoning. In conjunction with the latter, MatRIC's Research Coordinator Prof. Barbara Jaworski and MatRIC's Director Simon Goodchild led a one day workshop at NMBU on developmental research within a framework of Inquiry Based Mathematics Education. This took place at the end of November 2018.

Research activity includes the survey of active learning approaches in which MatRIC is collaborating with The Mathematics Council of Norway (NMR). Also, there is a research element embedded within each of the actions described below in the section "MatRIC as a change agent."

MatRIC as a change agent within the University of Agder

MatRIC has been working as a change agent at a range of levels (departmental, course, individual teacher) at UiA to initiate, support and evaluate innovations in the teaching and learning of mathematics. Here we focus on four such initiatives: one at course level, one at departmental level and two with individual colleagues.

In common with many university programmes in economics, both in Norway and internationally, there has been at UiA a recurrent problem of unsatisfactory performance of students in the mathematics course leading to higher failure and drop out, poor performance and progression. MatRIC is determined to address this. With additional support from internal research and development funds, and collaboration between UiA School of Business and Law and the Department of Mathematical Sciences, Ida Landgärds, one of MatRIC's PhD fellows is working to transform students learning experiences on the Mathematics for Economics course. The mathematics course was moved from the first to the second semester, thus allowing the creation of a pre-mathematics course to bridge between school mathematics and the university course. Ida created an on-line diagnostic instrument that students could test their knowledge and need for the pre-course. She also constructed the pre-course which combined on-line study materials,

lectures and problem-solving workshops. The response from students has been very positive and we are looking forward to evidence of impact at the conclusion of the regular mathematics course in the late spring.

The Engineering Department implemented an innovation to support incoming students in a programme called First Year Study Environment (FYSE). The Mathematics teachers also implemented approaches to engage students with greater commitment to the group work activities. MatRIC's researcher Hans Kristian Nilsen worked alongside this course generating data to explore the impact on students learning experiences. We look forward to the results from his work.

The basic Calculus 1 course provided within the Department of Mathematical Sciences included a pilot study using peer assessment based on comparative judgement. This study was inspired by the instructor's engagement in MatRIC activities. The study will be reported at the MNT Conference in Tromsø on March 28-29.

Also to be presented at the MNT conference, will be a report of an innovation in the use of 'podcasts' recorded by an instructor with the intention that students should listen to these approximately 10 minute recordings to prepare them for the lecture ahead. MatRIC's researcher Kirsten Bjørkestøl has been collaborating with the instructor to analyse teaching and learning analytics arising from the course to expose evidence of impact.

i. Activities/projects have had the desired results!

It is difficult to capture with hard evidence the feeling of excitement within MatRIC's activity that developed through 2018. During the autumn it seemed that many of the plans and actions that had been pursued over the previous four and a half years of MatRIC were bearing fruit in terms of enthusiastic engagement of mathematics teachers both at UiA and nationally. MatRIC events were well-attended. The engagement of MatRIC with the national bodies such as UHR and NMR revealed that MatRIC was being perceived as a valuable partner in education. MatRIC's influence was extending beyond mathematics within UiA – collaboration with the Centre for Teaching and Learning, the development of a new learning support centre, in the process for evaluating applications for 'excellent teacher' (meritteringsordning), and consultancy for new proposals for SFU status. Nationally, especially through the 2018 annual conference MatRIC was able to promote student engagement in education beyond the community of mathematics teachers by dedicating a day of the conference to the theme and including presentations from other SFUs – bioCEED, and CEMPE.

ii. Activities/projects that have not had the desired results and the lessons learned.

MatRIC has pursued the idea of developing a project modelled on the PIC-Math project in the USA (Preparation for Industrial Careers in Mathematics). The project is based upon close collaboration with enterprises that provide problems and some mentoring for university mathematics students modelling activity. MatRIC has invested time and resource to develop knowledge of the project and attempts to recruit local enterprises to participate. However, the reactions from local companies has not been enthusiastic and although there is a well-developed culture for internships in engineering, there appears to be little appetite for similar engagement in mathematics. The project in the USA is based on collaboration with very large corporations and research institutes that are not matched in Agder. It is also likely that if we were able to implement a similar project at UiA it would involve a rather small group of students, it is likely then that MatRIC's resource can be directed more effectively. With some reluctance we have decided against pursuing this further.

iii. MatRIC has been faithful in pursuing the action plan agreed with the mid-term evaluation panel.

