MatRIC, Centre for Research, Innovation and Coordination of Mathematics Teaching

Mid-term Self-Evaluation. March 2017.

Summary

- MatRIC is leading, promoting and disseminating excellence in development and research based education to enhance mathematics learning in higher education (HE) throughout Norway.
- MatRIC is lifting the status, and informing the discussion about quality of teaching and learning mathematics in Norwegian higher education institutions (HEIs).
- MatRIC is networking Norwegian HE mathematics teachers and mathematics education researchers and recognised international experts, to share and learn excellent practices.[1]

I. The goals put forward in MatRIC's application

1. Aims, objectives and achievements

MatRIC confronts major challenges in HE mathematics education in Norway – poor performance, poor progression and retention, and high failure rates (KfK, 2.4, 36-37). MatRIC's goal is to address these challenges and bring about university level education in mathematics that results in:

- *Motivated students, who enjoy mathematics and appreciate the relevance of mathematics.*
- *Students who understand fundamental mathematical ideas so that they can apply relevant mathematics to resolve non-routine problem situations.*
- *Students who have strategic knowledge and awareness of mathematics that enables effective problem solving and self-regulation.*
- *Students who have procedural fluency and reliability in routine operations and calculations.*
- *Students who possess competencies in mathematical modelling and the application of mathematics in the problems encountered in the work place and applied research situations.*

(MatRIC SFU Proposal, Section 3, p. 6).

To understand MatRIC's approach, one needs to appreciate the prevailing culture of HE mathematics teaching. The dominant methodology is for teachers to develop mathematical arguments for students and to demonstrate the production of mathematics.[2] Particularly in 'user subjects', mathematics lectures are delivered to large heterogeneous classes (often of several hundred). Traditionally, students remain largely passive in such lectures (apart from copying what is written on the board). This tradition is accompanied by scepticism about the value of modern technology and alternative approaches to learning. In addition, the HE mathematics community is

[1] This success story is consistent with the goal set out in KD (2016) Kultur for kvalitet I høyere utdanning, Melding til Stortinget 16, 2016-2017. [Culture for quality in higher education, Government white paper 16, 2016-2017]. https://www.regjeringen.no/no/dokumenter/meld.-st.-16-20162017/id2536007/ References to the 'white paper' will appear throughout this document as follows (KfK, para. number, page number).

[2] https://www.lms.ac.uk/sites/lms.ac.uk/files/Mathematics/Policy_repors/2010%20teaching_position_statement.pdf

fragmented, as eloquently described by one member of the community (Informant A):[3]

My perception of the community of professionals involved in teaching of mathematics in higher education is that an individual belongs to one of four groups:

- *Researcher in pure or applied mathematics with teaching duties*
- *Teacher at a university college with a background in pure or applied mathematics*
- *Teacher at a university college with a background in mathematics education*
- *Researcher in mathematics education*

I sense that there are several competing culturally founded hierarchies between these groups from different universities and university colleges, hence the amount of constructive interaction is usually kept to a minimum. The interests and viewpoints of people from the different groups are surprisingly different and incompatible.

MatRIC challenges the culture of teaching in HE that resists change - through the creation of networks, safe spaces and opportunities for dialogue about learning and research based teaching, and by engaging teachers from HEIs across Norway in innovation and research.

MatRIC proposed four work packages (WP) to drive this culture change: WP1 Networking; WP2 Promotion and evaluation of innovation; WP3 Development of modelling and simulation learning resources; WP4 Dissemination. Each WP has discrete tasks. Red/Amber/Green assessment of progress, and impact, with each of these tasks are presented in Appendices 1 & 2 (pp. 16 & 17).

From the outset, MatRIC made it clear that its aim was to be a ***Norwegian*** Centre *for* Excellence, not a ***UiA*** Centre *of* Excellence. Crucial to this aim has been securing the active participation of colleagues from institutions across Norway as part of MatRIC's community of practice. MatRIC has been successful here, with 535 delegates participating in MatRIC events. This represents 295 different individuals from 14 different Norwegian HEIs. In fact, there are only two target institutions[4] (Volda U. C. & Norwegian School of Economics) from which there has been no participation. In addition, there have been participants from NOKUT, the Ministry of Education and Research, Norwegian Association of Higher Education Institutions (UHR), Norwegian Centres for Mathematics Education (NSMO) and ICT Education, and about 25 international institutions.

It is possible to participate in MatRIC's activities at several degrees of engagement, from the periphery for those who merely wish to know more, through to those active within MatRIC and contributing through designing and delivering innovation projects, developing new learning resources, and piloting the use of new technologies in teaching. MatRIC welcomes all degrees of participation and aims to draw those on the periphery into greater engagement in MatRIC's activity.

[3] Names and institutions of informants (other than students) are available on request, contact MatRIC's Director.
[4] By 'target institution' we mean a state HEI in which mathematics is taught as a service subject.

