

Re-inventing Research-Based Teaching and Learning

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Introduction

Enhancement of teaching and learning with regard to relevance and quality is high on the agenda of universities in Europe (European University Association, 2016). One of the ambitions of many universities is to bring the two core academic activities – education and research - closer together and to integrate research into teaching more than up to now. This paper intends to provide a few informative building blocks thereto. We have consulted various scientific publications, policy documents and conference reports for answers to the following questions: What is research-based teaching? Why is research-based teaching desired? How is research-based teaching designed and implemented? Does research-based teaching work in practice? What to do for more research-based teaching?

What is research-based teaching?

What we want to describe here has different names in the literature. The ‘umbrella’ concepts are ‘teaching-research nexus’, ‘intertwining teaching and research’, and ‘research-informed teaching’. Research-based teaching is one of the crystallized forms thereof (together with ‘research-engaged teaching’, ‘research intensive learning’, ‘inquiry-based learning’, and ‘students as researchers pedagogy’; Aditomo, et al., 2013; Kinkead, 2003).

Conceptualizing the teaching-research nexus and the other overarching concepts calls for conceptualizations of three concepts: what is the essence of ‘teaching’, what constitutes ‘research’ (Schouteden, Verburch and Elen, 2016; Turner, et al., 2008), and when can we speak of a ‘nexus’ (Brew, 2003; Griffiths, 2004; Healey, 2005). In this paper we focus on the latter.

The teaching-research nexus takes shape in various forms. Students can learn from, about and through research (Hodson, 1992). Learning from research means that students acquire knowledge of important theories and research in their fields of discipline. Learning about research means that students gain knowledge of methods and techniques of research in courses methods and techniques of research and/or in research labs. Learning through research means that students acquire knowledge of their discipline by doing research themselves.

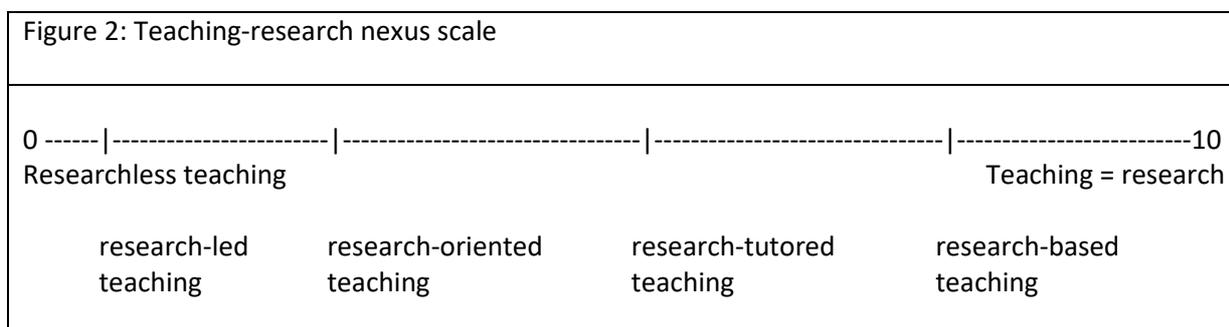
Another very useful distinction, partially overlapping with the previous one, is the distinction between ‘research-led’, ‘research-oriented’, ‘research-tutored’, and ‘research-based’ teaching. Healey (2005) made this distinction on the basis of two dimensions: the research focus - content versus process - and the role of the students - students as audience versus students as participants. In ‘research-led’ teaching the emphasis is on research-content and students are just audience. In ‘research-oriented’ teaching, the focus is shifted in the direction of research processes but students are still just audience. In ‘research-tutored’ teaching, the students are participants but the focus is on only research-content. In ‘research-based teaching students are participants and the focus is on research processes. The distinction is also applied to curricula (Healey, et al., 2014: 42). ‘Research-led’ curricula aim ‘to ensure that what students learn clearly reflects current and ongoing research in their discipline, possibly including research done by staff teaching them’. The focus in ‘research-oriented’ curricula is on ‘developing students’ knowledge of and ability to carry out the research methodologies and methods appropriate to their discipline(s) or profession’. In ‘research-tutored’ curricula the focus is on ‘students and staff critically discussing research in the discipline’. ‘Research-based’ curricula aims at ‘ensuring that as much as possible the student learns in research and or inquiry mode’ (Healey, et al., 2014: 42). Research-based curricula is preferred because ‘... universities should treat learning as not yet wholly solved problems and hence always in research mode’ (Healey and Jenkins, 2009: 3) and ‘All undergraduate students in all higher education institutions should experience learning through ... research and inquiry’ (Healey and Jenkins, 2009: 5; see also Miller, et al., 2012).