Dissemination

As explained above, MatRIC's activity external to UiA is fundamentally about building a sustainable community of inquiry in learning and teaching mathematics.
MatRIC disseminates vision and mission. To this end we have:

- Presented MatRIC at subject groups of Universities Norway (UHR) for Mathematics Science and Technology (MNT), and for Economics and Administration (ØA), and the Norwegian Mathematical Council. [Target Group – institutional leaders – Deans and Heads of Departments]
- Presented MatRIC on many higher education campuses around Norway – UiS, NTNU-Ålesund, UiT-Tromsø, UiT-Narvik, HVL-Bergen, HVL-Haugesund, NMBU. [Target Group – Mathematics teachers]
- At international Conferences – International Network for Dictdactic Research in University Mathematics (INDRUM) hosted by MatRIC at Kristiansand (5-7 April); SEFI-MWG conference in Coimbra Portugal (26-29 June); E-Assessment in Mathematics (EAMS) conference Newcastle University (MatRIC was a sponsor) (28-30 August). STACK Conference (Computer Aided Assessment) in Germany (November 15-16). [Target groups – international communities of mathematics teachers and mathematics education researchers]
- MatRIC's Mathematical Modelling Coordinator has brought together an international group in a successful ERASMUS+ Proposal that will explore active learning approaches to mathematics (Inquiry Based Mathematics education, blended learning). [Target groups – international communities of mathematics teachers].

MatRIC facilitates the enhancement and adoption of innovative practices in mathematics education. To this end we have:

- Organised a workshop on computer aided assessment in mathematics in Kristiansand (April 9-11). [Target group – Norwegian higher education mathematics teachers and connecting these with leading international mathematics teachers and innovators].
- Focused on innovation in teaching and learning calculus at the MatRIC annual conference in Gardermoen (September 17-18). [Target group – Norwegian higher education mathematics teachers and connecting these with leading international mathematics teachers and teaching developers].
- Focused on student engagement and student participation in education on the second day of the annual conference in Gardermoen (September 18). [All higher education teachers and educational leaders]
- Organised the teacher education workshop focusing on the use of GeoGebra in teaching and learning mathematics in Kristiansand (October 17). [Target group - Norwegian mathematics teacher educators and students in mathematics teacher education programmes]
- Collaborated with the SFU Centre for Computing and Science Education in the workshop on Programming and Simulation/visualization at Gardermoen 5-6 November. [Target group - Norwegian higher education teachers of mathematics, science and engineering]
- Presented a workshop on Inquiry based Mathematics education at NMBU Ås (November 30). [Target group – Mathematics teachers and mathematics education researchers at NMBU].

MatRIC stimulates sustainable self-generating change, to achieve this MatRIC has distributed research grants to groups led from HVL and NMBU. [Target group: the grants are open to all mathematics educators working in Norwegian institutions of higher education].

3. Aims of the SFU initiative: R&D-based education, integrated models and student engagement

The University of Agder has directed seven PhD fellowships to work within MatRIC and research the teaching and learning innovations that MatRIC initiates or supports. There are another two fellows that have chosen to research topics directly related to MatRIC's work. We await with interest the findings from these research projects. The research pursued aims to go into depth to understand better the nature of students' learning in the context of teaching innovation.

During 2019 MatRIC has made an effort to balance the in-depth qualitative research by the appointment of an experienced statistician as researcher and a new PhD fellow who is preparing for quantitative research

on large cohorts. We are currently negotiating with the Norwegian Data Protection Agency to gain permission to integrate teaching and learning analytics at individual student level. The General Data Protection Regulations introduced in 2018 impose strict requirements on eliciting students' consent to share data between different offices/functions within the university – even with the promise of complete anonymity before anything is seen by researchers. Briefly, we are making an effort to overcome obstacles and gain access to meaningful data that will enable us to make claims about the effect of MatRIC's actions on students' learning outcomes.

MatRIC's main focus is the teaching and learning of mathematics as a service subject. Superficially this seems an ideal context for developing courses in which the mathematics is integrated within other courses the subject serves. This has been attempted within the electrical engineering course at UiA. However, there are issues that have made permanent change very difficult to achieve. These issues include the need to ensure coverage of a syllabus in mathematics, that may not serve the concurrent subject studies, but rather subject studies that will be followed in later semesters. There is also a financial issue where mathematics as a service subject often happens in large classes that combine students from several programmes. In this latter situation MatRIC has been concerned to find ways to motivate students' engagement by making the mathematics more relevant. There are also issues where the service mathematics and the programme served 'belong' to different faculties (as with mathematics for economics). Integrated models of teaching and learning are an ideal for which MatRIC can campaign, but MatRIC does not 'own' programmes or courses and MatRIC has a limited resource (financial and human) that we use to be effective in authentic sustainable situations.

Student engagement in their education is prioritised within MatRIC's actions and we point to the development of student learning assistants, and the projects MatRIC has supported at UiA, in addition to the special feature at the annual conference in 2018.

