The transformative nature of research-based education: a thematic overview of the literature

Rijst, R.M. van der; Bastiaens, E.; Tilburg, J. van; Merriënboer, J. van (Eds)

The transformative nature of research-based education: A thematic overview of the literature

Roeland van der Rijst (Leiden University)

Introduction

A current trend in undergraduate education is the provision of authentic research activities that give students opportunities to develop essential skills for their discipline, and a deeper understanding of the fundamental concepts (cf. Healey; 2005; Hua & Shore, 2014; Jenkins, Healey & Zetter, 2007; Turner, Wuetherick, & Healey, 2008). Although much has been written about the benefits of incorporating research into undergraduate teaching and learning (cf. Breen & Lindsay, 1999; Brew, 2003; Healey, Jordan, Pell, & Short, 2010; Neumann, 1994; Robertson & Blackler, 2006; Spronken-Smith, Mirosa,, & Darrou, 2014; van der Rijst, Visser-Wijnveen, Verstelle, & van Driel, 2009; Verburgh & Elen, 2011), many issues are still contested, indistinct or even ambiguous (Malcolm, 2014; Simons & Elen, 2007).

While there are many ways to integrate research activities into teaching to improve student learning, such as inquiry-based education, research-intensive education, and research-based education (for an overview, see Aditomo, Goodyear, Bliuc, & Ellis, 2013; Furtak, Seidel, Iverson, & Briggs, 2012; Griffioen, Visser-Wijnveen, & Willems, 2013), all these teaching approaches are based on the principle idea that the research cycle and related activities are beneficial to the development of students' cognition, skills and attitudes. Therefore, in this chapter I adopt the definition that research-based education is "a cluster of student-centred approaches to learning and teaching that are driven by inquiry or research" (Minner, Levy, & Century, 2010). It might be rephrased towards student activities as: Research-based education is a teaching approach in which students learn by engaging in thinking processes and activities of scientists (cf. Furtak et al., 2012).

The central argument in this chapter is that authentic research opportunities (if well incorporated in learning activities, and well supervised by teaching staff) can and should provide students with a valuable transformative learning experience, which gives students more than only an increase of skills, knowledge and attitudes: it should give students a lived epistemological experience of what it means to construct knowledge in their discipline. I argue that such an experience for students is what we all should strive for in our teaching. It is the ultimate endeavour for any educator in undergraduate education and beyond to foster "learning opportunities that makes a difference in students' lives beyond course content and whether in or outside of the classroom" (J. Zubizeretta, personal communication, September 4, 2014).

In this chapter I will first, in part I, outline some perspectives of the role of research in undergraduate education. In part II, I will report findings of a literature review on the current state of knowledge of the benefits of research integration in undergraduate education. I will distinguish the variety of skills, knowledge, and dispositions students, educators and educational researchers instil upon research opportunities in undergraduate teaching. In part III, I will discuss and identify a number of potential new challenges for further improving our understandings of research in undergraduate education.

Part I: Ways of thinking about the role of research in undergraduate education

"*The meaning of 'knowing' has shifted from being able to remember and repeat information to being able to find and use it*" (National Research Council, 2007).

In order to set-the-stage for the discussion I recall a moment in time which gave the discussion about the role of research in undergraduate teaching impetus. Healey (2005) introduced a framework which distinguished ways to integrate research in undergraduate teaching (see previous chapter). This framework was based on his experience as an educator and had a remarkable intuitive strength. Many educational policy makers and deans of departments recognised the value of the framework in order to strengthen their argument to put more emphasis on research and research related activities in undergraduate education. The framework also spurred the need for new studies into the benefits and challenges of research integration in teaching and learning. Recently, some studies showed that this framework to some extent could be related to empirical data from student and staff experiences. They have also shed light on those elements of the framework that could not be validated in empirical studies (Elsen, Visser-Wijnveen, van der Rijst, & van Driel, 2009; Visser-Wijnveen, van der Rijst, & van Driel, in press).

Healey's framework provided us with a new way of thinking about how we could integrate research in teaching, but not the educational aims we have for teaching. In order to align learning objectives with the teaching strategies and the provided learning environments, we need to rethink the models and objectives of research-based education. In this part I will first introduce current typologies of research-based tasks and models of the research-teaching nexus which go beyond Healey's framework. Then I will relate these models to taxonomies of educational objectives. Finally, I discuss how these objectives provide us with a way forwards towards effective instructional design of research-based learning opportunities.