Figure 1: Teaching-research nexus variants				
Distinction	Research		Students	
	Content	Process	Audience	Participants
Research- 'led'	x		x	
'oriented'		x	x	
'tutored'	x			x
'based'		x		x
teaching				

Based on Healey (2005) .

Students' perceptions of the teaching-research nexus reflect the fourfold distinction between 'research-led', 'research-oriented', 'research-tutored', and 'research-based' teaching. In a qualitative study, first-year undergraduates on degree programmes in the arts, humanities and social sciences experience inquiry and research in four distinct ways. Research as 'gathering information' and 'exploring others' ideas' was associated with learning by engaging independently with a knowledge base. Research as 'evidencing and developing students' own ideas' and 'making discoveries' was associated with an emergent sense of participation in knowledge building, understood as the potential to bring something personal or new to an area of study (Levy and Petrulis, 2012: 85).

The teaching-research nexus can be seen as a continuum with no relationship between teaching and research with students as consumers at one end and a full relationship with students as producers at the other. 'Research-based' teaching gives the strongest relationship. The summum is: teaching = research.



Each educational unit (lecture, working group meeting, etc.) and each course, curriculum, and university can be placed on this scale by studying the level of integration of research in teaching in general and the research focus - content versus process - and the role of the students - students as audience versus students as participants in particular. Improvements can thus be regularly monitored. The highest objective may then be to move towards point 10 where 'students become scientists' (Winckler, 2011).

Why is research-based teaching desired?

The observation that many students are underachieving is a starting point. The Association of American Colleges & Universities (2009) asked after this observation the question what universities can do to help students to 'achieve the forms of learning that serve them best, in the economy, in civic society, and in their own personal and family lives' (Association, 2009: 17). The answer includes seven 'high-impact educational practices', i.e. practices that have been widely tested and have been shown to be beneficial for students from many backgrounds. Undergraduate research is one of these

'high-impact practices'. Student-faculty research has, according to the report, a positive relationship with many university educational objectives and with 'deep learning' (rather than surface-level learning). The goal of undergraduate research is 'to involve students with actively contested questions, empirical observation, cutting-edge technologies, and the sense of excitement that comes from working to answer important questions' (Association, 2009: 20).

Educational sciences provide various scientific motivations for research-based teaching. The National Commission on Educating Undergraduates in the Research University in the USA (hereafter referred to as the Boyer Commission, 1998) recommends to 'Make research-based learning the standard', referring to 'a point strongly made by John Dewey almost a century ago: learning is based on discovery guided by mentoring rather than on the transmission of information' (Boyer, 1998: 15).¹ The Commission recommends 'to turn the prevailing undergraduate culture of receivers into a culture of inquirers, a culture in which faculty, graduate students, and undergraduates share an adventure of discovery' (Boyer, 1998: 16). Every course in an undergraduate curriculum 'should provide an opportunity for a student to succeed through discovery-based methods' (Boyer, 1998: 17).² Research-based teaching and learning fits also well with more recent theories of motivation and learning, including the self-determination theory (Deci and Ryan, 1985, 2012; see also Martens and De Brabander, 2014).

The League of European Research Universities presents research-based teaching and learning more or less as self-evident: 'Research-intensive universities that couple world class research and education provide the most efficient means of providing this combination of basic research and research-based education'. LERU asks the EU 'to support the vital interaction between basic research and education in research universities' (League of European Research Universities, 2002: 1).

Documents from individual universities in Europe show that a close intertwining of teaching and research is important for these universities because this link strengthens their identity as an university. Coexistence and integration of education and research distinguishes universities from other research and educational institutions. Universities can give their students a genuine research experience they cannot get in any other setting. Research-based teaching and learning is also important for universities because it helps universities to fulfil their mission to stimulate, encourage and support students to develop the knowledge, insights, attitudes and skills they are expected to need in follow-up studies and professional careers (Giller, 2011).