4. Plan for 2019

MatRIC will continue to build on the successes it achieved in 2018 by implementing the following:

- Research fellows and supervisors' workshop in May (guest presenters Professors Pat Thompson and Marilyn Carlson from Arizona State University)
- Workshop on creativity and mathematics (guest speaker Professor Bharath Sriraman from University of Montana)
- Workshop on providing mathematics support (a collaboration with the German centre khdm to be held in Hannover. Guest speakers include Michael Grove, University of Birmingham UK; Dr. Ciarán Mac an Bhaird, Maynooth University, IRL; Professor Duncan Lawson, Coventry University UK).
- International research conference on teaching and learning Calculus at UiA Kristiansand
- Third cohort of mathematics teaching course begins autumn 2019 (this time in collaboration with khdm, guest speaker Emeritus Professor Tommy Dreyfus Tel Aviv University, Israel)
- MatRIC's sixth annual conference (Keynote speakers, Professor Michael Dorff, President of the Mathematical Association of America, Emeritus Professor John Mason Oxford University & Open University UK).
- Student Learning Assistant Camp – this year with UiA's Centre for Teaching and Learning.

In addition to the above specific events, MatRIC has plans to build on other positive developments from 2018 (and earlier) by

- Increasing the influence of MatRIC in the institutional structures of higher mathematics education in Norway (UHR-MNT, UHR-ØoA, NMR)
- Securing even greater levels of engagement with colleagues at other institutions through the MatRIC Contact Group.
- Embedding the culture of student partnership and expanding the work of student learning assistants and peer support, in courses and the MatRIC Drop-in.

- Improving communication and sharing MatRIC's vision for transformed and improved learning experiences in mathematics.
- Continuing to create and develop knowledge about higher mathematics education through our PhD fellows, MatRIC research awards, NMR-MatRIC survey of (active) learning approaches, and researching developments in teaching and learning mathematics at UiA.
- Promoting R&D based education and student engagement, at UiA and nationally.
- Further developing MatRIC as a forum for sharing and exchange of ideas to improve higher mathematics education through the events listed above, and the introduction of a MatRIC server that will be available through password protected log-in to mathematics teachers at other higher education institutions around Norway.

In light of the success of MatRIC's actions during 2018 as we have focused on implementing the revised action plan agreed from the mid-term evaluation, there is no need for adjustments of the centre's plans!

Appendix

In Table 1. below the left-hand column sets out MatRIC's objectives as in the agreed action plan for Phase 2, the numbers and headings correspond to the action plan. The right-hand column provides a very brief summary of MatRIC's actions during 2018 against each of these objectives. Following Table 1 we address key themes in MatRIC's activity, in many cases these combine several actions and objectives.

4.1 Primary Objective 1: Transforming students learning experiences.	
MatRIC's actions directed at students' learning to address issues of participation	
4.1.1 MatRIC TV.	Publication of all videos recorded for MatRIC is now complete and the videos are available at https://www.matric.no/tv. During 2019 we have discussed how MatRIC TV may be developed into a fully fledged learning resource with text, annimations and self-assessment quizzes. Discussion have been held with web-designers to provide a specification for the developments needed for the web-site prior to going out to public tender for the work.
4.1.2 Drop-in support.	Drop-in support centres on both Kristiansand and Grimstad campuses have continued and are now recognised as an element of UiA's student support provision. Discussions have been had with the German centre khdm to hold a joint workshop on student mathematics support. This will be held in June 2019.
4.1.3 Open lecture.	In 2018 MatRIC joined forces with TEKNA in the organisation of a Realfags day for upper secondary students. MatRIC's open lecture formed part of the programme at both Kristiansand and Grimstad campuses. The guest speaker was Magnus Dehli Vigeland.
4.1.4 Mathematics study skills course.	This was held at the Grimstad campus on September, 20. This was led by Professor Barbara Jaworski.
MatRIC's actions directed at involving students to improve educational provision	
4.1.5 Student Teaching Assistant development.	We now refer to these as student learning assistants. A two day 'camp' for learning assistants was held, August 9-10. Presentations at the camp included introductions to mathematics didactics, pedagogy, communication skills and mathematics problem solving.
4.1.6. Student internships.	Two interns were employed during the summer. These assisted MatRIC PhD fellow, Ida Landgärds in the development of resources for a pre-course in mathematics for students on the economics programme.
4.2 Primary Objective 2: Transforming mathematics teaching.	
4.2.1. Innovation networks	MatRIC's network for computer aided assessment joined with a similar Finnish network Abacus and held two days of workshop/seminar at UiA on April 11-12 (https://www.matric.no/events/27). MatRIC's Visualization and Simulation network joined with CCSE (SFU at UiO) to run a two day workshop on programming and simulation at Gardermoen, November 5-6 (https://www.matric.no/events/29).
4.2.2. Programme networks.	A discernible mathematics for engineering programme network has been established and MatRIC is leading the UHR – MNT subject group on developing learning outcomes for mathematics in engineering. A presentation at the end of 2018 to the UHR – Economics subject group has laid the foundation for the development of a network for mathematics in economics. Teacher Education network organised a workshop (October 17) focusing especially on the use of GeoGebra in illustrating and communicating mathematical ideas.