Typology of Research-based tasks

In a survey study Aditomo et al. (2013) collected self-reports of research-based teaching approaches of academics in Australian higher education institutions. Aditomo et al. used the term of inquiry-based learning to include teaching approaches such as problem-based learning, project-based learning, and case-based learning. Of the 500 respondents to the email survey 224 academics described a research-based teaching approach. Through a qualitative analysis of the descriptions, Aditomo et al. developed a typology of research-based tasks used in Australian higher education institutes. The typology consists of two dimensions: the use-oriented dimension, and the knowledge versus skills dimension. The use-orientation dimension concerns whether there is an emphasis on a practical application or whether the outcome of the task relates to a solution of a specific problem in practice. The knowledge-skills dimension relates to the focus of the inquiry task towards development of students' knowledge of research skills.

Although the descriptions of research-based teaching approaches were self-reported narratives, the value of the typology of tasks lies in the insight into educational focus and outcomes academics have when using research-based teaching approaches. However, the educational aims which inspired academics to use the research-based tasks are still concealed.

Knowledge model of the research-teaching nexus

In a recent publication Visser-Wijnveen (2013) presented a two-dimensional model of modes of research-based teaching approaches (Figure 1). In this model one dimension puts emphasis on the extent to which knowledge is developed or transmitted to students, while the other dimension runs from an emphasis in the courses on research products (such as theories, models, laws, and concepts) to an emphasis on research processes (such as research method, instruments, and data analysis). From this model, three levels of knowledge of research are discriminated: knowledge transmission; knowledge reproduction; and knowledge production.

<Include Figure 1 about here>

This model describes ways to integrate research into teaching, and puts an emphasis on the position of knowledge in the teaching of discipline specific research. The model provides us with a language to express different educational aims we have with the integration of knowledge about research in teaching. It shows that we can and should discriminate between aims focused on transmission of knowledge, and aims focused on reproduction or production of knowledge of research.

Taxonomy of educational objectives

Bloom's revised taxonomy of educational goals (as cited in Krathwohl, 2002), describes two dimensions on which we can classify and develop learning aims for teaching (see Figure 2). The knowledge dimension provides a way to discriminate between what kinds of knowledge we want students to learn. The taxonomy distinguishes between factual knowledge, conceptual knowledge, procedural knowledge, and meta-cognitive knowledge. Furthermore, the cognitive process dimension distinguishes between remembering and understanding, to more complex cognitive learning processes like applying, analysing, evaluating and creating. These two dimensions of Bloom's revised taxonomy are widely used not only to identify educational aims, but to also evaluate teaching strategies and assessment practices. The underlying assumption is that if the aims we have for students are in line with the teaching strategies, and with the assessment practices we use, then it is more likely that the aims are reached and students learn what we want them to learn. Bloom's revised taxonomy provides us with an unequivocal language (1) to express learning objectives, (2) to constructively align them with teaching strategies, and (3) to design appropriate assessment practices which support student learning towards these objectives.

<Include Figure 2 about here>

In order to gain a better understanding of the aims in research-based teaching and learning and their alignment with teaching strategies the two dimensions of the revised taxonomy of educational aims provide us with a valuable framework. In Figure 2 the two dimensions from the taxonomy of learning goals are plotted with the cognitive process dimension vertically and the knowledge dimension

horizontally. This taxonomy can support any classification of research-based courses grounded on the educational aims. This framework can help us, for example, to identify research-based activities in any course and any subject.

If the learning objective is that students remember facts of some seminal studies in their discipline, the teaching strategy should primarily be focused towards that aim. For example, if the aim is that each physics student should be able to remember the set-up and results of the double slit experiment (or Young's experiment which demonstrates the probabilistic nature of quantum mechanical phenomena, which is a threshold concept in learning quantum physics), an effective teaching strategy is to describe or to demonstrate the classic set-up of the experiment. However, if we want the students to understand or even apply it by themselves, a mere description and demonstration might not be sufficient to achieve the aim. The physics students probably achieve this aim best by building the classic set-up and reproducing the double slit diffraction pattern for themselves.

Another example: if the aim is that each psychology student understands the theory of cognitive dissonance, a threshold concept in learning cognitive psychology (Festinger, 1975), we can explain the theory, put it in context of other theories in social psychology, and ask students to explain the theory for themselves. However, if we want students also to understand how we can measure (procedural knowledge) a persons' cognitive conflict resolution strategies, we might better design a student assignment where they need to design an intervention in which resolution strategies might occur and can be measured.

