Technical University of Denmark

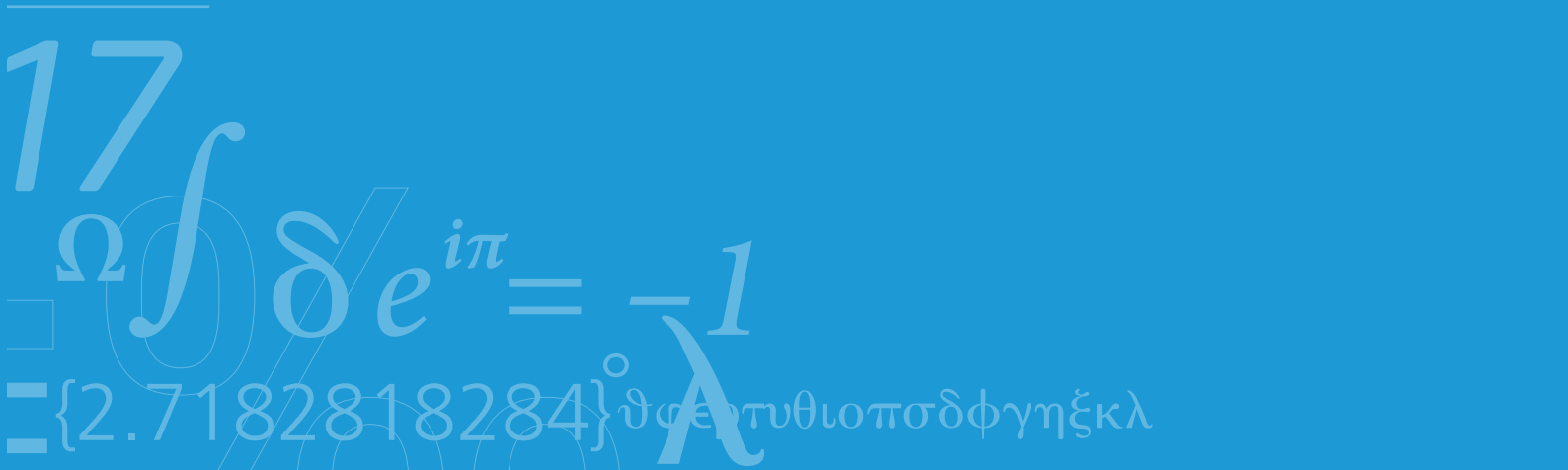
DTU

SEFI

ANNUAL CONFERENCE 17-21 SEPTEMBER 2018

COPENHAGEN, DENMARK

Proceedings



Proceedings
of the 46th SEFI Annual Conference 2018

Creativity, Innovation and Entrepreneurship for Engineering Education Excellence

Co-organized by SEFI and Technical University of Denmark

@SEFI Brussels, Belgium
SEFI - Société Européenne pour la Formation des Ingénieurs
39 rue des Deux Eglises, 1000 Brussels, Belgium

Editors: Robin Clark, Peter Munkebo Hussmann,
Hannu-Matti Järvinen, Mike Murphy & Martin Etchells Vigild

ISBN: 978-2-87352-016-8

Combining research and teaching in engineering.
Creating a pedagogical qualification programme on research-based learning for early stage researchers

UB Bulmann, Ulrike
Hamburg University of Technology
Hamburg, Germany
E-mail: ulrike.bulmann@tuhh.de

SB Bornhöft, Sara
Hamburg University of Technology
Hamburg, Germany
E-mail: sara.bornhoeft@tuhh.de

KV Vosgerau, Klaus
Hamburg University of Technology
Hamburg, Germany
E-mail: klaus.vosgerau@tuhh.de

DE Ellinger, Dorothea
Hamburg University of Technology
Hamburg, Germany
E-mail: dorothea.ellinger@tuhh.de

SK Knutzen, Sönke
Hamburg University of Technology
Hamburg, Germany
E-mail: s.knutzen@tuhh.de

Conference Key Areas: Innovative Teaching and Learning Methods, Educational and Organisational Development, Others
Keywords: Research-Based Learning, Engineering, Pedagogical Qualification Programme, Evaluation