4.2.3. Mathematics teaching Induction course.	The cohort that started in 2017 completed all the work and attendance necessary to gain their certificates of participation. The course had two meetings during 2018, April 9-10 and June 6. Both sessions were at UiA, Kristiansand. A new course will be announced to commence autumn 2019, it is intended to develop collaboration with the German centre khdm this time.
4.2.4. Mathematics lunches.	These have continued to be organised at the Grimstad campus.
4.3 Primary Objective 3: Research	
4.3.1. Research seminars and workshops.	A major European research conference for the International Network for Didactics research in Undergraduate Mathematics was hosted by MatRIC at UiA, Kristiansand, April 5-7. The conference drew researchers from across Europe. North Africa and the USA. MatRIC combined with University of Athens mathematics education researchers to hold a seminar for our PhD fellows who are researching higher mathematics education. Locally, in Kristiansand leading international researchers in the field have presented their work in seminars, and forums specially designed for the PhD fellows. Invited speakers include: Anna Sfard, Elena Nardi, Candia Morgan, Despina Potari. Barbara Jaworski, with MatRIC colleagues led a workshop in developmental research in inquiry based mathematics education at NMBU at the end of November.
4.3.2. Small R&D grants.	A new round of small grants was announced, this time with the option of a significantly larger amount than the 50K NOK that had previously been the upper limit. Two grants of 250K NOK were awarded following evaluation of proposals, one to a group led from HVL, and the other a group led from NMBU.
4.3.3. International engagement and networking.	See above: several entries include significant international collaboration and networking. In addition we note: Yuriy Rogvchenko was successful in bringing together an international group to obtain ERASMUS+ funding for the PLATINUM project (https://www.matric.no/articles/123). Morten Brekke has presented MatRIC at several international conferences (Portugal, UK, Germany). Frode Rønning has been leading the collaboration with the German centre khdm. MatRIC conference included leading researchers from the USA and UK, and HE teaching developers from the UK.
4.3.4. Systematic inquiry into MatRIC's actions.	During 2018 MatRIC recruited a new PhD fellow (started January 2019) and appointed two full-time researchers to focus on systematic inquiry into mathematics teaching development, starting at UiA, we hope to move beyond the institutional boundaries later. The researchers represent interpretive and positivist traditions, the PhD fellow was recruited especially to help develop quantitative approaches.
4.3.5. White papers.	White papers have not yet been produced. MatRIC has contributed to national developments: Frode Rønning prepared a response to 'Leidutvalgtet' on behalf of MatRIC. Simon Goodchild prepared a response to the school curriculum development committee.

4.4. Secondary Objective (a) didactical development of student teaching assistants (STAs);	
4.4.1. Summer training camp.	See above: 4.1.5. An outcome of the camp has been collaboration with the university centre for professional development (PULS). Previously had tried to establish a course for learning assistants, but with very little response from students or departments. Using MatRIC's success to provide a critical mass, PULS and MatRIC are collaborating to extend MatRIC's course to be university-wide.
4.4.2. Regular mentoring of STAs.	The regular meeting of student learning assistants with the teachers of courses they support is strongly encouraged by MatRIC. Support is offered in the form of refreshments and hours on students' contracts.
4.5. Secondary Objective (b) development of students as partners in learning, teaching and assessment;	
4.5.1. Internships.	See above: 4.1.6
4.5.2. Student teaching assistants.	See above: 4.1.5, 4.4.1, 4.4.2
4.5.3. Engaging with and learning from external networks.	See above: 4.3.1, 4.3.3
4.6. Secondary Objective (c) development of active learning approaches, developing innovative approaches for teaching and assessment.	
4.6.1. MatRIC R&D grants.	See above: 4.3.2
4.6.2. Participation in MatRIC innovation networks.	Network events for computer aided assessment, visualisation and simulation, and teacher education have attracted pleasing levels of participation and interest. See 4.2.1, 4.2.2.
4.7. Tertiary Objective (i) to influence course structure and content	
4.7.1. White papers	See above 4.3.5
4.7.2. Ambassadors.	Arvid Siqveland visited the Haugesund campus of HVL. Frode Rønning made use of his research leave in Germany to develop the collaboration with khdm. Morten Brekke visited UiStavanger, and with Simon Goodchild UiT (Narvik and Tromsø campuses), HVL (Bergen and Haugesund campuses), NTNU (Ålesund campus). The result of the national activity has been the development of a MatRIC contact group, composed of colleagues from most campuses in which mathematics is a significant part of the educational portfolio.
4.7.3. Local coordinators.	The result of the national activity outlined immediately above has been the development of a MatRIC contact group, composed of colleagues from most campuses in which mathematics is a significant part of the educational portfolio.
4.8. Tertiary Objective (ii) to influence programme design and implementation.	
4.8.1. White papers **4.8.2. Ambassadors** **4.8.3. Local coordinators**	See above
Dissemination	