MatRIC proposed to establish Special Interest Groups (SIG); these were re-named 'networks', to lower the perceived threshold of participation. Networks cover: video instruction, computer aided assessment (CAA), visualisation & simulation, mathematical modelling and teacher education. Space constraints preclude a full account of their successes; however, two brief examples are given.

Example 1: The CAA network has evolved into a European expert group with international experts participating in MatRIC annual conferences, and meetings of the network now take place around Europe and Norway. Informant B describes the value of his participation in this network as follows: *Through MatRIC's network, we have the opportunity to share information with other Norwegian HEIs, about NUMBAS* [a CAA package] *and other tools. We see the outlines of interesting collaboration in the development of similar*[assessment] *tasks, especially directed towards similar foundation subjects in mathematics within undergraduate engineering programmes … MatRIC has made a positive contribution to our developmental processes … making it possible to measure our own activity against expert international groups.* [Translated from Norwegian].

Example 2: The SFU proposal deliberately gave SIGs (now networks) the opportunity to develop their own directions in line with the overall aims of the SFU. The video production network, in collaboration with UHR, has established MatRIC TV, an online bank of tutorials to support transition in mathematics from school to university. Around 70 videos have been published with a similar number going through the final stages of quality control. This resource is not yet complete, and has not been extensively publicised, nevertheless it has been receiving around 1000 visits per month over the last year.

Whilst MatRIC promotes innovation, it is also a fundamental belief that innovation must be rigorously evaluated and underpinned by high quality educational research (KfK, 3.1, 45; indeed, R&D-based education is at the heart of the whole SFU programme). Within WP2, MatRIC funds a post-doctoral researcher and six PhD fellows, in addition to the work of many academic staff connected with MatRIC. Between them, they have produced a wide range of R&D reports (available on the MatRIC website), made presentations at national and international conferences and published in scientific journals. Especially of note are the research projects stimulated by MatRIC grants. A key achievement in WP2, which goes beyond the original proposal, has been the establishment of a Norwegian research group in HE mathematics education. MatRIC has been fortunate to secure the services of an International Expert Research Coordinator (K) to provide scientific leadership for this group.

MatRIC's goal is to engage students in research and development based education, and thus achieve the learning goals set out at the beginning of this report (KfK, 3.1, 45). The tasks within WP3 are principally the domain of the Mathematical Modelling Network. The success of the network is

evident in the collaboration with bioCEED and the positive impact on biology students' learning and motivation. MatRIC is collaborating with bioCEED and the Mathematics Department at UiB to address concerns about biology students' motivation to study, and performance in, mathematics. A small MatRIC developmental research team has been piloting biological mathematics modelling activities with first year biology students. The students have been very receptive and responded positively to this pilot study, as indicated by the following representative comments in an evaluation questionnaire: The best thing about the activity was … "*It put the mathematics in content* [context?] *with what I'm studying and with what I ultimately want to work with (research).*" (Student α). "*It was great to get an insight in how math can be used to solve realistic biological problems. It was a lot of fun (even though we did a lot of horrible math).*" (Student β).[5]

This network is successfully stimulating innovation, research and cross-field collaboration in mathematics teaching such as a project inspired by international presenters in the 2016 Modelling Colloquium (cf. Section 8, Case 1). The network is also highly successful in connecting with teachers and researchers internationally, including several EEA funded research and development projects with groups in the Czech Republic. These international connections are the outcome of determined effort, which has also resulted in collaboration with colleagues in the US that will ensure the success of Task 3.1 (cf. Appendix 1) in the remainder of this first funding period.

New tasks and objectives that have emerged as MatRIC has developed

It is a sign of the health of MatRIC that some tasks (such as 4.2, the establishment of a professional journal) should drop off the agenda (see Section 4 below) and others added as MatRIC develops a deeper understanding of the context and greater exposure to leading international practices. Consequently, MatRIC has added two major strands to its programme of activities:

1. Development of mathematics support – 'MatRIC Drop-in'.
2. Professional development for teaching HE mathematics, for teachers and student assistants.

The initiative to develop mathematics support through the provision of drop-in centres came about through interaction with the international community. This approach has proved highly successful in the UK, Ireland and Australia. In the UK's Centre for Excellence programme, **sigma**, one of the most successful centres, focused solely on mathematics and statistics support. Drop-in centres have been established on both UiA's campuses and students' usage of these centres has shown significant growth. Drop-in support has been shown to be an effective way of improving retention and helping students to succeed.[6] Student feedback about the value of this service is almost unremittingly

[5] These student quotes illustrate that MatRIC has been successful in addressing the aims quoted on page 1 of this document, notably *enjoying mathematics and appreciating the relevance of mathematics*.