Academics also expect that students by engaging them in research can better develop highly valued competencies such as a critical attitude, a humble attitude because researchers accept that there is nothing like 'the' truth, to think independently, and to express thoughts clearly (Elen, et al., 2007). 'For me the most important thing is to get the students critical towards everything ... Not to accept anything as truth' said a law lecturer from the University of Helsinki (Elen, et al., 2007: 132). More research-based teaching is also expected to contribute to transferable skills such as problem solving and team working and to attitudes such as intellectual curiosity, persistence, and identification with and a sense of attachment to a particular discipline, institute, and/or university (which is an important intrinsic motivation factor). More research in teaching is also desirable for academics who love doing research because they can integrate what they love (and maybe love most) in their teaching and can in this way make their teaching more attractive for themselves. Research-based teaching can also be instrumental to the teacher's own research when students

¹ The National Commission on Educating Undergraduates in the Research University was created in 1995 under the auspices of the Carnegie Foundation for the Advancement of Teaching. Membership included, among others, Shirley Strum Kenny (President of the State University of New York at Stony Brook; Chair), Bruce Alberts (President of the National Academy of Sciences), Stanley O. Ikenberry (President of the American Council on Education), and Kathleen Hall Jamieson (Dean of the Annenberg School of Communication, University of Pennsylvania). See also Katkin (2003).

² All ten recommendations are: 1. Make research-based learning the standard; 2. Construct an inquiry-based freshman year, 3. Build on the freshman foundation ('Inquiry-based learning, collaborative experience, writing and speaking expectations need to characterize the whole of a research university education', page 21), 4. Remove barriers to interdisciplinary education, 5. Link communication skills and course work, 6. Use information technology creatively, 7. Culminate with a capstone experience, 8. Educate graduate students as apprentice teachers, 9. Change faculty reward systems, 10. Cultivate a sense of community (Boyer, 1998).

discuss conducted research and plans for future research and when they assist in data collection and analysis. A professor emeritus of English and Rhetoric of the University of Chicago wrote: 'My books would have been quite different—and to me less valuable—if I had produced them in solitude or after talking only with professional colleagues. It was not just that thinking about how to teach students to read responsibly led me to ideas that I would otherwise have overlooked. Responding to students' rival readings actually changed my opinions about how to appreciate a given novel or work of criticism. For this and other reasons, teaching and publishing have always felt absolutely inseparable' (Boyer, 1998: 16). Reciprocity is a characteristic of research-based teaching: academics learn from students when they, for example, ask good questions about the academics' research.³

How is research-based teaching designed and implemented?

The literature offers various examples of designs for research-based teaching in study programs and individual courses.

A continuum of undergraduate research within a bachelor's degree program has been designed by, for example, the Office of Undergraduate Research of the University of Illinois at Urbana-Champaign. Students start as consumers of knowledge and move toward knowledge producers in eight steps. Step 1: students are provided with an overview of the basic facts, terms, and ideas related to the discipline. Step 2: Students learn about research findings in the (sub)field through lectures and readings dedicated to current research. Step 3: Students discuss and critique research findings and approaches in the discipline or (sub)field; assignments include literature reviews or summaries. Step 4: Students learn some research methodologies, engage in limited applications of those approaches in course assignments, such as statistical analyses. Step 5: Students learn in a course dedicated to the research methodologies, engage in extensive applications of a variety of approaches. Step 6: Students engage in faculty designed and led original (to the student) research such as replications of existing studies. Step 7: Students engage in faculty designed and led original research such as research related to faculty projects and/or conducted in faculty labs. Step 8: Students engage in student designed and led original (to the discipline) research such as a senior thesis or capstone project (Office of Undergraduate Research, 2015: 3).

An ideal teaching-research nexus within individual courses consists of five teaching activities according to academics who were interviewed about their views on an ideal research-teaching nexus: 1) teaching research results, 2) making research known, 3) showing what it means to be a researcher, 4) helping to conduct research, and 5) providing research experience (Visser-Wijnveen, et al., 2010). The activities 4 and 5 fit into 'research-based' teaching and curricula.

Various publications offer academics concrete strategies for research-based teaching (among others, Healey & Jenkins 2009, Healey, et al. 2013, 2014; Walkington 2015, 2016). Hensel (2012) is a summary of best practices that support and sustain highly effective undergraduate research environments. Based on these publications and individual universities' and academics' reports we have compiled the following list of research-based activities for and by students.

³ After the presentation of an attitude explanatory study a student seriously challenged the relevance of the research of the first author of this paper by asking 'Do attitudes have any relevance for behavior?'. The author had to confess that he assumed that attitude is a strong predictor of behavior and that he has taken the attitude-behavior relationship for granted. Then the student asked if he was allowed to test empirically the relationship with the help of the researcher. Together they decided to submit the assumption to an empirical test and to do their utmost to show the opposite, that is that attitude has no or a small effect on behavior. The student wrote a thesis and the student, researcher plus a statistician wrote a conference paper which was later published as a chapter in an edited and refereed book (Dekker, Dijkgraaf and Meijerink, 2007).