Dissemination for Awareness	*MatRIC web site; MatRIC Newsletter; Social media; SFU Magazine; Personal contact.* Personal contact remains the most effective way of making MatRIC's activities known. Despite announcements on the MatRIC web-page, Newsletters and social media, it is still necessary to send personal e-mails (around 150 individually addressed) to gain attention.
Dissemination for Understanding	*Workshops, colloquiums, symposiums, seminars, conferences; Journal articles; Mathematics Teachers' Lunches* MatRIC's national activity is focused on the organisation of events that bring mathematics teachers together. To have presentations by internationally highly regarded scholars and teachers, as well as 'local' input from Norwegian institutions. A significant amount of MatRIC's budget, and human resource is expended on making these events possible. The events seek to develop an understanding of teaching development for excellence, to move towards MatRIC's vision of students enjoying transformed and improved learning experiences of mathematics. In addition, through the events we hope to develop a national identity for MatRIC, and a national community that shares a sense of ownership of MatRIC, and MatRIC's vision, goals and actions.
Dissemination for Action	*Networks' activities (other than events); Induction Teaching course;* So far, the up-take on the teaching development course has been rather small. We hope as the course continues and becomes known it will prove more popular. Participation in the network events is also stimulating engagement and action – designing assessment tasks, designing simulations, engaging further with software such as GeoGebra.
Dissemination for self-generating sustainable development	*MatRIC small research grants; Support for innovation and collaboration.* We wait to evaluate the impact of the larger research grants within the communities to which they are awarded. The smaller grants were not as popular as anticipated, probably because it is not too difficult to find similar amounts of support from within institutions.

Table 1. Summary of MatRIC's actions during 2019 referenced to objectives in the action plan for phase 2.

Attachments to the report:

o Personnel
o Financial accounts (submitted to Diku earlier)
o Publications

Attachments

1. Personnel

Simon Goodchild	Director
Thomas Gjesteland	Co-Director
Lillian Egelandsaa	Project Manager
Morten Brekke	Contact Group, Computer Aided Assessment, Video
Per Henrik Hogstad	Simulation, visualization, programming
Yuriy Rogovchenko	Mathematical modelling, Leader of Erasmus+ project PLATINUM
Linda G. Opheim	Mathematics Teacher Education (designated coordinator)
Barbara Jaworski	Research Coordinator
Svitlana Rogovchenko	Drop-in Leader (Grimstad)
Anne Berit Fuglesatd	Drop-in Leader (Kristiansand) until August 2018
Elna Svege	Drop-in Leader (Kristiansand) from September 2018
Hans Kristian Nilsen	Researcher
Kirsten Bjørkestøl	Researcher
Yannis Liakos	PhD fellow
Shaista Kanwal	PhD fellow
Helge Fredriksen	PhD fellow
Henrik Kjelsrud	PhD fellow
Ida Landgärds	PhD fellow
Yusuf F Zakariya	PhD fellow

Administrative support

Elisabeth Rasmussen	Conferences and events
Ling Jiang	Travel, accommodation, contracts
Ninni Marie Hogstad	Conference web-site, proceedings, support.