[6] O'Sullivan, C., Mac an Bhaird, C., Fitzmaurice, O. and Ni Fhloinn, E (2014) *Student Evaluation of Mathematics Learning Supoort*, MCE-MSTL, Limerick, Ireland.

positive with the following being typical of the sentiments expressed in Drop-in centre evaluations: "*[You] receive help at exactly your level. The mentors are clever to be considerate that some individuals have much worse foreknowledge than others." (Student γ). "One gets help to solve tasks, and can ask about things which subject lecturers will not go through (when it is perhaps conceived as basic)." (Student δ)*

Initial pedagogic training (induction) for academic staff was introduced by the Higher Education Academy's Maths, Stats & OR Subject Centre in the UK over 10 years ago, followed a few years later by briefer training for student teaching assistants. The purpose of this training is to provide a highly subject specific addition to generic teaching development courses that are delivered by many universities for new staff. The unique nature of mathematics as a discipline makes such a subject specific focus highly valued by participants. MatRIC delivered a pilot induction course in 2015-16, with over 70% of respondents agreeing with the statements: 'The course has led me to think more deeply about teaching and learning,' and 'the course has motivated me to explore new approaches to teaching and learning that I may want to implement in the future.' A second course is planned to begin in 2017. Teaching education for student teaching assistants is another new development that MatRIC will pilot for the first time in 2017.

2. Greatest achievements

MatRIC's proposal assumed that enduring improvement in students' learning experiences in HE mathematics requires working with the teachers of mathematics in HEIs. Sustainable transformation of teaching will impact generations of students, whereas working directly with students may impact only the cohort involved. MatRIC works to develop R&D based education and student engagement because we believe they are characteristics of excellent education, and MatRIC must be a showcase of excellence as well as a driving force *for* excellence. The development of 'drop-in' support centres, MatRIC TV and the expansion of the CAA network into a European group are achievements that deserve recognition. However, MatRIC seeks transformed teaching, sustained by learning communities of stakeholders that include teachers of mathematics and the subjects that use mathematics, researchers of mathematics and mathematics education, AND students. MatRIC seeks nothing less than to change the prevailing culture of teaching and learning mathematics.

Lasting culture change does not happen overnight. Midway through MatRIC's first period of SFU funding, it would be an exaggeration to claim that the desired culture change has been secured – and indeed, it was never envisaged that such a sizeable change could be achieved in relatively such a short time. However, MatRIC can assert with pride that there has been a noticeable shift. Matters relating to learning and teaching are higher on the agenda within the HE mathematics community than ever before. Engagement in these issues takes place at a variety of levels, ranging from

colleagues who attend a ‘mathematics teachers lunch’ (a MatRIC innovation at UiA) to spend an hour of their time debating a current ‘hot topic’ in teaching, through those who participate in a MatRIC workshop and consequently modify their classroom practice, to those who collaborate with their own students and with colleagues around Norway (and possibly internationally) to develop new learning resources to enhance student motivation and encourage their engagement in deeper learning of mathematics.

Thus, MatRIC’s greatest achievement lies in the cultural change that MatRIC is creating through the development of networks and breaking through the intellectual barriers between the stakeholder groups. The networks include the four stakeholder groups across UiA, throughout Norway and internationally. MatRIC conferences and events, engagement with the international community, the research grants, and mathematics lunches all contribute to the development of this community of HE mathematics teachers. MatRIC’s achievement is nicely summarised by Informant A:

The main goal for me is that "my students learn more mathematics in a better way", and I think that this goal can be achieved with more exchange of knowledge and experience between the four groups [see p.2 of this report]. *For me, the most important input from the MatRIC-events is the network of colleagues that I get to meet and discuss different issues regarding teaching of mathematics with. I find it very interesting to pick up and try different ideas and tools; for example, visualization tools, assessment tools, tools for student interaction in the classroom and so on. The MatRIC-conference recognizes teaching as something important, … I think that perspective is essential to reach the goal of better teaching,*

MatRIC seeks *better* teaching and sustainable improvement in students’ learning, and will continue to nurture and develop the networks and MatRIC’s community because these facilitate the flow of knowledge, experience and expertise that drives efforts to attain excellence in students’ learning.

3. Innovative features

We cite three features: Inclusion of teachers; Engagement of students; Importation of practice.

Inclusion of teachers. MatRIC challenges unhelpful boundaries and rivalries that hinder the flow of knowledge about excellent practice. MatRIC’s networks embrace participants from many institutions and supports participation in MatRIC activities in Norway and abroad. MatRIC events are used to present excellent teaching and learning practices existing in HE across Norway and elsewhere; events bring together stakeholders from different fields and subject disciplines. MatRIC disburses funds to Norwegian HE teachers to research teaching and learning (KfK 5.1, 81).

Engagement of students. MatRIC supports student-inspired and implemented teaching and learning projects creating new tools for teaching and learning, and student management of these projects.

MatRIC creates opportunities for students to make their products known to teachers (KfK, 3.1, 45).

Importation of practices. MatRIC has introduced to UiA and Norway practices that have been developed over many years in UK, Europe, US and Australia. These include, 'drop-in' mathematics support for students, a mathematics teaching course for HE mathematics teachers; and competence development for student teaching assistants (KfK, 3.7, 63).