INTRODUCTION

It is of high importance for modern societies that universities of technology provide higher engineering education that enables students to solve new problems with solid expert knowledge, methodological skills and critical thinking. Thus, students should be enabled to develop extensive competencies at the university also by experiencing research and development on important questions. In doing so, research-based learning is supposed to be a promising educational practice of high impact [1]. It is connected with a long tradition, especially in Germany [2]. Integrating research into teaching follows disciplinary prerequisites [3]. Notably, academics play a key role in enabling a positive research experience for students. Across disciplines, Brew and Mantai [4] have already found that a lack of academic knowledge, skills and mindsets are barriers in implementing research-based learning, among other factors. This leads to a strong desire to implement a qualification programme for academics. In Germany, workshops on research-based learning are mostly offered with a one to a few days duration, tailored to interested, often experienced academics. In contrast, little attention is given to what could be achieved with a more complex qualification programme on research-based learning for early stage researchers in higher engineering education. This article highlights how participants respond to a one-year programme consisting of workshops, teaching projects and a final presentation. It is questioned how they react to the programme, how they reflect their learning, whether they intend to integrate research-based learning in their teaching and why they do so.

1 MATERIAL AND METHODS

1.1 Initiating staff development on research-based learning

There are several ways to develop students' research skills [4]. Enriching teaching and learning in single courses by integrating research seems to be promising, but nevertheless pedagogically challenging. This is even more the case if early stage researchers having mostly little experience in research and teaching, strive to competently integrate research into their courses, which also have to complement their professors' lectures. To overcome these difficulties, the executive committee of a University of Technology in Germany assigned its centre for teaching and learning (CLL) in 2015 to create a compulsory in-house qualification programme on research-based learning for early stage researchers. The ongoing overall aim of this pedagogical qualification programme is to:

- introduce participants to research-based learning, and
- facilitate integration of research results, methods or processes in their courses.

1.2 Providing a complex qualification programme on research-based learning

The qualification programme on research-based learning aims to qualify participants to teach according to modern pedagogical principles, to design research-based learning scenarios and to inspire communication within a network of early stage researchers across departments. In the training, *research-based learning* is used for

course inventory and development in a wider sense as a pedagogical framework according to Rueß, Gess, and Deicke [5] which is based on the model by Healey [3]. However, in a narrow sense *research-based learning* is also used to mark a possible course development perspective i.e. as a teaching format enabling students to experience the whole research cycle, ranging from formulating their own research questions to producing interesting findings for others according to Huber [2]. Benefits from a double connection of integrating research into teaching as well as researching on teaching were expected. Thus, in the first cohort of the programme, research-based learning was combined with *classroom action research,* according to Mettetal [6], which can be seen as a pragmatic approach of *scholarship of teaching and learning* (e.g. Wankat et al. [7] for engineering). However, this approach was changed in the following cohorts, resulting in a different focus (basic pedagogics instead of classroom action research), products (writing abstracts instead of reports) and effort (60 hours instead of 110 hours compulsory). Currently, the one-year programme starts twice a year and consists of a series of workshops, a teaching project and a final presentation. Supervision is realised throughout the year by experts on research-based learning. Participants concentrate on research-based learning along with teaching and learning approaches, course design, teaching methods, digital tools, assessment techniques, and evaluation approaches. Participants, mostly in teams of two, apply their pedagogical knowledge in a teaching project, wherein they design and implement classroom activities in one of their own courses, mostly within the programme period. With respect to the underlying pedagogical problems that occur in exercises, seminars, laboratory courses or problem-based learning courses, the project objectives vary e.g. from increasing students' research interest, autonomy, activity or practical experience. Thus, the corresponding classroom activities also vary a lot. The teaching projects are discussed in a final event on campus with poster presentations along with reports or abstracts and are partly published on the homepage of the CLL [8].

1.3 Evaluating the participants' perspective on the qualification programme

To evaluate this qualification programme on the individual level, the perspective of the participants was gathered, i.e. cohorts 1 to 4 with altogether 77 participants conducting 46 projects. The evaluation was designed according to Kirkpatricks *four-level model of evaluating training programmes* [9]. The research questions focused on the three individual levels of the model, asking how participants assess their reaction, learning, and behaviour after completing the training. It was also of interest to gain a deeper understanding of the participants' perception. Data was collected using a mixed-method approach. To begin with, quantitative online surveys were conducted. Using a 5-point Likert scale, participants were asked to:

- value the qualification programme (level 1: reaction),
- assess their knowledge and skills in respect of general principles used for classroom instruction, research-based learning, classroom action research, dissemination and value the combination of research and teaching (level 2: learning),

- indicate their future intention towards course development, research-based learning, classroom action research and dissemination (level 3: behaviour).

Furthermore, semi-structured interviews were conducted with 13 participants. These were selected according to a specific criteria catalogue resulting in a wide variation of interviewees. The interviews addressed the three levels and several additional aspects of the relationship between research and teaching. The data was analysed using descriptive statistics and thematic investigations. Surveys and interviews indicated barriers and potentials for implementing research-based learning at this university. These were categorized, quite similar to Brew and Mantai [4], here as (1) culture, (2) structures, (3) resources, (4) academic qualification and (5) academics' views on student qualification.