List 1: Research-based teaching activities for and by students.

- . Interviewing leading figures in the student's field of study about their research, and reporting the interview findings to their fellow-students (see, for example, the Kingston University course module Employer Insights on Marketing in University Alliance, 2016);
- . Studying and discussing authentic scientific research articles;
- . Writing a review of a scientific research article, presenting this review to fellow-students, and discuss this review with the author of the reviewed article (in class, optionally by using skype);
- . Writing and presenting a state-of-the-art paper;
- . Deriving hypotheses from this state-of-the-art paper;
- . Formulating a research question
- . Developing a full research proposal;
- . Collecting and analysing data to answer a research question (for example Dekker F., 2016)⁴;
- . Writing a paper about one's own research;
- . Presenting this research paper and/or a poster of the research at a student research conference of one's own department and/or university⁵ and/or at a national student research conference (Walkington, et al., 2016)⁶;
- . Publishing an article in an (undergraduate) research journal (Walkington, 2012)⁷;
- . Reporting about the research on a research blog;
- . Writing a reflective assessment of one's own learning process.

In addition, some universities offer local communities the opportunity to submit questions for undergraduate research (resulting in a triple nexus, i.e. a research - public engagement - teaching nexus; Stevenson and McArthur, 2015). Some universities also offer a separate module on 'real' academic research projects of the students' teacher and/or other faculty.⁸ Various organizations in the USA help universities and individual academics to design their research-based education, for example, the Council on Undergraduate Research.⁹ Some national organizations offer financial support to undergraduate researchers.¹⁰

⁴ Friedo W. Dekker (Leiden University Medical Center) asked all 1st year Bachelor of Medicine students to do a 2-week internship in a nursing home in September, to collect data on 3 selected patients (comorbidity, lab, medication, ADL, cognition), to make a SPSS database, to go back to the nursing home in December, to collect same data, to formulate a research question, to participate in a course with 5 days of lectures, assignments, practical and small working group sessions, to present a research question, to present a research project, and to write a short report. See his presentation at the 7th Innovation Room on 'Investigative Learning' of the Centre for Education and Learning on 11 November 2016: <http://www.educationandlearning.nl/news/cel-innovation-room-7-investigative-learning>.

⁵ An example of university student research conferences is the student research conference of Oxford Brookes University (<https://www.brookes.ac.uk/staff/pese/get-published/student-research-conference/student-research-conference-2016/>)

⁶ Examples of national student research conferences are in Ireland: the All-Ireland Conference of Undergraduate Research (AICUR; <http://www3.ul.ie/ctl/aicur-conference-2015>), in the Netherlands: the Student Research Conference (SRC; <http://www.studentresearchconference.nl/home.html>), and in the USA: the National Conference on Undergraduate Research (NCUR; http://www.cur.org/ncur_2016/).

⁷ Examples of undergraduate research journals are *SURE!*, Student Undergraduate Research E-journal is the e-journal of the annual Student Research Conference in the Netherlands (<http://journals.library.tudelft.nl/index.php/sure/index>), and *Geoverse*, a national e-journal of undergraduate research in Geography (<http://geoverse.brookes.ac.uk/>).

⁸ For example, the Research Based Learning Module of the University of Portsmouth, the Scholarship Projects for Undergraduate Researchers of the Nottingham Trent University, and the Student as Producer project of the University of Lincoln. In the Research Based Learning Module of the University of Portsmouth (20-credit, optional, level 5), students can apply for research jobs advertised by staff. Staff are incentivised via a small research bursary for every post they offer and fill. In the Scholarship Projects for Undergraduate Researchers (SPUR) of the Nottingham Trent University, projects are required to feed back into the curriculum to ensure teaching and learning continue to be informed by research. The Student as Producer project of the University of Lincoln provides students at all levels with opportunities to work on real academic research projects (University Alliance, 2016).

⁹ The Council on Undergraduate Research (CUR) defines undergraduate research as 'an inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline'

Teachers and students can be partners and work together not only in the research part of the teaching but also in the other elements of teaching and teaching preparation in order to give students an opportunity to shaping and enhancing their own learning experiences. In such a partnership in learning and teaching are teachers and students actively engaged in and stand to gain from the process of learning and working together. 'Engaging students and staff effectively as partners in learning and teaching is arguably one of the most important issues facing higher education in the 21st century' (Healey, et al., 2014: 7).¹¹

Does research-based teaching work in practice?

On what scale is research-based teaching applied? What are the main obstacles? How effective is research-based teaching?