Again, space constraints prevent the sharing of great detail about these so we will restrict to one illustrative example in relation to 'Engagement of students'. The student leader (SL) of one of MatRIC's Student Advisory Groups was approached by students for support for their initiative of creating a web-based resource for learning programming. MatRIC supported this work, commissioning SL to act as project manager. When complete, the students demonstrated their resource at a mathematics teachers lunch and then at the MatRIC conference. At the lunch, one teacher, Informant C, saw potential for the use of a modified form of the resource in her numerical methods course. A second phase of the project was then scoped, funded by MatRIC and duly completed. 'C' is about to trial the new resource.

4. Expectations that have not been achieved

The table in Appendix 1, shows three tasks where progress at this point is not what had been planned. Regarding 4.2, it was decided early in MatRIC's existence that this task was not worth pursuing. The announcement by Springer that they would be publishing a new journal in this area, also the amount of time, energy and resource needed to meet this expectation made this decision an obvious one to take. This decision was fully supported by the Management Board and International Advisory Board. MatRIC has pursued publication through other channels, most notably the negotiation of a special issue of the journal NOMAD, which will be published in autumn 2017.

It had been anticipated that Task 2.2, the survey of current activities to improve learning and teaching across universities in Norway, would emerge naturally from the work of the SIGs (networks). Although much information does come to light through the networks, this could not be viewed as systematic or exhaustive. The MatRIC Ambassador scheme will address this. Three MatRIC Ambassadors have been appointed – their goal is to visit every Norwegian target HEI with a twofold purpose: to gather information about local practices and initiatives to improve learning and teaching in mathematics and to inform local departments about the scope of MatRIC activities and opportunities for participation including downloading resources, participating in network meetings, bidding for development grants and collaborative resource development. The Ambassadors will reinforce the message that MatRIC is a Centre ***for*** Excellence wherever it is found and promote wider involvement in the MatRIC community of practice.

The development of workplace simulations (Task 3.1) has been hindered by low participation rates in the Modelling Network events. To address this challenge, the network coordinator is leading research with colleagues from MEC Loughborough University to survey HE mathematics teachers' views of mathematical modelling as a research activity and a teaching activity. In addition, having seen the success of the PIC-Math project (Preparation for Industrial Careers in Mathematics) in the US, MatRIC is investing in the development of a Norwegian version. This project engages undergraduate students, HE mathematics teachers and mathematicians from industry in working on actual problems from the business/industrial arena (KfK, 3.1, 46; 3.6, 59).

5. Contribution of internal and external management

MatRIC's management is shared by three groups: an executive team (ET), a Management Board (MB), and an International Advisory Board (IAB). These are composed to ensure representation of all stakeholders (mathematicians, teachers, users, mathematics education researchers) in each group, also to facilitate MatRIC's engagement within UiA, the Norwegian HE mathematics community and networking with the international community concerned with HE mathematics education. As MatRIC has matured members invited into one group have taken on additional roles and contribute to the function of other groups. Attention is particularly drawn to two features of the groups: strategic appointment, and evolving roles; space constraints prevents more (The integration of functions is illustrated in Appendix 3).

The IAB is composed of five members from UK, Germany, Denmark and Norway, it provides strategic advice from an international and disciplinary perspective, contributing:

- Experience of establishing and leading successful centres of excellence in mathematics education.
- Deep first-hand knowledge of university leadership from positions of senior management.
- Experience of leadership of key international bodies, such as Mathematics Working Group of the European Society for Engineering Education.
- Experience of leadership of a key Norwegian network - Norwegian Mathematics Council.
- International recognition for research in university mathematics education.

The advisory tasks of members of this group have evolved to take on diverse roles to capitalize on their knowledge and expertise. One has broadened the scope of advice to include the development and management of UiA's institutional strategy. Another is taking on the role of MatRIC Ambassador, and a third the role of MatRIC research coordinator. Altogether, the members of IAB have facilitated the development of MatRIC's international network and provided extremely valuable advice to ET and MB regarding the actions and development of MatRIC.

MB provides strategic direction with an institutional and Norwegian perspective, it includes UiA

Vice-Rector for Education (Chair), Faculty Dean and Head of Department of Mathematical Sciences, teachers from both campuses, student representatives and representatives from collaborating partners NTNU and NMBU. The active engagement of the Vice Rector has drawn MatRIC into UiA's strategic development at institutional level, and ensures that MatRIC contributes to the implementation of UiA's strategy. MB members' roles have evolved, eg. the NTNU representative is a co-leader of the 'induction course' (cf. Part 1, p. 5) and is taking on the role of MatRIC Ambassador (cf Part 4, p. 7), he also provides a link with mathematics teaching development at NTNU to enable joint events and contributions at national and international events.