Similar to the three levels of knowledge in the model of Visser-Wijnveen (2013), the educational aims of research-based learning can be loosely summarised as threefold, namely, learning about research, learning through research, and learning to do research (Hodson, 1992). Comparing the knowledge model of Visser-Wijnveen and the representation of the taxonomy of learning goals we notice that the axes are to a certain extent similar. For example, the top part of both frameworks relates to intentions to create or produce new knowledge, while the bottom part of the frameworks describe intentions that students remember the knowledge which is transmitted to them. Also the horizontal axes are related. An emphasis on research products, such as theories, models, laws, and concepts, is in more general terms a focus on factual and conceptual knowledge, while a focus on research processes, such as research method, instruments, and data analysis, is an emphasis on procedural and meta-cognitive knowledge. Thus, the knowledge model of Visser-Wijnveen (2013) can be interpreted as a representation of the taxonomy of learning goals for research-based learning contexts.

Instructional design

Based on the educational aims for research-based learning, teaching approaches and instructional strategies for complex learning can be designed according to well described principles (Merrill, 2002; van Merrienboer, & Kirschner, 2013). Merrill (2002) concisely formulated five principles of effective instructional design based on a review of design theories. Learning is promoted when (1) learners are engaged in solving real-world problems, (2) existing knowledge is activated as a foundation for new knowledge, (3) new knowledge is demonstrated to the learner, (4) new knowledge is applied by the learner, and (5) new knowledge is integrated into the learner's world (Merrill, 2002). In research-based education 'research activities' provide the real-world problems with which students engage in

learning related activities. However, the principles also show effective research-based teaching is more than only engaging students in research activities. Educators should be aware that for research-based education to become transformative experiences for all students, emphasis should be placed on all the principles of effective instruction while keeping in mind the specific learning goals we have for research-based education.

Part II: Benefits of inquiry for student learning: A thematic literature review

"Some things cannot be taught, they have to be lived to be understood" (Miller, 1981).

Over the last few decades, a large number of studies from a variety of perspectives have been published about student research opportunities in higher education. Malcolm (2014) gives a critical overview of recent studies about the research-teaching nexus and evaluated to what extent the main research questions in this field of study have been answered. She concludes that we have not yet conclusively answered the questions raised in the early 1990s as to whether research-teaching links are core elements of higher education. Although fundamental questions are not yet solved, recent studies do provide us with an in-depth understanding of the diverse practices of research-teaching links in higher education. Based on a search query, I will describe the main topics of recent studies related to research-based approaches to teaching and learning, focusing on the benefits of inquiry for student learning. This review of the literature is guided by the research question: What are the benefits of research related activities for student learning?

In order to gain an overview of the available literature about research-based teaching and learning, an integrative literature review (Torraco, 2005) was conducted. The integrative literature review consisted of three subsequent steps and was limited to peer-reviewed articles in journals included in the Social Science Citation Index Expanded (ISI Thomson Reuters). First, the search terms were defined based on initial search queries, reading of abstracts, and re-reading of seminal articles. Initial inclusion criteria were described. Finally , the main search query was conducted. Table 1 gives an overview of the search terms collected during the pilot searches and used in the main literature search.

<Include Table 1 about here>

Although studies on problem-based learning, inquiry-based teaching, and research supervision are strongly related to the topics in the main search query, these broad fields of study are not included in the main search query for two reasons. First, these fields of study are already covered in well described overviews (cf. Furtak et al., 2012; Hmelo-Silver, 2004; McCallin & Nayar, 2012). Second, these fields of study have established their own research traditions, research questions, and challenges. And third, these fields of study have their own history and pathways from which they developed. Based on the title, abstracts and keywords of all articles an initial content selection was performed in which articles that did not relate to research-based education in higher education contexts were excluded. A total of 40 articles were included in the review process (these articles are

indexed with an asterisk in the list of references). During the third and last steps, articles were categorised based on the full text content. Each article was read, and a brief summary in key terms was made. Based on the summaries articles with similar aims and research questions were clustered.

I will start with a brief overview of studies from institutional and programmatic perspectives (institutional policies, academic identity, communities of practice, and student evaluations of research-based education) in order to arrive at issues about teaching and learning at course level (student outcomes and student experiences). Four case descriptions of research-based courses at Leiden University are inserted in the result section to provide illustrations of the broad variety of ways to integrate research in teaching and give students a transformative experience through disciplinary research activities.

Institutional and programmatic perspective

Institutional policies.