We have no recent empirical data found about the levels of integration of research in teaching in courses, curricula, or universities based on the two dimensions of research focus (content versus process) and the role of the students (audience or participants), as proposed above. A survey among research universities in the USA in 2001 revealed that only a few campuses systematically collect data about how many of their undergraduates are involved in research (Boyer Commission 2002). Two studies report about perceptions of teachers and students of a research-intensive university of the level of research participation by students. In the first report, it is written that 'students indicate that they, on average, relatively little participated in research, have not come to know much about the own research of their teachers and did not feel included in the research community' (Van der Rijst, et al., 2009: 223).¹² The second report concludes that authentic research conducted by students in curricula of three bachelor degree programs happens 'only sporadically' (Van der Rijst & Jacobi, 2009: 33; see also Van der Rijst, 2016). Note that these publications are already a number of years old and we can expect that the situation has been improved following the publication of these reports. Indeed report a lot of universities in the USA and Europe in 2015 that they offer opportunities for undergraduate research (Hensley 2015). But whether research-based teaching occurs in all, many or few courses is not known. Whether all students or only the most talented enjoy this kind of education, we also do not know.

There are several obstacles for more research-based education reported in the literature. The first obstacle according to faculty is that it is not very rational to invest extra time in teaching because in practice research and not teaching is at the core in many universities and research productivity and not teaching quality is the main element in tenure and promotion (Elen, et al., 2007).¹³ This view is confirmed in the Trends 2015 study of the European University Association: a majority agrees with the statement that 'Research plays a more important role than teaching for the career development of young academics' ('yes': 54%). Most notably – more than 75% - was the answer 'yes' in Norway (91%), France (83%), Portugal (79%), Spain (78%) and Switzerland (78%). On the other hand, a majority of the respondents also agrees with the statement that 'There is a growing recognition of the importance of teaching' (59%). Most notably is the answer positive in the Netherlands (89%), the

(<http://www.cur.org/about.html>). The CUR Quarterly and CURQ on the Web provide information about student-faculty collaborative research from all types of institutions.

¹⁰ For example, the National Science Foundation in the USA. 'NSF funds a large number of research opportunities for undergraduate students through its REU Sites program. An REU Site consists of a group of ten or so undergraduates who work in the research programs of the host institution. Each student is associated with a specific research project, where he/she works closely with the faculty and other researchers. Students are granted stipends and, in many cases, assistance with housing and travel' (<https://www.nsf.gov/crssprgm/reu/>).

¹¹ See also <https://www.youtube.com/watch?v=TNKhQghFV1Y>

¹² The questionnaire was filled out by 201 students (105 from the Science faculty and 96 from the Humanities faculty) and 24 teachers (11 from the Science faculty and 13 from the Humanities faculty).

¹³ Teaching and research are even increasingly falling apart as two distinct activities is the conclusion of another empirical study among 48 academics in biotechnology and medieval history in eight research units in research-led universities in England and The Netherlands (Leisyte, et al., 2009).

United Kingdom (87%), Denmark (86%), Turkey (76%), Belgium (75%), and Finland (75%). The importance of teaching seems unrelated to the institutional profile: also respondents in the institutions which define themselves as 'primarily research based' report that the importance of teaching is growing (European University Association, Surssock, 2015: 80/81; see also Zhang, 2016).¹⁴

A second obstacle is that research-based teaching places high discipline-related and pedagogical demands on teachers (e.g., being an experienced researcher, being now engaged in research, a positive attitude toward student research¹⁵, and competent to assist students in research; Gresty, et al. 2013). Academics themselves think that it is a great advantage that university teachers are also researchers because they have insight in the evolution in their domain, are experienced in research methodologies, know the success factors and pitfalls of doing research, are aware of the impact of changes in society on research and of the impact of research on society, and when they discuss their own research they become more enthusiastic (Elen, et al., 2007). Students appreciate that their teachers are also researchers and 'believe that academics' engagement in research deepens student understanding, increases enthusiasm for learning and teaching, encourages postgraduate study, develops skills useful for employment and enhances undergraduate research activities' (Hajdarpasic et al., 2015: 644). But, it is by no means certain that good researchers are also good teachers. For good teaching other knowledge, attitudes and skills are needed than for good research. A meta-analysis in 1996 concluded that the correlation between the teachers' research activities and their teaching success was 'close to zero' (.06) and that good researchers are no more and no less likely effective teachers than not good researchers (Hattie and Marsh, 1996). In a follow-up study among 182 academics from 20 departments at a university in Australia, the correlation between 'teaching effectiveness' - measured on the basis of student evaluations of the teacher, the course, the course materials and presentations - and 'research productivity' - that is the number of publications - was even not significant (Marsh and Hattie, 2002). Studies have investigated also other significant challenges in the implementation of research-based teaching (Simons and Elen, 2007). Curriculum design and technology can help to address these challenges (Edelson, et al., 1999). It is of paramount importance that universities offer their researcher-teachers opportunities for continuing professional training so that they can improve their competencies also in the field of research-based teaching and curriculum development.