ET has grown as MatRIC's actions have increased. MatRIC's Director, Project Manager, Network Coordinators and Drop-in Centre leaders provide a model for the collaboration across stakeholder groups, and provide connections with existing networks within the stakeholder groups that have enabled MatRIC's integrated community of teachers, researchers and users to develop.

6. Desirable changes to aims and objectives

Three years of MatRIC's activity have been a rich learning experience for the MatRIC team. We have gained a deeper understanding of the national and cultural context of teaching mathematics, and the challenges that confront efforts to develop teaching in this context. We have developed competencies in the operationalisation and implementation of MatRIC actions. We have acquired more confidence in asserting a philosophy of teaching that is often at odds with the prevailing culture. We have better insight into the firmly held rationale behind the didactical decisions taken by HE mathematics teachers. We have a better sense of the reasons for students' poor performance, progression, and retention that are rooted in their experiences of mathematics in HE and school. This accumulation of knowledge reinforces, inspires and informs renewed efforts to achieve the original overarching aims and objectives – to improve students' experiences of learning mathematics, by attending to teaching development and student engagement. The balance of MatRIC's proposed aims and objectives is weighted towards working with mathematics teachers, for the reasons outlined above. We would not want to change these aims and objectives, but we do want to set aims and objectives that give more emphasis directly towards students' learning experiences – especially student engagement/participation in R&D based education. This increased emphasis is becoming possible in ways that could not be imagined in the application because of the developments in practice that MatRIC has initiated and supported.

II. The goals set for the Centres for Excellence

7. Four SFU objectives

The material already presented in the previous sections of this self-evaluation illustrates MatRIC's commitment to the provision of excellent R&D-based education and the promotion of innovation in

teaching throughout Norway. It should be noted that MatRIC itself does not provide education, but it has worked with mathematics teachers at UiA and throughout Norway to stimulate such excellent teaching. As noted in Section 1, the HE mathematics community has a strong commitment to a particular form of teaching, and securing widespread change of practice will require a number of different strategies – especially that innovation must be research-informed and rigorously evaluated.

A key strategy has been to stimulate and reward work involving the interaction of students and staff. At MatRIC's last conference, there were several student-led presentations (further details of one of these projects are given in Section 3 above). The competitive small grants programme has also been an important element in this strategy.

MatRIC's commitment to and strategy for dissemination are discussed in Section 12 below.

III. Impact, dissemination and sustainability

8. Making a difference for students' learning

Three cases have been chosen to illustrate the effect of MatRIC activity on students' learning.

Case 1: This entails, cross-field collaboration, design, student engagement, research and development. Informant D teaches mathematics and physics. 'D' attended the pilot induction course and other MatRIC events, including the modelling colloquium where he was impressed by presentations by colleagues from Mexico and the Netherlands. These gave him ideas for how his physics students could be motivated to engage in mathematical modelling. Working with a mathematics education colleague, he secured a MatRIC grant to develop a new approach to teaching his Phyiscs Lab course in which his students used mobile technology to take videos of moving objects and graphing software to create mathematical models of the motion. Around 350 students were involved. In the post-course evaluation, more than 90% responded positively to these tasks. One student summarises the feelings expressed by many: *I would like more assignments like this in the future. It has been a really fun and learning full experience, it has also spiked my curiosity for the motion we chose to study and I will definitely take the project further. (Student ε).*

Case 2: Towards the end of the autumn semester 2016, MatRIC worked with the staff teaching the mathematics for engineering course at UIA to help the 434 students prepare for the examination. This included promoting the Grimstad drop-in centre, and running five voluntary topic-based revision sessions. Around 150 students participated in each session. Although there was a small improvement in performance (the mean grade improved from D to C) this was not as large as had been hoped for. The low impact may be because the actions came at the end of the course and did not address the fundamental causes of poor performance: large classes, general mathematics (not specific to the programmes of engineering studied), a poor culture of learning and under-developed learning approaches. Case 3 presents a significant contrast to this.

Case 3: Informant E teaches mathematics to 32 first year electronics engineering students. Drawing on his own experience and expertise from within the MatRIC networks, he has developed teaching approaches that integrate video and CAA technologies with problem based teaching, and bespoke resources that present mathematics in the context of electronic engineering. In this course, in 2016, the average grade was B and there were no failures. The approach taken here addresses the causes of low impact identified in Case 2 above.

MatRIC's actions, locally and nationally are aimed at challenging the prevailing culture of traditional lectures about general mathematics taught to very large (400+) heterogeneous groups of students. MatRIC events provide opportunities for mathematics teachers to meet others who are successfully using digital technologies, inquiry and problem based learning, and alternative teaching approaches. The cases described above provide convincing evidence that the strategy is correct. Over the last three years MatRIC has been learning from excellent practice in other countries, and introducing international experts to the Norwegian community of mathematics teachers.