Although many academics perceive the link between research and teaching as positive and inherent to the core business of university education, there is a number of external factors and systematic influences which are detrimental to accomplishing a close relationship in practice (Coate, 2001; Hordern, 2013). In an international comparison of eight research units in research intensive universities in the UK and the Netherlands, Leisyte, Enders, and de Boer (2009) showed that academics perceived competition between teaching and research time, which leads to conflicts in establishing close relationships between teaching and research in practice. Similar results were obtained in an international comparative study of institutional cases in Sweden and the UK (Taylor, 2008). In all educational units participating in this study accountability and assessment of teaching and research were commonly undertaken as separate activities. Furthermore, at the level of undergraduate research the "interconnectivity" between research and teaching at contemporary higher education still seems to be a myth (Hordern, 2013). In order to purposefully enhance research-teaching relations Healey and Jenkins (2009) provided a comprehensive list of institutional strategies. All studies into the institutional perspective show that research-teaching links do not come about naturally. Therefore focused, purposeful, and persistent institutional strategies are necessary to establish a sustainable research-teaching nexus. Recently, Hu, van der Rijst, van Veen, and Verloop (2015) showed that besides inter-disciplinary differences, institutional policies have an influence on the way academics perceive and act upon research-teaching links. Hu et al. compared academic's perceptions of the role of research in teaching in both research-intensive universities and teaching-focused higher education institutes. Both the perceived research support as well as the perceived research culture significantly related to academic's conception of the role of research in teaching. Therefore, the authors suggest that institutional policy efforts to strengthen research support and research culture, will help academics to strengthen the role of research in education.

<include Case description 1 about here>

Academic Identity.

Beside the institutional perspective, authors problematize the same challenge of strengthening links between research and teaching from an academic identity perspective (cf. Lopes, Boyd, Andrew, & Pereira, 2014; Visser-Wijnveen et al., 2009). At established research-intensive universities, academics identify themselves with their disciplinary research activities more than they identify with their teaching activities. They conceive of themselves as experts within their discipline, and to a lesser extent, as educators. While at higher education institutes which are in a transition towards incorporating research activities beside their core business of teaching (like some polytechnics and universities of applied sciences, sometimes referred to as 'newer' universities; Kyvik & Lepori, 2010; Melles, 2011), academics identify more strongly with their roles as educators. Overall, in recent literature the idea of a single 'academic identity' is shifted towards a better understanding of the multi-layered character of academic identity. Academic identity consists of at least a researcher identity, educator identity, professional identity, but also of an organisational or managerial identity.

At polytechnics and universities of applied sciences, academics also identify with the field of practice. Lopes and colleagues (2014) study academics' identity perceptions in professional fields, such as nursing. Academics in these professional fields often make a clear distinction between how they speak about their educator role and about their research role, while Visser-Wijnveen and colleagues (2009) show that academics at established research-intensive universities addressed the interconnectivity between knowledge development, research and teaching in their discipline.

Based on academic literature and experiences at higher education institutes in academic drift (Neave, 1979), van Winkel, Poell, van der Rijst, & Jurriëns (2011) developed a framework to conceptually integrate the varied roles academics have and need to develop. The context of universities of applied sciences in the Netherlands provides an excellent research object to study academics' identity development for educator roles into researcher roles, because academics at Dutch universities of applied sciences are currently stimulated to develop research activities beside their well-established teaching roles. The developed framework describes the dynamic interactions between academics' roles and practices (teaching, research and disciplinary profession). Based on this framework the authors develop new lines of research to increase our understanding of academic identity as a multi-layered and dynamic construct (Van Winkel et al., 2011).

<include Case description 2 about here>

Communities of Practice.

Strengthening the linkage between research and teaching boils down to establishing sustainable interconnections between research environments and learning environments within higher education (Jacobi & van der Rijst, 2010). Although there are many ways of developing interconnections between research environments and learning environments, communities of practice in which both students and research staff participate have been advocated as highly sustainable in the literature about research-based education (Brew, 2003; Jones, 2013; Smith & Rust, 2011). Brew (2003) describes a model of undergraduate education in which academic communities of practice have a central role. The conception of teaching underlying this model is student-focused