An important issue is the effectiveness of research-based teaching. Is a course with student research better than one without student research into it? Does a research-based variant of a course works better than a variant of the same course without student-research? Not surprisingly because of the complexity of such a study we have not found many publications that answer this question (Crowe and Brakke, 2008). There are indications for an affirmative answer. For example, Dekker compared students' perceptions of and performances in his course without student research with the perceptions and performances in the course with about the same objectives but now with student research in the following year. More students thought that sufficient attention was paid to scientific development and scientific skills. The scores on a test with 18 items about research and methods were higher. Written abstracts received higher grades from the six reviewers. The scores were also higher for familiarity with current research, beliefs on value of research for practice, critical reflection and motivation for research (Dekker, F. 2016). The effectiveness question can also be formulated as: Are new, higher objectives set by the introduction of research-based teaching in an already existing course and are these objectives achieved? With research-based teaching educational

¹⁴ 'Trends 2015 is the seventh in the series of Trends reports published by the European University Association. The main goal of Trends 2015 is to document the universities' perceptions of the changes that have taken place in European higher education in the past five years particularly in relation to learning and teaching. It is based on a questionnaire to which 451 higher education institutions, from 46 countries responded. The respondents represent more than 10 million students or about a quarter of the students enrolled in the institutions of the European Higher Education Area' (European University Association, Surssock, 2015: 10).

¹⁵ Teachers mention various reasons for a negative or neutral attitude towards research-based teaching. One of these reasons is the fear of negative effects on the students' study motivation of epistemological belief that there is no such thing as 'the' truth. More research is needed to find out how widespread that fear is, whether that fear is justified, and if so, what can be done to avoid this negative side effect.

objectives can be achieved in the highest levels of cognitive and affective taxonomies, including problem-solving, critical thinking, and creativity. These and other benefits for students in engaging in undergraduate research are documented in several publications (Bauer and Bennett, 2003; Hensel 2012; Kinkead, 2011; Spronken-Smith and Walker, 2010; Walkington, 2015). A professor of English wrote 'The higher education literature confirms that students who engage in undergraduate research receive numerous benefits. They improve and refine their research, writing, revision, and collaboration skills. Undergraduate research promotes creativity and alternative ways of thinking and sharpens students' ability to analyse, interpret, and synthesize, and gives them the opportunity to understand research ethics, particularly in the context of their disciplinary community' (Kinkead, 2011: 21-22). Students' evaluations of research-based teaching and learning are also usually positive. For example, Microbiology students report that the quality of an investigative lab experience was much better than that of any of their previous lab experiences (Seifert, et al., 2009). In another study, students describe opportunities to frame their own lines of inquiry, and inquiry experiences with an open-ended, knowledge-building orientation, as especially empowering in their intellectual and personal development (Levy & Petrulis, 2012: 85). Several academics - sometimes together with one or more students - report positively about their research-based courses. For example, a head of Psychology together with an undergraduate student wrote 'When you see the words "Researchers from the University of Portsmouth" in articles about research findings ... , "researchers" are staff and students ... teaching has become the key to growing our research activity while offering our students a transformational learning experience. We encourage and support our students to create knowledge with us. ... a research-based learning module which ultimately evolved to transform departmental culture to one in which our students work alongside us as co-creators of knowledge' (Hoskins and Mitchell, 2015: 11/12).

What to do for more research-based teaching?

The literature offers various suggestions about what universities and their executive boards, faculty boards and educational directors in particular can do to promote research-based teaching (Brew & Jewell, 2012; Elsen, et al., 2009; Schapper and Mayson, 2010¹⁶; Trowler and Wareham, 2008). Based on these and other publications we have compiled the following list of decisions and measures that can be taken by university administrators to promote and facilitate research-based teaching. Preliminary is: setting a general context in which effective teaching-research relations can be developed.

¹⁶ Schapper and Mayson (2010) want to help to better 'marry' research and teaching activities in higher education settings and offer a set of principles that could be used by university leaders to guide the implementation of research-based teaching.