9. Impact

a1. MatRIC is connecting innovation in teaching with research in mathematics education. MatRIC has facilitated dialogue between HE mathematics teachers and researchers, mathematics education researchers, teachers and researchers in programmes mathematics 'serves' and students. MatRIC is connecting innovation in teaching with research in mathematics education.

a2. MatRIC is raising awareness about the importance of student engagement and R&D based education. As has been observed in other teaching development activity, teachers and institutions use MatRIC as a resource to achieve their own goals such as seeking merit awards for teaching, employment and institutional reorganization (KfK, 4.3, 73; 4.5, 77), (Informants B & G).

a3. MatRIC has been the Norwegian partner in several EEA Norway Grants projects with Brno University of Technology and Masaryk University in the Czech Republic. These have resulted in knowledge flow, especially about mathematical modelling in education and mathematics support for students. Further, MatRIC has initiated and facilitated the development of an international group focusing on computer aided assessment in mathematics. The group includes international leaders in the field (KfK, 3.7, 63). Informant F offers an international perspective about MatRIC's impact: *"the MatRIC community have been immensely valuable as a meeting point for European colleagues to discuss university mathematics and statistics teaching. MatRIC has a strong pragmatic focus, underpinned by a respect for educational theory and educational research*."

b. MatRIC contributed to the development of the UiA Strategy 2016-2020, and will continue to be part of the implementation of the strategy, through membership of the Management Group for one strategic focus (Learning and Education for the Future), and through providing exemplars of

good practice (student support and teaching development). Internationally, the coordinator of the Video and CAA networks has been invited to share experience with the University of Southern Denmark, and MatRIC Director addressed the 2016 meeting of University Colleges Denmark.[7]

c. MatRIC is motivating upper secondary school students; MatRIC holds an annual 'Open Lecture' to which upper secondary students are invited. The speakers invited to deliver these lectures are asked to give an inspirational presentation that will motivate engagement in Mathematics. The PIC-Math project that is being developed will result in MatRIC's impact within business and industry, and develop international ties with the US designers of the project.

10. Effects triggered by SFU status

SFU status has released human and financial resources that have made most of the actions described in this report possible. The triggered effects with the greatest potential to make a difference are the networking and dialogue across the boundaries of disciplines and research fields. Without the SFU funding teachers working for excellence in their practice would have continued as unconnected and largely unnoticed pools of expertise and experience. Further, the SFU funding has, within a short period, enabled the development of a national group of researchers of university level mathematics education, which has achieved international recognition. One of UiA's Vice-Rectors observes:

"UiA has taken advantage of MatRIC as well as the international and national discussions arising from the SFU centres in general. The UiA strategy as well as development plan for the next four years are hence influenced by numerous issues. Worth mentioning here are; variation in teaching methods and formal /informal assessment, evaluation techniques embedded within quality cultures, course management and educational leadership, student engagement and learning environments, praxis in all study programmes, teacher qualifications and R&D based learning and teaching."

11. Approaches to evaluation – centre, project and personal levels

Internal to UiA, MB has responsibility for the evaluation of MatRIC and receives reports and evidence as set out in Table 1. Centre leaders evaluate events and actions with the goal of improvement, several sources of evidence are used, according to the nature of the action, as set out in Table 1. Leader reports are produced for Management Board meetings. IAB receives all papers prepared for MB and minutes of meetings, IAB maintains regular contact with MatRIC Leader as a ready source of advice and suggestions. IAB meets with MB at the time of the annual conference and this provides the opportunity for an oral report of IAB's appraisal of MatRIC's activities, and offers advice for MatRIC's strategy and development. MatRIC's overall goals for the first five years of funding are set to be achieved although, as would be expected in a dynamic, evolving Centre there will be some variation from the originally proposed tasks to bring about these goals.

[7] http://xn--danskeprofessionshjskoler-xtc.dk/aarsmoede-fokus-paa-videnspredning/

Level	Approaches – Sources of evidence
Centre	Leader Reports presented and discussed at MB and IAB meetings. Annual Report presented and discussed at MB NOKUT Developmental evaluation November, 2015. MB Day workshop December, 2016 - MatRIC team presents activity and progress.
Project	Events: On-line survey evaluation questionnaire. Research & development projects: Reports published on MatRIC web pages; presentation at MatRIC events. MatRIC TV: National workshop (October 2015); evaluation meeting (March 2016) Drop-in: Student Advisory Panels; student user survey; weekly information provided by support teachers.
Personal	One-one discussions; inference from Centre and Project evaluations.

Table 1. MatRIC's approaches to evaluation and sources of evidence

12. Successful dissemination

Since MatRIC's key goal is to promote a lasting culture change, dissemination is essential to success. Dissemination has been designed as an integral part of MatRIC's activities from the outset, rather than as a 'bolt on'. The MatRIC team at UiA do not work in isolation to produce resources and then unveil them to the world. Instead, MatRIC networks, comprised of colleagues from several institutions, work together to achieve the outcomes MatRIC is aiming for.