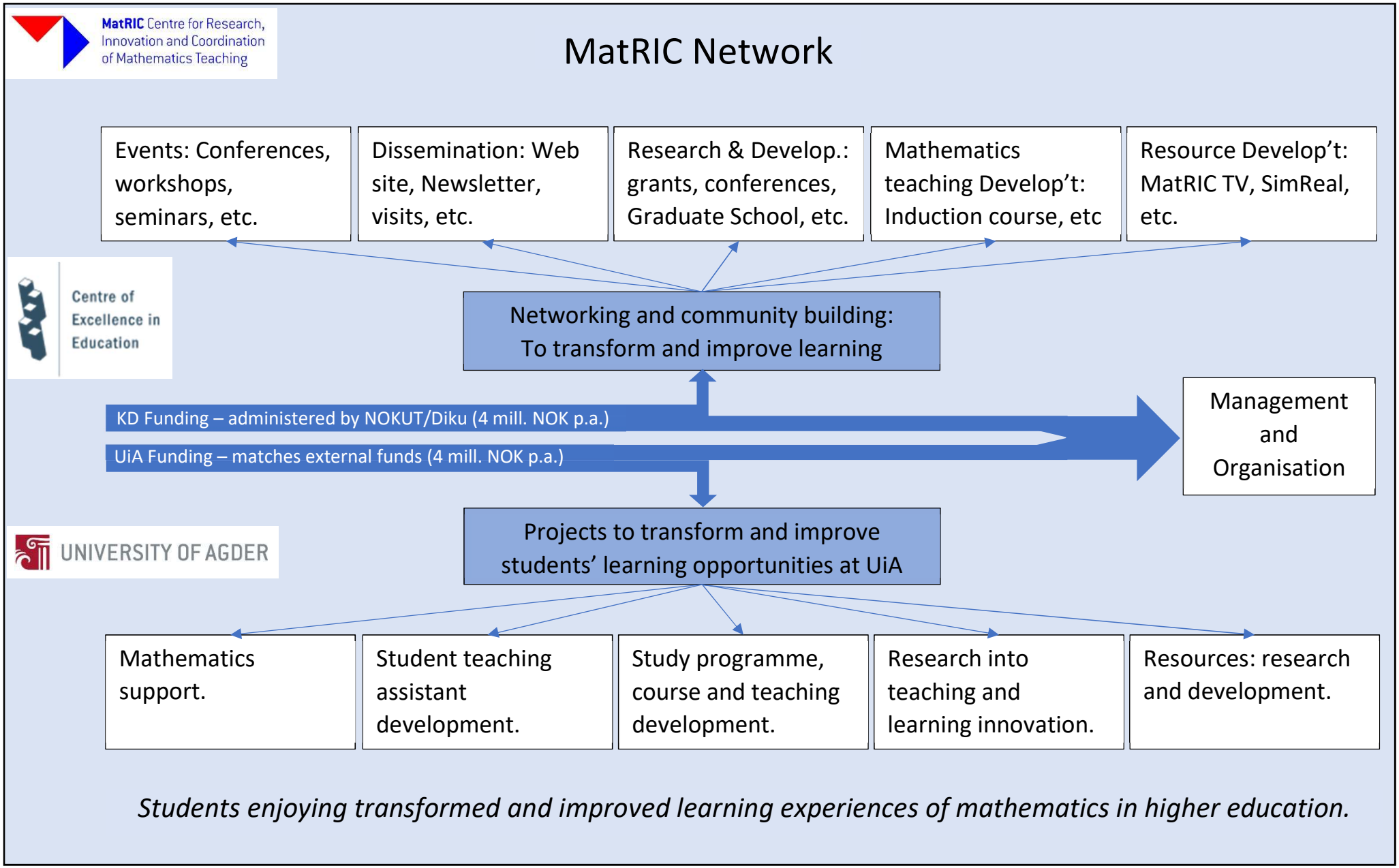
2. Budget Commentary

MatRIC receives 4 mill. NOK from KD distributed by NOKUT/Diku. An additional 4 mill. NOK is received received from the University of Agder (3 mill. From central allocation and 1 mill. From the Faculty of Engineering and Sciences).

Conceptually the use of funds differs from that detailed in the accounts. MatRIC's budget is used in three conceptual areas: Centre costs, mainly for personnel, external costs supporting dissemination and events, and internal costs supporting MatRIC's actions within UiA.

- Centre costs are covered jointly by funds coming from KD (NOKUT/Diku) and funds from UiA.
- External costs are covered by the remainder of funds coming from KD (NOKUT/Diku).
- Internal costs are covered by the remainder of funds coming from UiA.

This distribution is illustrated by the graphic on the following page:


MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching
MatRIC Network
Events: Conferences, workshops, seminars, etc.
Dissemination: Web site, Newsletter, visits, etc.
Research & Develop.: grants, conferences, Graduate School, etc.
Mathematics teaching Develop't: Induction course, etc
Resource Develop't: MatRIC TV, SimReal, etc.
Centre of Excellence in Education
Networking and community building: To transform and improve learning
KD Funding – administered by NOKUT/Diku (4 mill. NOK p.a.)
UiA Funding – matches external funds (4 mill. NOK p.a.)
Management and Organisation
UNIVERSITY OF AGDER
Projects to transform and improve students' learning opportunities at UiA
Mathematics support.
Student teaching assistant development.
Study programme, course and teaching development.
Research into teaching and learning innovation.
Resources: research and development.
Students enjoying transformed and improved learning experiences of mathematics in higher education.