with a concentration on conceptual change. This means that students and staff participate on an equal footing especially related to knowledge co-construction (legitimate peripheral participation; Lave & Wenger, 1991). On the one hand, this idea, away from teacher-focused approaches to teaching, requires a reconceptualization of higher education in the sense that most current curricula are still designed from the conception that there are teachers who 'know-it-all', and whose role is to instil their knowledge and skill in those new to the discipline. On the other hand, the strong disciplinary boundaries, power distance between academics and support staff, and the divide between students and staff (cf. Smith & Rust, 2011) also need to be re-negotiated in order to create sustainable academic communities of practice in which academic staff, support staff, and students can participate equally based on their passion and commitment with the groups' expertise (Ng & Pemberton, 2013). Jones (2013) presents a way of working within communities of practice based on principles similar to learning cycles within action-research approaches. Although these learning cycles are contested to some extent (Simons & Elen, 2007), all academic communities of practice are based on the participants' disposition to increase their understanding of the topic. Therefore, these academic communities of practice are communities of learners, in which the teaching staff also are learners in their discipline. Thus, in these settings a research-based teacher is becoming a *primus inter pares* within a learning community. Teaching roles are changing from being an instructor towards being a coach and advisor. Therefore, research supervision approaches which align with student-focused/conceptual change conceptions of teaching are relevant topics to study in order to improve teaching approaches in research-based learning contexts (de Kleijn et al., 2012; Hu, van der Rijst, van Veen, & Verloop, in press; Spiller, 2013).

Student evaluations of research-based education.

Recently, several studies used a survey methodology to increase our understanding of students' perceptions of research-based education (Breen & Lindsay, 1999; Healey et al., 2010; Spronken-Smith et al., 2014; Turner, Wuetherick, & Healey, 2008; Verburgh & Elen, 2011). These survey studies focused on students' perceptions of positive or negative benefits of research, and their awareness of research conducted by academic staff. A recently developed course experience questionnaire specifically modelled to capture students' perceptions of research-based teaching approaches is the Student Perception of Research Integration Questionnaire (SPRIQ; Visser-Wijnveen et al., in press). The main construct in the questionnaire of interest here is 'research integration'. The construct of 'research integration' consisted of both tangible and intangible items. The five tangible scales were: focus on 'research product'; 'research process'; 'students as participants'; 'current research'; and 'teacher's own research'. Three other subscales focused on the intangible aspects: 'integration in research community'; 'motivation for research'; and 'academic disposition'. This questionnaire can be used as a tool to indicate to what extent students perceive their courses as research-based (Vereijken, van der Rijst, de Beaufort, & Dekker, in press). In another study into staff conceptions of research-based teaching and learning, this questionnaire was adapted in order to capture staff conceptions in two different international contexts (Hu et al., 2014). The findings from this last study suggest that beliefs about teaching as conceptual change/student-focused are closely related to the way teachers value the role of research in teaching. Appreciation for research related teaching activities is associated with emphasis on teaching approaches focused towards conceptual change. Among others, this could mean that to strengthen the link between research and teaching, we need teaching approaches which put emphasis on student's cognitive change (Hu et al., 2014).

Teaching and learning at course level

Many of the studies found in the literature search describe authentic cases of research-based teaching at a course level. In these studies, the benefits of research-based teaching approaches as perceived by staff and students have been well documented (e.g. Breen & Lindsay, 1999; Healey et al., 2010; Neumann, 1994; Robertson & Blackler, 2006; Seymour, Hunter, Laursen & Deantoni, 2004; Spronken-Smith et al., 2014; Turner et al., 2008; van der Rijst et al., 2009; Verburgh & Elen, 2011). However, these studies do not present a clear and distinct categorisation of the benefits. In general, there are two main categories on which the benefits are described, on the level of student outcomes (skills, dispositions, and knowledge), and on the level of student experience (relatedness, competence, and autonomy). Below I give an overview of relevant elements of each of these sub-levels of the benefits of research-based teaching and learning at course level.

Student outcomes

Improved skills.

Research-based teaching approaches are beneficial to students' cognitive skills, such as problem solving skills and critical thinking skills (Healey et al., 2010; Robertson & Blackler, 2006; Turner et al., 2008; van der Rijst et al., 2013). Seymour, Hunter, Laursen and Deantoni (2004) conducted a study into research-based teaching approaches in undergraduate courses. They reported positive benefits, of students improve specific disciplinary critical thinking skills, among others. In a follow-up study, Hunter, Laursen and Seymour (2006) describe the benefits of learning communities to students. Both students' skills and their attitude towards the topic improved according to the participating students. Furthermore, perceived benefits of research-based teaching approaches as described in studies in a variety of contexts are improved higher-order cognitive skills (Deakins, 2009), acquiring transferable skills (McLean, 2004), and enriched general research literacy (Cuthbert, 2012).

Matured dispositions.

Other studies report students' attitudinal changes in research-based classes (Healey et al., 2010). Students appreciated the 'critical questioning approach' and discussion about research findings in research-based classes (Neumann, 1994). Both teaching approaches are thought to enhance students' academic attitude (Neumann, 1994) and mature their epistemological disposition (van der Rijst, 2009; Verburgh, Elen, & Lindblom-Ylänne, 2007). Research-based teaching approaches illustrate to students that knowledge construction is never finished (Turner et al., 2008; van der Rijst et al., 2013).