Dissemination for awareness starts with conventional methods such as the e-newsletter, with links to the MatRIC web-site. Distribution has increased steadily to its current level of 517. Experience shows that the personal approach, with individually addressed e-mails, is most effective.
Dissemination for understanding occurs primarily through the wide range of events including the annual conference, supported by the web-site. Post-event evaluations by online surveys reveal high levels of satisfaction and expectations that learning from the events will impact on practice. Further, MatRIC team members have participated in many conferences and published in scientific journals.
Dissemination for engagement and change is secured through a variety of mechanisms including: the participatory nature of the MatRIC networks; the provision of funding for visits to international centres of excellence; the competitive small grants scheme, with its requirement for final reports which can lead to external publications.

13. Exit strategies

Continued endeavour for excellence in mathematics education in HE, and sustained strategies for improving students' teaching and learning is the exit point sought. MatRIC will achieve this in part after five years of funding and secure it after ten. However, it is our belief that there is a place for a

permanent Norwegian Centre for HE Mathematics Education, like the Norwegian Centre for (school) Mathematics Education (NSMO). MatRIC intends to be such a centre.

MatRIC's contributions to students' learning and teaching development, innovation and research will continue because of their momentum and the achieved critical mass of mathematics teachers.

UiA will, as part of its present strategy, create a coherent learning support centre for students that will embrace language and writing support and incorporate the mathematics Drop-in pioneered by MatRIC. MatRIC's actions to develop student teaching assistants will be accommodated within departmental programmes as they are seen to be highly beneficial. Collaboration across departments and subject fields will be sustained because barriers have been dismantled.

Merit awards for excellent teaching are being introduced nationally, and the efforts and experience gained from MatRIC's 'induction course' for university mathematics teachers will contribute to national efforts. MatRIC is bringing teachers together and networking them into national and international activities and conferences, such as the MNT [STEM] Conference and International conferences (INDRUM, RUME, CERME). These are not dependent upon the Centre for Excellence funding. MatRIC's focus on research, innovation and coordination of teaching will ensure a cultural change that will be sustained beyond MatRIC's life.

UiA's Rector observes: *"MatRIC has demonstrated the great value of academic communities working across faculty and organizational boundaries. UiA will continue to be a national driver for better mathematics education based on our MatRIC network and cooperations. The UiA steering board will discuss measures and plans to finance and support activities within the next three years. UiA has encouraged new initiatives to drive and demonstrate our excellence in teaching by applying for future SFUs in new areas. MatRIC has contributed to improve our understanding how to link with partner institutions across the world for better education.*

Thanks to MatRIC we are now cooperating with other SFUs that are important to us. bioCEED and ENGAGE are two examples of SFUs that will help us in advancing our programs. Our leadership of MatRIC has given us a better understanding how to coordinate national efforts in education, and how to be a good partner and contributor to other SFUs."

IV. Plans for second period

14. Three steps

MatRIC is well placed to be an effective powerhouse that will drive educational reforms set out in the Government White Paper No. 16 'Culture for Quality'. It is crucial that we build on foundations laid in MatRIC's networks and on-going mathematics teaching developmental research that are described above. In the next phase, MatRIC will scale-up to embrace comprehensively all

stakeholders in Norwegian HE mathematics teaching and learning; MatRIC Ambassadors will have a key role in this expansion. Other factors that will contribute to success include:

- Close alignment of MatRIC's and UiA's strategies and goals.
- MatRIC's networks that are connecting the Norwegian and international communities.
- MatRIC's development and application of modern teaching and learning technologies.
- MatRIC's leading position in Nordic research in undergraduate mathematics education.

Dissemination continues to be central to MatRIC's activities, the networks, events, website, and newsletter have established an effective platform for communication. Nevertheless, we will continue to seek new ways, such as MatRIC Ambassadors, for making contact with stakeholders in HE mathematics education to bring awareness, understanding, action and change.

Step 1. *Learning support:* MatRIC will initiate a Norwegian network that focuses on student support: promoting drop-in and other mathematics learning support, creating support materials to complement MatRIC TV, development and training of student teaching assistants. This network will connect with the international networks for mathematics support, such as the **sigma** network in the UK.

Step 2. *Teaching, course and programme development:* MatRIC will develop ways of promoting and rewarding excellence in teaching mathematics in HE. MatRIC will promote student participation in course and programme development, approaches that motivate and engage students in R&D based active learning, collaboration between teachers across subject boundaries and peer observation, development and application of new technologies to support teaching and learning mathematics. (KfK, 3.1, 45; 3.4, 51-52; 4.1, 70; 4.3, 73; 4.5, 77).

Step 3. *Development of teaching and learning resources:* MatRIC will set up a group of teachers from several HE institutions to work on the integration of educational technologies applied in mathematics such as video, computer aided assessment, computer algebra systems and modelling software, simulations and visualizations. The aim will be to develop 'smart' learning platforms. This group will collaborate with the recently formed Centre for Artificial Intelligence Research at UiA. (KfK, 3.4, 51-52)

MatRIC will nurture mathematics teachers to become more engaged, from 'awareness' of MatRIC's actions, through 'participation and understanding' developmental strategies, to being active in transformation of their own practice and achieving excellent educational experiences for students.

