Improving First-Year Teaching with Project-Based Learning and Support of STEM Modules

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Abstract—**This Work-in-Progress article in the Difference Makers track describes experiences in managing a project in the German Teaching Quality Pact, a nationwide project running from 2011 to 2021. Change management principles are employed to ensure that the project work has a sustained impact. Different phases of the innovation cycle require different measures and communications to address stakeholders. Evaluation shows that the quality-in-teaching project has made an impact on education at our university, and the current focus is on sustaining the improvements.**

Keywords—Difference Makers, change management, first-year teaching, project passed learning

I. INTRODUCTION

In 2010, the German government announced a nine-year project to improve quality of teaching in higher education ("Qualitätspakt Lehre"). From October 2011 to December 2016 1,115 million. Euro was allocated in a first project phase. From 2017 to 2021 another 800 million Euro was allocated in a second project phase [1]. All public universities in Germany could apply for funding.

The Hochschule Bonn-Rhein-Sieg is a university of applied sciences with currently 9,000 students and 1,000 staff, including 150 professors. It was granted 6.2 million Euro in the first project phase and, after a positive evaluation, another 5.7 million Euro in the second project phase.

The funding is used to help all faculties of the university improve first-year teaching. The focus is on introducing project-based learning and supporting STEM (science, technology, engineering and mathematics) modules.

Managing the project requires considerations to be made when applying for funding, initiating activities in the university, preparing to submit a new application mid-project and transitioning to a sustained change in the organization. This article describes the quality-in-teaching project and change management in the university-wide project, with a focus on the engineering department.

In Chapter 2, different change management models are discussed. A combined structure is derived, and Chapter 3 describes its application to the quality-in-teaching project. Chapter 4 discusses approaches for evaluating the change process and project achievements.

II. CHANGE MANAGEMENT

A. Considerations

Implementing changes in an existing organization is always a challenging process, because organizations and people in them have a strong tendency to maintain their existing structure and are sceptical about any change [2]. It is important to involve all stakeholders in the transformation process, which for a university are professors, teaching staff, students and university management.

Pursuing a top-down change process led by university leaders or administrators is difficult, if not impossible, because of the strong position and self-conception of professors [3]. Instead, agreement to change has to be achieved from the bottom up as well [4]. Support from the abovementioned stakeholders is required in order to achieve support and "buy-in" at all levels of a university.

B. Eight Stages of Change Processes

General factors for successful change processes have been discussed by Kotter [5], and eight stages to obtain lasting change have been identified:

1. Establish a sense of urgency
2. Form a powerful guiding coalition
3. Create a vision
4. Communicate the vision
5. Empower others to act on the vision
6. Plan for and create short-term wins
7. Consolidate improvements and produce more change
8. Institutionalize new approaches

C. FIE Difference Makers

The FIE 2020 Working Group Proposal identifies four stages of innovation in education [6]:

1. The Champion: The role of the lead in developing and launching a program innovation.
2. The Program Entrepreneur: Shaping an educational innovation into a startup.
3. The Handoff: Transitioning from the startup team into a continuing program.
4. Sustainability: How success is sustained and maintained as an innovative program develops into an established program that continues to evolve and improve.

D. Achieving Excellence in Engineering Education

The British Royal Academy of Engineering investigates several case studies and identifies common features of successful change [7]. Four headlines categorize them: "Context for change", "Leadership and faculty engagement", "Educational design and implementation", "Sustaining change".

The report also names influencing factors that are not associated with change, like student engagement in the change process.

An important observation are stages, where unsuccessful change can occur. One of the stages mentioned is the transition from planning to implementation, when a change process relies on a small number of supporters.

E. Technology Adoption Life Cycle

Moore also stresses the transition between stages of an innovation process [8]. The technology adoption life cycle describes five groups of adopters and there is a "chasm" between innovation and implementation of a product or idea.

F. Combined Structure for Change Management

The approaches by Kotter and the FIE difference makers are similar, where two steps taken by Kotter relate to one step of the FIE difference makers. This article will work with and explore a combined structure of these two. The Royal Academy supports the steps and, together with Moore, emphasizes the transition between project phases.