2 RESULTS AND INTERPRETATION

2.1 Reaction after participation in the training programme

Participants' evaluation of the qualification programme in respect to their reaction, learning, and behaviour is summarised in Table 1.

Table 1. Evaluation of the qualification programme on research-based learning.

level	#	item	n	mean	sd
reaction	1	I find a structured pedagogical qualification important in the first year as research assistant.	38	2,1	1,0
	2	I find it valuable for me that I participated in a programme for pedagogical qualification in STEM.	37	2,8	1,3
learning	3	I am able to explain principles of good teaching and learning.	40	1,9	0,6
	4	I am able to select various pedagogical methods for research-based learning for my course.	38	2,2	1,0
	5	I am able to select methods to systematically collect data with respect to my problems in teaching.	40	2,2	1,0
	6	I am able to implement at least two principles of good teaching and learning in my own course.	40	1,9	0,7
	7	I am able to apply different teaching methods for research-based learning in my course.	37	2,7	1,1
	8	I am able to develop an appropriate research design to investigate problems in my teaching.	39	2,3	0,7
	9	I was able to present my teaching project at the final event well.	36	1,8	1,0
	10	I think it is important to see research and teaching as a unity.	38	1,9	0,9
	11	I think it is important to integrate research in my own teaching.	38	2,5	1,1
behaviour	12	I am motivated to continuously develop my teaching.	38	1,6	0,8
	13	I am planning to design my teaching according to research-based learning in the future.	38	3,1	1,0
	14	I envisage integration of course analyses according to classroom action research into my daily teaching routine in the future.	36	3,4	1,1
	15	I am interested in publicly presenting and discussing questions and approaches on the development of my teaching.	38	3,9	1,1
	16	I would write about course analyses or innovations in a similar format in the future.	37	3,8	1,0

#3-5: relate to knowledge, #6-9: indicate to skills, #10-11: mention attitude, n: number of persons taking part in the survey, mean: arithmetic mean of answers of cohort 1 to 4 with respect to the specific item on a 5-point Likert scale (1: totally agree and 5: totally disagree), sd: standard deviation

First of all, it was found that on average participants consider a structured pedagogical qualification as important (#1). In respect to the interviews, this suggests that on average participants accepted the training programme. This can indicate to a desire to enhance their own pedagogical competence and to solve prevalent problems in teaching and learning. However, participants' satisfaction might be diminished, since the training was compulsory. However, interviews in cohort 3 and 4 indicate that this aspect of the programme might not be a dominant issue for participants.

Interestingly, participants find participating in the programme only moderately valuable (#2). Here, a high variability in responses was detected. Four aspects evolve in the interviews: Firstly, the institutionally demanded focus on research-based learning, might have affected the direct usability for some participants, setting aside the need for a basic pedagogical qualification. Secondly, the effort spent on the programme, while other tasks are important and often urgent, might have lowered the acceptance of the programme for some participants. Thirdly, the prominent focus of research could have reduced the relevance of teaching for some, and thus of a training programme focusing on integrating both. Finally, future career prospects seemed to influence how participants acknowledge such a pedagogical qualification. It seems that participants see a lower need for teaching qualification if they seek a non-academic career after their PhD studies.

2.2 Learning after participation in the qualification programme

Participants consider themselves as well qualified in respect to basic pedagogical knowledge and skills (#3, #6). Remarkably, the standard deviation is low which indicates that participants assess their competencies in core areas quite similar.

Furthermore, participants estimate their knowledge regarding the advanced format of research-based learning as good (#4) and their skills as moderate (#7). Interestingly, the standard deviation is relatively high. This is probably due to varying possibilities to experiment with research-based learning within the programme period. Secondly, interviews indicate the participants' need for more experience in research in order to combine research and teaching. Questions regarding participants' attitude are answered differently. Although participants see research and teaching as a unity (#10), they rate the importance of integrating research into their own teaching as moderate (#11).

Moreover, participants feel competent to gather data for analysing problems in teaching (#5) and applying those using an appropriate research design (#8). Considering that participants dealt basically with quantitative data and open questions from surveys, they could have probably knotted this topic to their prior knowledge and skills. Finally, participants rate their presentation skills as quite good (#9). This is probably due to the participants' prior experience in presenting during the workshops.