Enhanced knowledge and understanding.

Some studies also emphasised that research-based teaching approaches enhanced students' understanding of the topics (Jenkins, Healey & Zetter, 2007; Turner et al., 2008). Enhancement of depth of learning and understanding is described as the basic goal of research-based approaches to teaching (Healey, 2005). Students perceive an increased understanding of and interest in the subject,

and an improvement of their own research skills when they are taught or supervised by active researchers (Turner et al., 2008). Hua and colleagues (2014) showed that academics perceive the impact of research-based teaching (in this study undergraduate research) to promote subject-matter currency, to model ways of thinking in the discipline, and to help staff explain difficult concepts. Although these studies report the perceptions of students and staff about the benefits to students' understanding, they were conducted in authentic research-based learning contexts.

<include Case description 3 about here>

Student experiences

Engagement and relatedness.

Students are more motivated when they come into contact with staff research at their institution at an early stage in their studies (Healey & Jenkins, 2009; Visser-Wijnveen, van Driel, van der Rijst, Verloop, & Visser, 2010). Robertson and Blackler (2006) also found that students in research-based courses were motivated by the enthusiasm of their teachers. According to the students, teachers became more enthusiastic when talking about their own studies. Furthermore, the perceived reputation of the staff and the institution increases when teachers also have research responsibilities (Jenkins, Blackman, Lindsay, & Paton-Saltzberg, 1998). Students perceive the added value of studying in a research culture (Spronken-Smith et al., 2014), and appreciate being socially and intellectually involved in staff research (Healey, Jordan, Pell, & Short, 2010; Kardash, 2012). Overall, these studies indicate that students' engagement with the course content and their relatedness to the programme and institute both increase in research-based environments.

Efficacy and competence.

Seymour and colleagues (2004) showed participating in undergraduate research projects increased students' confidence in their skills to perform research. Students' research efficacy beliefs and their feeling of competence to complete research projects increased. Students experience courses as up-to-date and intellectually stimulating when teachers bring into play elements of their own research (Healey & Jenkins, 2009; Horta, 2012; Visser-Wijnveen et al., 2012). And classes were considered more challenging and intellectually stimulating, especially when research assignments were given to students (Neumann 1994; Robertson & Blackler 2006). These studies indicate that research-based teaching approaches are beneficial to students' research efficacy beliefs and feelings of competence to do research in the discipline.

<include Case description 4 about here>

Students' feeling of autonomy.

Students typically appreciated participation in staff research. However, merely being used as a student work force for their teachers was considered a risk (Buckley, 2011; Gresty, Pan, Heffernan, & Edwards-Jones , 2013). Similarly, students reported low levels of ownership over the staff research projects in which they participated, because they were only indirectly or partially involved in these projects (Healey et al., 2010). In a longitudinal questionnaire study on the value of research-based teaching approaches students reported enjoying independent working, having responsibility, feeling accepted as co-worker, interacting with the faculty, and being intellectually stimulated as benefits (Goodlad, 1998). In order for research-projects to become transformative learning experiences, students need to have the feeling of ownership and autonomy over their research projects. Therefore, research-based teaching approaches need to balance on the thin line between providing support and giving autonomy to students. Students experience classes and projects intellectually stimulating and challenging when the degree of student-regulation and teacher-regulation is matched in order to maintain a 'constructive friction' between teacher support and student-regulation (Vermunt & Verloop, 1999).

Part III: Discussion

During the last two decades, the interest in integrating research activities into teaching has rapidly increased. Many studies were published on a wide variety of topics related to the institutional level, the programme level, and the level of teaching and learning in courses. More recently, an increase in studies into research opportunities for undergraduate students can be seen. Geographically most studies were conducted in the UK, Australia, New Zealand and the Netherlands. This might indicate that the terminology used by academics in the North Americas might be distinct from the search terms applied in this study, or issues related to research-based education are studied from a different perspective. Further research should pay attention to the variety in terminology and perspectives used to indicate issues related to integration of research in teaching.

Many studies in the literature search apply a qualitative design in which the perceptions of both students and staff were identified. No studies use (quasi-)experimental designs or longitudinal cohort designs in order to understand the effectiveness of research opportunities for student learning. Only recently were questionnaires designed in order to represent students' experience of undergraduate research opportunities (cf. Spronken-Smith et al., 2012; Visser-Wijnveen et al., in press). Based on data from these questionnaire studies, in combination with previous knowledge from qualitative studies, empirical models can be formulated which might steer future studies. Particularly important will be studies into the relation between research-based teaching approaches and student achievement are required, because until now only speculative assumptions exist about the effects of research-based education on student conceptual change. Understanding of the effects of various research-based teaching approaches, such as group discussion, laboratory assignments, paper writing, research presentations, and research internship, will provide educators and researchers towards improvements of their teaching practices.