Appendix 1 – Progress against Work Package Tasks in MatRIC SFU Proposal

Task	Description	Outcome*	Notes
1.1	Develop MatRIC website	GREEN	www.matric.no online autumn 2014. In 2016, there were almost 14,000 visits (76% from Norway)
1.2	Establish annual conference	GREEN	4 conferences held (including launch event). Total of 307 participants over these 4 events.
1.3	Organise regional workshops	GREEN	8 regional events, with a total of 344 delegates. Topics include: video production, CAA, mathematical modelling, visualisation, flipped classroom. In addition, 4 international workshops organised by MatRIC with almost 100 delegates.
1.4	Support visits to international centres	GREEN	Visits to centres of excellence in UK, Germany and the US by staff from 5 Norwegian HEIs.
2.1	Survey research related to innovation in teaching	AMBER	Survey of the use of video in mathematics teaching published on MatRIC web-site. 6 further surveys including flipped classroom, use of CAA, video, visualisation and modelling are underway.
2.2	Survey current activities to improve learning and teaching	AMBER/ RED	Expectation that this information would be accumulated through networking activities has not been met, yet. The introduction of the MatRIC Ambassador scheme will systematise this data collection.
2.3	Support research by providing small grants	GREEN	Annual scheme has run three times. 14 grants of up to 50K NOK awarded to colleagues from 7 HEIs. Projects include: students as co-researchers, use of Khan Academy, flipped classroom approaches, video production, visualisation and modelling. Project reports are published on MatRIC website.
3.1	Develop workplace simulations	RED	Network development has proved challenging. A Norwegian PIC-Math project is being developed (following the ideas of the US PIC-Math project)
3.2	Develop student laboratory workshops	GREEN	Collaboration with SFU bioCEED at Bergen developed modelling workshops for biology students.
4.1	Produce a newsletter (2 per year)	GREEN	e-newsletter has been produced (6 issues in 2014, 3 in 2015, 4 in 2016). Distribution list has grown from 32 (first issue) to 517 (March 2017).
4.2	Establish a professional journal	RED	Decided not to go ahead with this task due to the announcement in 2013 of a new Springer journal *International Journal of Research in Undergraduate Mathematics Education*.

*Outcome gradings: **GREEN** – task completed or on track with expectation at this stage; **AMBER** – task marginally behind expectation at this stage; **RED** – task significantly behind expectation at this stage or abandoned.

Appendix 2 – Impact/Value of Work Package Tasks in MatRIC SFU Proposal

Task	Description	Impact/ Value*	Notes
1.1	MatRIC website	**HIGH**	Website is the repository of information about MatRIC. On average about 40 visits per day indicate it is serving a need. The website remains under development to ensure it continues to be fit for purpose.
1.2	Annual conference	**HIGH**	The conference is the 'centre piece' of MatRIC's calendar. Programme attracts participation, with high profile international guests. This is crucial in building MatRIC's integrated stakeholder community.
1.3	Regional workshops	**HIGH**	Taking the workshops around Norway facilitates wide participation. Feedback indicates workshops have an impact on practice.
1.4	Visits to international centres	**HIGH**	The development of Drop-in support, the teaching course and course for student teaching assistants are outcomes of these visits. Also the growth of the international network is a valuable outcome.
2.1	Research survey related to innovation in teaching	**MEDIUM**	MatRIC's Post-doc research fellow has produced a survey of research into the use of video in teaching mathematics at HE. This has been shared in MatRIC events and submitted to a major international journal.
2.2	Survey current activities to improve learning and teaching	**MEDIUM**	MatRIC networks are successful in locating HE mathematics teachers and students who are working innovatively. As these are found they are encouraged to share their work at a MatRIC event.
2.3	Small grants to support research	**HIGH**	These attract proposals for small scale action research as intended. 50% of the grant is withheld until the project is reported. Grant holders are encouraged to report their work at a MatRIC event or conference.
3.1	Workplace simulations	**X**	Remains to be developed
3.2	Student laboratory workshops	**MEDIUM**	Modelling workshops for biology students at UiB, and physics 'lab' in UiA have had high effect. Action needs to become more widespread. MatRIC is creating a bank of successful Norwegian case studies.
4.1	Newsletter	**HIGH**	Provides direct communication to individual's e-mail inboxes. Links to articles and information on the web-site. 'Pro-active' and not labour intensive.
4.2	Professional journal	**X**	Not attempted

*Outcome gradings: **HIGH** – task is valuable and fulfilling the intended purpose; **MEDIUM –** valuable, impact is anticipated but not yet sufficiently developed**; X** – task is not sufficiently developed to evaluate.

Appendix 3 - MatRIC's integrated management structure.