The management of our university project will be presented and discussed according to the consolidated structure by Kotter and the FIE difference makers.

III. QUALITY-IN-TEACHING PROJECT

A. Champion: Establish a sense of urgency

Government project funding is used as an external stimulus. The project call asks for improvements in the quality of teaching and tutoring of students. Key findings from literature about student drop-out are put together for the project proposal and for presentations at the university. Existing results from student evaluations are also analyzed to identify students' demand for improvements in lecturing.

In addition, a large-scale analysis of examination results has been performed to provide an additional empirical basis for the project [9]. All first-year examination results from 2009 were analysed, making a total of 13,700 examinations, and percentages of failed examinations calculated. As a result, study programs and subjects with high failure rates have been identified.

B. Champion: Form a powerful guiding coalition

This analysis of the evaluation and examinations, as well as project call and findings from the literature are presented to different stakeholders of the university. An important forum is the commission for teaching and learning with representatives from all faculties, students, and university institutions such as the language center, library and administration. As a second step, the university management with the deans are informed about the project proposal.

Here, it is important not to use evaluation data and examination results to demand improvement. They have to be used as a starting point for an open discussion. All study programs have different characteristics and it is neither possible nor meaningful to determine a uniform university-wide pass rate. Data is used to enter into a dialogue with deans and managers of the study program.

After the project funding was granted, a project agreement was concluded between project management, university management and faculties/institutions to formalize the guiding coalition. This agreement sets out the resources to be provided to the faculties and institutions in exchange for their approval of the project goals. The university management is included in the agreement as supporter, supervisor and arbiter.

C. Entrepreneur: Create a vision

Based on the coalition, project goals are formulated. These goals are based on the results of step A and B and the boundary conditions of the project funding. For our project we condensed and simplified these constraints into three goals, to clearly specify the project vision.

The project improves teaching:

1. In the first year of Bachelor programs

2. Through project-based learning

3. By supporting STEM subjects

These goals are also used for the project title "Pro-MINT-us", where "Pro" stands for project-based learning, "MINT" is the German equivalent of STEM, and the English word "us" has the sense of "at our university". The project name echoes Prometheus from Greek mythology and his quest for knowledge.

D. Entrepreneur: Communicate the vision

The project grant allowed about 25 people to be funded, some of them part-time. To make the project visible and stimulate communication inside the university, the project members are based in the individual organizational parts of the university that are relevant for teaching. In other words, they do not sit in a separate department or a separate building. Being part of existing groups give them close communication links to people outside the project.
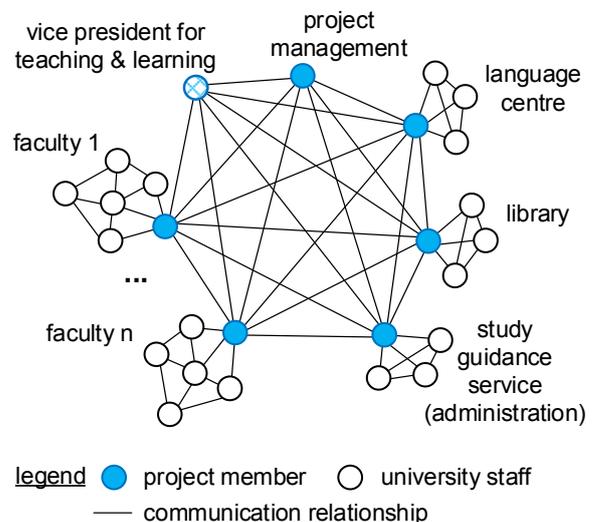

Fig. 1. Project members form a network inside the university

Fig. 1 illustrates this concept [10]. Project members are part of the faculties, the language center, the library, which also organizes e-learning, and the study guidance service, which is part of the administration. Within the project, a communication network exists among the project members, including project management and the vice president for teaching and learning, representing university management.

Further activities are organized to promote a general discussion about quality of teaching. An "education evening" is offered once a semester where professors dine at a restaurant and discuss an education-related topic. Every two

years, "teaching days" are organized with talks from university staff and external speakers. A teaching award is also presented at this event.