Emerging domains of study are 'supervision of (undergraduate) research' (cf. Hu et al., in press; Vereijken, van der Rijst, Dekker, & van Driel, 2015) and 'international comparison of teaching strategies' (cf. Hu et al., 2014). In many graduate programmes, and also in some undergraduate programmes at higher education institutions, students conduct their own research under the

guidance of a supervisor. Although studies on research supervision were not included in the presented literature search, there are clear relations with undergraduate research opportunities. Clark (1997) argues that the tight blending of research activities, teaching activities and student learning can be studied in the authentic context of supervision of student research. Research supervision is a specific form of research-based education in which students and researchers work together (cf. McCallin & Nayar, 2012; Todd, Smith, & Bannister, 2006). Hu and colleagues (2014) showed in a study among academics in Western and Asian universities that the role of research in teaching was perceived in different ways dependent on cultural, institutional and individual factors. Further studies in diverse international and institutional contexts will give us a better understanding of the influence of cultural and institutional factors on research-based teaching initiatives.

No studies were found focusing on the 'assessment of research-based activities' and 'pedagogical content knowledge' of teachers about learning to do research in the higher education context. Both aspects seem to be relevant for the improvement of research-based teaching initiatives from the point of the educators. The assessment of research-based student activities and products, such as research papers, laboratory work, and research internships is often a time-consuming process in which the expertise of the assessor about both the research process and knowledge of the topic is necessary. Often the research process and content are inseparable, which means an extra challenge for the assessors to individually assess students' achievements in both areas. In this assessment process, but also in the teaching of research-based activities, the expertise and experience of the educator is required. The special knowledge an educator needs to effectively teach research-based education is encapsulated in the pedagogical content knowledge of a teacher. An accurate description of teachers' knowledge concerning students learning to research can help us understand this process. This will lead to better support for university teachers when they are guiding students in their learning process.

Final remarks

Research-based learning activities have the potential to be transformative experiences for students. Student research can both steer cognitive change processes and stimulate student engagement. The presented literature indicated that research-based teaching approaches provide students with a lived epistemological experience of what it means to construct knowledge in their discipline. Research-based learning can be a unique experience when the activities are well embedded in the programme and related to other learning experiences. In order to develop research-based teaching and learning activities which are transformative for students, we, educators and educational researchers alike, need to design new teaching approaches and study the effects on student experience and student learning. Therefore, I propose to focus our efforts on developing new practices and future research towards increasing the transformative nature of research-based teaching and learning at our institutes. I sincerely hope that in the future all students at our institutes experience research activities in their discipline as life-changing transformative events.

References

Aditomo, A., Goodyear, P., Bliuc, A., & Ellis, R. A. (2013). Inquiry-based learning in higher education: principle forms, educational objectives, and disciplinary variations. *Studies in Higher Education, 38*, 1239-1258.

*Breen, R., & Lindsay, R. (1999). Academic research and student motivation. *Studies in Higher Education, 24*, 75–93.

*Brew, A. (2003). Teaching and research: New relationships and their implications for inquiry-based teaching and learning in higher education. *Higher Education Research &Development, 22*, 3–18.

*Buckley, C. A. (2011). Student and staff perceptions of the research-teaching nexus. *Innovations in Education & Teaching International, 48*, 313-322.

Coate, K., Barnett, R., & Williams, G. (2001). Relationships between teaching and research in higher education in England. *Higher Education Quarterly, 55*, 158–174.

*Cuthbert, D., Arunachalam, D., & Licina, D. (2012). 'It feels more important than other classes I have done': An 'authentic' undergraduate research experience in sociology. *Studies in Higher Education, 37*, 129-142.

*Deakins, E. (2009). Helping students value cultural diversity through research-based teaching. *Higher Education Research & Development, 28*, 209-226.

de Kleijn, R. A. M., Mainhard, M. T., Meijer, P. C., Pilot, A., & Brekelmans, M. (2012). Master's thesis supervision: Relations between perceptions of the supervisor–student relationship, final grade, perceived supervisor contribution to learning and student satisfaction. *Studies in Higher Education, 37*, 925-939.

*Elsen, G. M. F., Visser-Wijnveen, G. J., van der Rijst, R. M., & van Driel, J. H. (2009). How to strengthen the connection between research and teaching in undergraduate university education. *Higher Education Quarterly, 36*, 64-85.