3. Publications

Abboud, M., **Goodchild, S., Jaworski, B.**, Potari, D., Robert, & A., Rogalski, J. (2018). Use of activity theory to make sense of mathematics teaching: A dialogue between perspectives. *Annales de Didactique et de Sciences Cognitives ;Vol. Spécial English-French*: p. 61-92.

Brekke, M. (2018). *Deling av god utdanningspraksis i matematikk på tvers av institusjoner*. Pulslunsj, Kristiansand, Universitetet i Agder.

Brekke, M. (2018). *Development of new content in Mathematics for pre-Calculus students using STACK at University of Agder*. Paper presented at the 1st Annual Stack Conference, Fürth, Germany. https://www.stack-konferenz.de/

Brekke, M. (2018). *Erfaringer med Digital eksamen innen tekniske fag*. Konferanse om norsk 3 årig ingeniørutdanning med vekt på tema innen kjemi og matematikk, Forskerforbundet. Bergen, Høgskolen på Vestlandet.

Brekke, M. (2018). *Presentasjon av MatRIC*. Utdanningsseminar "Mot fremragende fagmiljø innen MNT-utdanning på TN", Stavanger, Universitetet i Stavanger. https://ansatt.uis.no/aktuelt/article122850-2955.html

Brekke, M. (2018). *New pre-Courses in Mathematics for Economy and Engineering using e-Assessment, supported by MatRIC*. E-Assessment in Mathematical Sciences – EAMS Concerence 2018, Newcastle, Newcastle University. https://eams.ncl.ac.uk/

Brekke, M. (2018). *Teaching Mathematics for Engineers as the Norwegian National Framework suggests – is it possible?* Keynote at the 19th SEFI-MWG European Seminar on Mathematics in Engineering Education, Coimbra, Coimbra Institute of Engineering. https://www.isec.pt/eventos/SEFIMWG2017/Default.aspx

Brekke, M. (2018). *Teaching Mathematics for Engineers using short videos and Digital assessment tools*. Instead – II Workshop on Innovative Teaching Methodologies for Math Courses on Engineering degrees, Porto, Instituto Superior de Engenharia do Porto (ISEP). http://www.isep.ipp.pt/Page/ViewPage/WorkshopII

Durand-Guerrier, V., Hochmuth, R., **Goodchild, S., & Hogstad, N.M.** (Eds.) (2018), *Proceedings of the Second Conference of the International Network for Didactic Research in University Mathematics (INDRUM 2018, 5-7 April 2018)*. Kristiansand, Norway: University of Agder and INDRUM.

Fredriksen, H. (2018). An exploration of teaching and learning activities in flipped mathematics classrooms for engineers*. Seminar for researchers and students at "Centre for Research In Mathematics and Science Education" at San Diego State University*: 2018-09-24

Farstad, W., & **Fredriksen, H**. (2018). Samkjøring av undervisning for campus, fjerncampus og nettstudenter, praktiske erfaringer*. Konferanse-foredrag på «Rom foraktive studenter» ved UiT-Tromsø 2018-11-29 - 2018-11-30.*

Fredriksen, H. (2018). Analyzing tasks for the Flipped Classroom from the perspective of Realistic Mathematical Education. MatRIC seminar, Athens, 22nd to 24th of May 2018.

Gjesteland T., Vos P., & Wold M. (2018). Mathematical modelling and activation – a study on a large class, a project-based task and students' flow (2018). In V. Durand-Guerrier, R. Hochmuth, S. Goodchild, & N.M. Hogstad (Eds.), *Proceedings of the Second Conference of the International Network for Didactical Research in University Mathematics*. (pp. 175 – 184). Kristiansand, Norway: University of Agder. Kristiansand, Norway: University of Agder and INDRUM.

Gjesteland, T., **Wold, M., & Vos, P.** (2018). Students experiencing flow in a mathematical modelling task. MatRIC conference 17.-18. Sept 2018

Goodchild, S. (2018). Students enjoying transformed and improved learning experiences of mathematics in higher education. *Presentation to UHR-MNT meeting Bergen April 26, 2018*.

Goodchild, S. (2018). Introduction to MatRIC. *Presentation to NMR meeting Oslo September 20, 2018*.

Goodchild, S. (2018). Mathematics teaching development in higher education. *Presentation to PhD Workshop/seminar Athens May 23-24, 2018*.

Goodchild, S. (2018). MatRIC, a Norwegian centre for excellence in mathematics higher education – foundation, paradigms and research. Presentation at research seminar Copenhagen University March 7, 2018.