E. Handoff: Empower others to act on the vision

As well as being based in the faculties, project members are also authorized and encouraged to implement new teaching approaches according to the requirements of the faculties and their study courses. Although the project goals (section III.C.) serve as a constraint, this boundary is so wide that different approaches to improve teaching and learning are still possible.

The positions were open to members of the university, who, for instance, could progress from a research assistant to a lecturer, to recent graduates and to applicants from outside the university. The people who ultimately became project members came from all of these groups and formed a diverse project team. The combination of knowledge from inside the university with ideas from other institutions proved valuable and inspiring.

Interaction between the project members was encouraged and common approaches emerged. Some approaches originated directly from the project goals, such as project-based learning and tutoring in STEM modules. Other approaches picked up ideas from general trends in didactics, such as using lecture videos and writing in the disciplines.

F. Handoff: Create short-term wins

Positive feedback about new learning approaches are given to project members to encourage and motivate them. In the context of the project, "new learning approaches" means measures that are new for the university or for a study program. Adopting ideas from other practitioners is thus encouraged.

The teaching day provides an opportunity to present learning approaches. Having an internal event also allows people to prepare for presentations at national and international conferences. Lecturers are used to publishing about their discipline but need encouragement to present and reflect their teaching activities. Conference invitations and calls for papers are distributed amongst the project team to stimulate articles.

Furthermore, data is collected by the project administration team to analyze the effect of new teaching approaches. This includes exam results, students' feedback and evaluations as well as usage statistics for e-learning elements. The results are communicated to all project members, to deans and university management. Of course, not all statistics show a positive effect, but they document the achievements and lessons learned in improving teaching.

G. Sustainability: Consolidate improvements

By working together in these activities, project members and other university staff establish a network of lecturers who cooperate across faculties on new approaches for teaching. For some ideas, such as using video lecturers, quizzes or writing in the disciplines, it is helpful to have the support of colleagues and opportunity to exchange ideas and opinions with them. They share their experience and can be helpful as a "critical friend". Discussing new ideas with an open-minded person stimulates enthusiasm and is often the small bit of momentum that is needed to bring an idea to fruition.

The concept of different project stages (section II.D) is applied here. Communication on project activities switches from project goals (section III.C) to project achievements. To reinforce these achievements, an external evaluation is performed and results are presented. A brochure highlights project activities and project members.

H. Sustainability: Institutionalize new approaches

As the change process targets a lasting improvement in teaching at our university, consolidating the project improvements is important. This consolidation has to be implemented at several levels.

The new teaching approaches need to be included in the study programs. This is achieved by study modules that provide project-based learning and tutoring. The engineering department runs a first-semester starter project that helps students to relate theoretical concepts from other lectures to real-life topics of engineering. Other departments provide modules on an Introduction to Scientific Work with an emphasis on writing in the disciplines.

The project will come to an end in 2020, and structure for offering didactic activities and for continuing to network about teaching improvements is needed. A center for teaching development was set up for this purpose. The transition from a temporary project to a permanent institution is another change in response to different phases of the innovation cycle.

Finally, funding for new teaching approaches must be secured. Some resources can be allocated by shifting priorities within the faculties. As an example, the engineering faculty has introduced a first-semester project with project funding and, with the project drawing to a close, is now dropping a sixth-semester project. Nevertheless, additional teaching work needs additional funding. The German government has provided budgets to strengthen the quantity and quality of teaching. The allocation of these funds is ongoing.

IV. PROJECT EVALUATION AND RESULTS

The direct and indirect impact of the project is continuously observed by the project management team. The results are used to communicate project achievements (section III.F) and adapt project management.