2.3 Behaviour after participation in the qualification programme

Participants report a quite high motivation to further developing their teaching and learning, with low variation (#12). This suggests a high and broad fundamental interest in teaching innovation. Remarkably, participants seem to have only moderate interest in designing future courses in regard to research-based learning (#13). This is addressed in Chapter 3.1. Additionally, they indicate to have moderate intentions to routinely integrate classroom action research (#14). Interestingly, interviews show that participants made their decision on conducting classroom action research based on pragmatic reasoning. The cost-benefit relation and supervisors' support seem of importance here, besides intrinsic motivational aspects, affecting their teaching engagement in an already busy daily routine. Finally, participants state low interest in further dialogue on teaching innovations (#15) and analyses (#16). It is assumed that low intentions relate to the presumed efforts in regard of dissemination. Also, this kind of communication might not be the prior focus of departments and might thus be rewarded lower than research publications.

3 DISCUSSION

3.1 Detecting barriers and identifying potentials for implementing research-based learning

To find out more about the participants' low interest in implementing research-based learning, it is necessary to explore the presumed constraints. Participants indicate obstacles in all five categories, i.e. (1) culture, (2) structures, (3) resources, (4) academic qualification and (5) academics' views on student qualification. In regard to culture, participants report that research and teaching are 'two different ball games', i.e. two separate academic tasks. Furthermore, teaching focusing on content and basic knowledge is seen as very important in engineering study programmes, whereas the integration of research results, methods or processes is seen to be of secondary importance. As to structures, a perceived high responsibility for students' success and, at the same time, low pedagogical autonomy, which is implicated by the traditional structure of lectures and accompanying courses, were experienced as impeding. Limited resources, such as low numbers of staff for supervision, limited time for guiding through a complete research cycle, no appropriate facilities, and large classes are also crucial. With the emphasis on academic qualification, when participants target a career in industry, they focus on research in their academic practice which results in a perceived low relevance of research-based learning. In addition, low interest of some professors affects the participants as well. Participants also see research-based learning predominantly suitable for higher semesters. In regard to the academics' view on student qualification, participants report a lack of basic knowledge and low student motivation as hindering aspects.

Consequently, participants suggest several facilitating aspects in all categories to implement research-based learning. To begin with, they recommend showcasing a broad variation of good practices. Secondly, they propose concentrating on small courses and certain course types, such as laboratory courses and seminars. Other

aspects include updating syllabuses regularly, making use of state-of-the-art research in departments, allowing more time for studying or reducing content, integrating obligatory courses on scientific methods and research into the curriculum, and revising teaching approaches on the level of modules, rather than on single sessions. Thirdly, participants suggest to actually making use of already available support for course innovations and available facilities. Fourthly, they highlight the need for qualified supervision of students' research. This requires open minded professors in regard to teaching innovations, and professors encouraging staff training as well as drawing professors' attention to the benefits of research-based learning. Finally, they suggest motivating students with additional credits and product-orientation.

3.2 Proposing an improved qualification programme on research-based learning

An improved qualification programme, which considers the participants' personal satisfaction and their qualification towards research-based learning, is a prerequisite to enable an appropriate implementation of research-based learning.

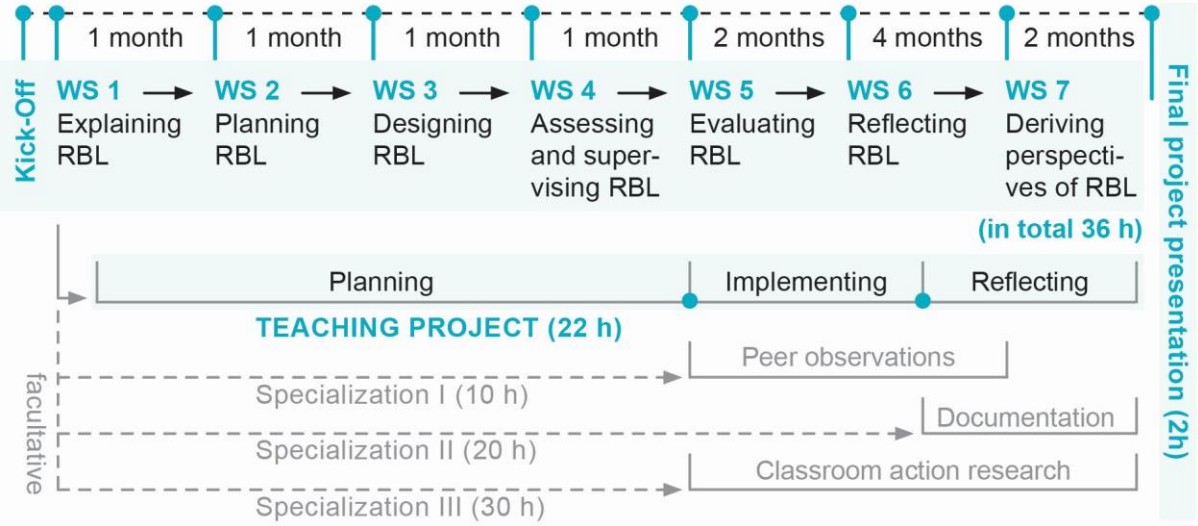


Figure 1. Improved qualification programme on research-based learning (RBL).