Hadjerrouit, S., Gautestad, H. H. (2018). Using the visualization tool SimReal to orchestrate mathematical teaching for engineering students. *IEEE Global Engineering Education Conference, EDUCON;Vol. 2018-April*: 38-42

Hillesund, E. (2018). Using schematic representation of resource systems to examine how first year engineering students use resources in their studies of mathematics. In V. Durand-Guerrier, R. Hochmuth, S. Goodchild, & N.M. Hogstad (Eds.), *Proceedings of the Second Conference of the International Network for Didactical Research in University Mathematics*. (pp. 185-186). Kristiansand, Norway: University of Agder. Kristiansand, Norway: University of Agder and INDRUM.

Hillesund, E. (2018). Using an app to collect data on students' use of resources for learning mathematics. In Gitirana, V., Miyakawa, T., Rafalska, M., Soury-Lavergne, S., & Trouche, L. (Eds.), *Proceedings of Re(s)sources 2018 International Conferens ENS de Lyon May 2018* (pp. 283-287). Lyon, France: ENS de Lyon

Hillesund, E. (2018). First year engineering students' use of resources to learn mathematics. *First year seminar at University of Agder, March 1*.

Hillesund, E. (2018). Presentation of own analysis work at Research fellows' day at University of Agder, September 21.

Kanwal, S. (2018). **Mathematical Competencies and E-Learning: A Case Study of Engineering Students' Use of Digital Resources**. In A. Weinberg, C. Rasmussen, J. Rabin, M. Wawro, and S. Brown (Eds.), *Proceedings of the 21st Annual Conference on Research in Undergraduate Mathematics Education*, San Diego, California.

Kanwal, S. (2018). **Engineering students' engagement with resources in an online learning environment**. In V. Durand-Guerrier, R. Hochmuth, S. Goodchild and N. M. Hogstad (Eds.), *Proceedings of Second conference of the International Network for Didactic Research in University Mathematics (INDRUM)* (pp.145 – 154), Kristiansand: University of Agder and INDRUM.

Landgärds, I. (2018). Mathematics Teaching for Economics Students, But How?. In V. Durand-Guerrier, R. Hochmuth, S. Goodchild & N.M Hogstad (Eds.), *Proceedings of the Second Conference of the International Network for Didactic Research in University Mathematics (INDRUM 2018, 5-7 April 2018),* (pp. 187-188). Kristiansand, Norway: University of Agder and INDRUM.

Landgärds, I. (2018). Project presentation at Instituttseminar for nordisk og medifag in Lyngdal 14 June.

Landgärds, I. (2018). Project presentation at the UHR-ØA seminar at the business school of UiA, 12 November.

Landgärds, I. (2018). Project presentation at the DDU seminar at University of Agder, 18 December.

Landgärds, I. (2018). Project presentation video recorded as short videos for the DDU-project follow up: "sharing of experience from Canvas use."

Liakos, I. E., Rogovchenko, S., Rogovchenko, Y. (2018). A New Tool for the Assessment of the Development of Students' Mathematical Competencies. In: *The 19th SEFI Mathematics Working Group Seminar on Mathematics in Engineering Education*. (pp. 158-163). Coimbra, Portugal: European Society for Engineering Education.

Liakos, I. E., & Rogovchenko, Y. (2018). Assessing the Development of Students' Mathematical Modeling Competencies: An Information Entropy Approach. *In A. Weinberg, C. Rasmussen, J. Rabin, M. Wawro, and S. Brown (Eds.), Proceedings of the 21st Annual Conference on Research in Undergraduate Mathematics Education* (pp. 213-225), San Diego, CA.

Rogovchenko, S., Rogovchenko, Y., & Thomas, S. (2018). Non-standard Problems in an Ordinary Differential Equations Course. In V. Durand-Guerrier, R. Hochmuth, S. Goodchild & N.M Hogstad (Eds.), *Proceedings of the Second Conference of the International Network for Didactic Research in University Mathematics (INDRUM 2018, 5-7 April 2018)*; (pp. 189-190). Kristiansand, Norway: University of Agder and INDRUM.

Rogovchenko, S., Rogovchenko, Y., & Thomas, S. (2018). The use of nonstandard problems in an ODE course for engineering students. In Bergquist, M. Österholm, Granberg, L. Sumpter. (Eds.), *Proceedings of the 42nd Conference of the International Group for the Psychology of Mathematics Education Vol. 4* (pp. 283-290). Umeå, Sweden: International Group for the Psychology of Mathematics Education.

Thomas, S., **Rogovchenko, S., & Rogovchenko, Y**. (2018). Development of Students Mathematical Discourse through Individual and Group Work with Nonstandard Problems on Existence and Uniqueness Theorems. *In A. Weinberg, C. Rasmussen, J. Rabin, M. Wawro, and S. Brown (Eds.), Proceedings of the 21st Annual Conference on Research in Undergraduate Mathematics Education* (pp. 1611-1612), San Diego, CA.