List 2: Research-based teaching promotion and facilitation.

- . Deciding that education and research are equally important,
- . Appointing at least one university professor of higher education,
- . Establishing an university Centre for Teaching and Learning,¹⁷
- . Building an university Teaching and Learning House,¹⁸
- . Linking research and teaching committees, and
- . Bridging any divides between research staff and teaching staff,
- . Appointing only academics who excel in both research and teaching,
- . Strengthening positive attitudes towards research by students among staff and students,
- . Making resources available for students to do research¹⁹,
- . Making it possible that libraries give information literacy instruction to students²⁰,
- . Offering opportunities and incentives for teachers for further development of their 'research-based' teaching competence and excellence,²¹
- . Creating and stimulating opportunities for dissemination of successful practices²²,
- . Recognizing teaching excellence,²³

¹⁷ The alliance of Leiden University, Delft University of Technology and Erasmus University Rotterdam established the Centre for Education and Learning (CEL) in 2014. The Centre is an interuniversity and interdisciplinary research centre as well as an innovation and training platform that aims to discover what makes university teaching and learning work and how it can be innovated and improved. The three universities are the testing ground for continuous innovation and improvement of university teaching and learning. The main activities of CEL are research, development and professional training. Within the three universities, educational scientists conduct research into teaching and learning in order to discover the conditions for study success. Research in the centre is multidisciplinary and profits from comparative analyses, mixed methods, large research populations and big data. PhD students work on the CEL research programme that concentrates on online learning and covers the three main areas of characteristics of teachers, students, and learning environments. CEL also aims to give a powerful impetus to the development of innovative online, blended, and on-campus teaching strategies and materials. The Centre brings together higher education developers from various universities to exchange ideas and projects and to take new joint initiatives during symposia that are called 'Innovation Rooms'. Teaching staff is supported in developing their teaching skills by directly involving them in innovating their courses and designing their own training. The 'Academic Teaching Lab' provides teachers context and ideas to practically learn and hands-on develop the education they would like to provide. Each year the 'Leadership in Education Course' enables and empowers directors and managers of education to develop a broad en practice-oriented vision on education and educational innovation. For more information about the Centre for Education and Teaching (CEL), see <http://www.educationandlearning.nl/>.

¹⁸ The Delft University of Technology's new education building on the campus aims to be 'a central place bringing students and teachers together to make contacts, collaborate, share knowledge, conduct research, and develop themselves'. For more information, see <http://campusdevelopment.tudelft.nl/en/project/pulse/>.

¹⁹ For example, university licenses for all students to use data collection software such as Qualtrics for quantitative research and Atlas.ti for qualitative research.

²⁰ Libraries' information literacy instruction may include advanced database searching, citation management, coaching related to the publishing process, copyright and information around open-access publishing (Hensley 2015).

²¹ The 'Academic Teaching Lab' of the Centre for Education and Learning provides teachers context and ideas to practically learn and hands-on develop the education they would like to provide. The CEL Academic Teaching Lab is an exclusive opportunity for university teachers to immerse themselves in educational innovation for two days. The participants collaborate with colleagues and experts to improve their academic education through very practical and hands-on learning. The Academic Teaching Lab aims to provide teachers and educators with inspiration, flow and focus to improve the teaching they provide and the learning they facilitate. Together with educational experts and advisors, learning developers, teacher trainers and other professionals, ideas for development will be refined and various solutions explored. Feedback from peers and experts will strengthen their approach and guide them towards a solid plan of action that can be executed after these intensive days of study. For more information, see <http://www.educationandlearning.nl/professional-training/academic-teaching-lab>.

²² For example, an annual conference about student research, an university repository which archives students' research work and which is open for future students to expand upon them.

²³ Leiden University, for example, has set up a Teacher's Academy in October 2014. The members are the best teachers of the university. The teachers get as Teaching Fellow not only recognition of their achievements as a teacher but also the possibility of further development of their educational innovation. They receive a grant € 25,000 to carry out one or more educational projects. With collegial exchange, peer review and, where appropriate interdepartmental cooperation, these projects are implemented within the Teachers' Academy. The Teachers' Academy organizes at least

- . Introducing an undergraduate student research award, and, last but not least,
- . Monitoring the growth of ‘research-based’ teaching,
- . Ordering and financing more research of the teaching-research nexus and of research-based teaching and learning in particular.