The recent qualification programme (see Fig. 1) integrates general principles in qualifying for research-based learning within 60 hours, finalized with a poster and an abstract. The emphasis is on deriving personal benefits for participants' career, reflecting own perceptions, as well as experiencing and testing a set of teaching methods and digital tools for research-based learning. This improved programme integrates professors and supervisors, spreading good in-house practices, and supporting networking on campus in respect to research-based learning. Additionally, interested participants can enhance their competencies during the training period by selecting specializations, for instance, peer observations, classroom action research, or documentation. More programme insights are provided by the CLL [8].

4 SUMMARY AND OUTLOOK

This study presents a qualification programme on research-based learning for early stage researchers and its perception. In conclusion, the foremost aim of the programme, that is introducing research-based learning, has been reached in an acceptingly manner. Still, attempts for enhancement on the three individual levels reaction, learning, and behaviour have been recently realized by an improved qualification programme and will be evaluated soon. However, implementing research-based learning clearly faces substantial obstacles in regard to disciplinary and institutional characteristics, among others. As a consequence, this requires additional in-depth investigations of the results on the institutional level, and identification of the profound barriers and potentials for research-based learning experienced by various university stakeholders. Adjusting those findings with prerequisites of higher engineering education could help to overcome barriers cooperatively. To do so, recommendations by participants can serve as a first source to take actions. To summarise, qualifying early stage researchers proved to be a promising approach to integrate research into teaching and learning as part of a comprehensive institutional strategy towards modern higher engineering education.

ACKNOWLEDGEMENTS

We gratefully thank all early career assistants and their supervisors for their efforts and inspiring ideas in respect to the qualification programme. We express our great gratitude to the persons taking part in surveys and interviews. This project was partly funded by the Federal Ministry of Education and Research of Germany.

REFERENCES

[1] Kuh, G.D. (2008), High-Impact Educational Practices: What they are, who has assess to them and why they matter. Washington, DC. Association of American Colleges and Universities (AAC&U).

[2] Huber, L. (2009), Warum forschendes Lernen nötig und möglich ist, In: Huber, L., Hellmer, J. and Schneider, F. (eds.): Forschendes Lernen im Studium: Aktuelle Konzepte und Erfahrungen. Bielefeld. Universitätsverlag Webler, pp. 9-35.

[3] Healey, M. (2005), Linking research and teaching: Exploring disciplinary spaces and the role of inquiry-based learning. In: Barnett, R. (ed.): Reshaping the University: New Relationships between Research, Scholarship and Teaching. McGraw Hill / Open University Press, pp. 67-78.

[4] Brew, A., and Mantai, L. (2017), Academics' perceptions of the challenges and barriers to implementing research-based experiences for undergraduates, Teaching in Higher Education, Vol. 2, No. 5, pp. 551-568.

[5] Rueß, J., Gess, C., and Deicke, W. (2016), Forschendes Lernen und forschungsbezogene Lehre - empirisch gestützte Systematisierung des Forschungsbezugs hochschulischer Lehre, Zeitschrift für Hochschulentwicklung, Vol. 11, No. 2, pp. 23-44.

[6] Mettetal, G. (2001), The What, Why and How of Classroom Action Research, The Journal of Scholarship of Teaching and Learning, Vol. 2, No. 1, pp.6-13.

[7] Wankat, P.C., Felder, R.M., Smith, K.A., and Oreovicz, F.S. (2002), The Scholarship of Teaching and Learning in Engineering, In. Huber, M.T. and Morreale, S. (eds.): Disciplinary Styles in the Scholarship of Teaching and Learning: Exploring Common Ground. AAHE/Carnegie Foundation for the Advancement of Teaching, Washington.

[8]. Centre for Teaching and Learning (2018), Qualification research-based learning. Available under https://www2.tuhh.de/zll/qualification-research-based-learning/. Verified: 09.07.2018.

[9] Kirkpatrick, D.L., and Kirkpatrick, J.D. (2015), Evaluating Training Programs: the four levels, 3rd. ed., San Francisco. Berrett-Koehler Publisher.