A. Project participation

The participation of university staff in project activities is observed as an indicator of project communication and general acceptance in accordance with III.D "Communicate the Vision".
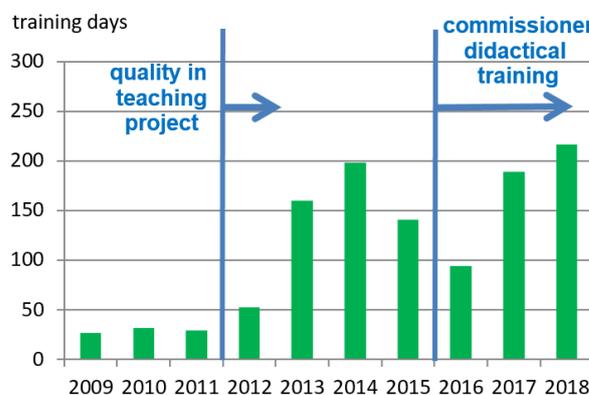

Fig. 2. Didactical training for Hochschule Bonn-Rhein-Sieg staff

Fig. 2 shows the number of training days at didactic workshops for our university. Before the project started, attendance was about 30 days per year. In 2012, our project started and the numbers increased significantly, peaking at about 200 training days. In 2016, a commissioner for didactical training was installed as a first measure in step III.H "institutionalize new approaches". This measure has maintained the number of training days at about 200 days per year.

Attendance at the teaching day is also monitored. This day is held every other year, and we had 150 participants if the event was held at our main campus and 100 participants at the slightly smaller second campus.

The education evening with dinner and a guest speaker is held once per semester, and the 12 places are nearly always booked up within hours of the announcement. All this shows a high level of interest in the activities of the quality-in-teaching project.

B. Teaching success

Examination results were analyzed in the initial phase of the project (section III.A), and this analysis was repeated during the project to measure project success. The initial analysis was performed for the examinations held in 2009 and repeated for those held in 2014 and 2018 [11]. The results were expected to provide short-term wins (section III.F) in the middle of the project.

However, it was hard to compare examination results because of external and internal influences. External influences are changes in the education system, such as reducing the length of school education from 13 to 12 years in 2013 and the end of compulsory military service in 2011. Internal influences are changes in study programs and new lecturers on a course.

We concluded that although the large-scale analysis of examination results provides a valuable snapshot, it is not well suited to monitoring long-term effects. It is more advisable to look at individual examinations together with lecturers and use the empirical results as a basis for discussion.

C. Outreach and Achievements

The engagement of university staff outside project activities is monitored to measure consolidated improvements (section III.G). Fig. 3 shows the participation of university staff in the IEEE Educon conference, a major conference for engineering education in Europe, Middle East and North Africa.
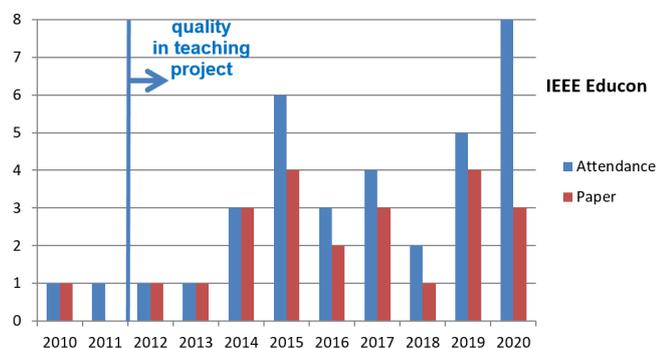

Fig. 3.   Participation of Hochschule Bonn-Rhein-Sieg staff at IEEE Educon

After the project had started, a number of university members involved in research into engineering education attended the conference and presented a paper. Attendance at German education conferences also increased.

Sustainability in the form of institutionalizing new approaches (section III.H) is achieved by transitioning the project into a permanent structure. A call for workspaces was announced to give lecturers a structure for networking on new approaches for teaching. Ten initiatives formed across the university, most of them involving several faculties. Topics include laboratory didactics, online labs and e-assessment.

Finally, the project is also proving a source for new university initiatives in teaching. One project member was presented with the prestigious German *Ars legendi* faculty award. Other project members have initiated new education projects and taken on responsibility for managing them.

V.   CONCLUSION

Innovation projects in education consist of several stages, and every stage requires different activities and communication. A project has to be adapted in order to transition between the stages and convert a promising project start into a sustained impact within a university.

A combined structure for change management and its application in the Pro-MINT-us quality-in-teaching project have been presented. The project has achieved a successful transition between different project stages and is currently being institutionalized as a permanent center for teaching development and innovation.

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