Research, development and training can probably best be carried out in partnership with other universities in the same region (e.g., the Center for Education and Learning of the alliance of Leiden University, Delft University of Technology and Erasmus University Rotterdam in the Netherlands²⁴), at the national level (e.g., the Higher Education Academy in the United Kingdom²⁵) and in an international context (e.g. the European Forum for Enhanced Collaboration in Teaching of the European University Association²⁶), benefiting from the collaboration’s advantages of a greater variety of expertise, comparative analyses, mixed methods, larger research populations, and big data.

Summary

Universities want to enable their students to acquire high-level subject-based, research, leadership and personal competencies in order to prepare them for higher positions in a future society. Research-based teaching seems to be a suitable approach for this purpose. This paper intends to provide universities a couple of informative building blocks for bringing the two core academic activities – education and research - closer together and for integrating research into teaching more than up to now.

What is research-based teaching? Research-based teaching is teaching through meaningful and real hands-on experiences in research: students are researchers and ask complex questions, search for answers by doing research, and report about their research journey. The teaching-research nexus can be viewed as a continuum with no relationship between teaching and research at one end and a full relationship - teaching = researching - at the other end.

Why is research-based teaching desired? Universities can improve the relevance of their education and can better prepare the students for follow-up studies and to the new and emerging demands of the labour market in the twenty-first century. Moreover, a close intertwining of teaching and research strengthens their identity. Academics can help students by engaging them in research

once a year, a university-wide symposium on educational innovation at Leiden University, aimed at exchanging information and experiences on best practices. For more information, see <http://medewerkers.leidenuniv.nl/p-en-o/loopbaanontwikkeling-opleidingen/teachersacademy/over-teachers-academy/leiden-teachers-academy-stimulans-voor-onderwijskwaliteit.html>.

²⁴ The Centre for Education and Teaching (CEL) recently organised a conference – ‘Innovation Room’ – about the teaching-research nexus under the title ‘Investigative Learning’. For a report and the Power Point presentations, see <http://www.educationandlearning.nl/news/cel-innovation-room-7-investigative-learning>.

²⁵ The mission of the Higher Education Academy is ‘Improving learning outcomes by raising the status and quality of teaching in higher education’. The Academy offers several publications on student research. For more information, see <https://www.heacademy.ac.uk/>.

²⁶ The European Forum for Enhanced Collaboration in Teaching (EFFECT) project aims to facilitate exchange and collaboration between European actors and stakeholders for the enhancement of higher education teaching; identify good practices and develop new and innovative approaches to learning and teaching enhancement; support institutions in the development of strategic approaches to the enhancement of learning and teaching; develop a model for a sustainable European structure for the enhancement of learning and teaching. The project seeks through its activities responses to grand challenges for higher education teaching, such as for instance the growing and ever more diverse student body – and stagnating staff and financial resources; drop out and retention; maximising opportunities and addressing challenges of ICT based learning; recognising teaching excellence and its link to student success. It may also provide recommendations for the policy level, in particular with regards to a European perspective with the aim of enhancing higher education teaching at institutions. The European University Association is the project coordinator of this Forward Looking Cooperation Project, co-funded by the Erasmus+ Programme of the European Union. For more information, see <http://www.eua.be/activities-services/projects/current-projects/higher-education-policy/effect>.

to better develop highly valued competencies. More research-based teaching can also make teaching more attractive for academics and can make teaching instrumental to the academics' own research.

How is research-based teaching designed and implemented? The literature gives examples of research within a degree program and research-based teaching within individual courses. We compiled a list of concrete research-based teaching activities for and by teachers and students.

How does research-based teaching work in practice? We have no recent empirical data found about the levels of integration of research in teaching in courses, curricula, or universities. Many universities in the USA and Europe say that they offer opportunities for undergraduate research but whether research-based teaching occurs in all, many or a few courses and whether all students or only the most talented enjoy this kind of education is not known. An important obstacle is that research plays a more important role than teaching for academics' career development. Research-based teaching also places high discipline-related and pedagogical demands on teachers. Not surprisingly because of the complexity of such a study we have not found much data that answer the question whether a research-based variant of a course works better than a variant of the same course without student-research though several publications document the benefits for students of engaging in undergraduate research.

What to do for more research-based teaching? We compiled a list of concrete decisions and activities for university executive boards, faculty boards and educational directors to promote and facilitate research-based teaching. The start is setting a general context in which effective teaching-research relations can be developed, including deciding that education and research are equally important. Given the expected added value, regional, national and international cooperation of universities is recommended for research into, development of, and training in research-based teaching, with the ultimate goal to offer all students more opportunities to learn not only from research and about research but also and above all through research.

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