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford, CA: Stanford University Press.

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Teaching : A meta-analysis experimental and quasi-experimental studies of inquiry-based science. *Review of Educational Research, 82*, 300-329.

*Goodlad, S. (1998). Research opportunities for undergraduates. *Studies in Higher Education, 23*, 349-356.

*Gresty, K. A., Pan, W., Heffernan, T., & Edwards-Jones, A. (2013). Research-informed teaching from a risk perspective. *Teaching in Higher Education, 18*, 570-585.

Griffioen, D. M. E., Visser-Wijnveen, G. J., & Willems J. M. H. M. (Eds) (2013). *Integratie van onderzoek in het hoger onderwijs: Effectieve inbedding van onderzoek in curricula* [In Dutch: Integration of research in higher education: Effective embedding of research into the curriculum]. Groningen: Noordhoff Uitgevers.

*Healey, M. (2005). Linking research and teaching to benefit student learning. *Journal of Geography in Higher Education, 29*, 183-201.

Healey, M., & Jenkins, A. (2009). *Developing undergraduate research*. York: The Higher Education Academy.

*Healey, M., Jordan, F., Pell, B., & Short, C. (2010). The research-teaching nexus: A case study of students' awareness, experiences and perceptions of research. *Innovations in Education and Teaching International, 47*, 235–264.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. *Educational Psychology Review, 16*, 235-266.

Hodson, D. (1992). In search of a meaningful relationship: An exploration of some issues relating to integration in science and science education. *International Journal of Science Education, 14*, 541-562.

*Hordern, J. (2013). Undergraduates and research: connectivity in the university. *Educational Studies, 39*, 535- 547.

*Horta, H., Dautel, V., & Veloso, F. M. (2012). An output perspective on the teaching-research nexus: an analysis focusing on the United States higher education system. *Studies in Higher Education, 37*, 171-187.

Hu, Y., van der Rijst, R. M., van Veen, K., & Verloop, N. (in press). The purposes and processes of master's thesis supervision: A comparison of Chinese and Dutch supervisors. *Higher Education Research & Development*.

Hu, Y., van der Rijst, R. M., van Veen, K., & Verloop, N. (2015). The role of research in teaching: A comparison of teachers from research universities and those from universities of applied sciences. *Higher Education Policy, 28*, 535-554.

*Hu, Y., van der Rijst, R. M., van Veen, K., & Verloop, N. (2014). 'And never the two shall meet'? Comparing Chinese and Dutch university teachers about the role of research in teaching. *Higher Education, 68*, 607-622.

*Hua, O., & Shore, B. M. (2014). Chemistry professors' descriptions of the impact of research engagement on teaching. *Higher Education Research & Development, 33*, 298-311.

*Hunter, A. B., Laursen, S. L., & Seymour, E. (2006). Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development. *Science Education, 91*, 36-74.

Jacobi, R. K., & van der Rijst, R. M. (2010). *Ontwerpprincipes voor het versterken van de verwevenheid van onderzoek en onderwijs in universitaire bacheloropleidingen* [In Dutch: Design principles for strengthening the integration of research in undergraduate programmes at Universities]. *Tijdschrift voor Hoger Onderwijs & Management, 17*(4), 4-12.

*Jenkins, A., Blackman, T., Lindsay, R., & Paton-Saltzberg, R. (1998). Teaching and research: Student perspectives and policy implications. *Studies in Higher Education, 23*, 127-141.

Jenkins, A., Healey, M., & Zetter, R. (2007). *Linking teaching and research in departments and disciplines*. York: Higher Education Academy.

*Jones, S. (2013). Beyond the teaching-research nexus: the Scholarship-Teaching-Action-Research (STAR) conceptual framework. *Higher Education Research & Development, 32*, 381-391.

*Kardash, C. M., & Edwards, O. V. (2012). Thinking and behaving like scientists: Perceptions of undergraduate science interns and their faculty mentors. *Instructional Science, 40*, 875-899.

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory Into Practice, 41*, 212-218.

Kyvik, S., & Lepori, B. (2010). Research in higher education institutions outside the university sector. In S. Kyvik, & B. Lepori (Eds.), *The research mission of higher education institutions outside the university sector: Striving for differentiation* (pp. 3-21). London: Springer.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

*Leisyte, L., Enders, J., & de Boer, H. (2009). The balance between teaching and research in Dutch and English universities in the context of university governance reforms. *Higher Education, 58*, 619-635.

*Lopes, A., Boyd, P., Andrew, N., & Pereira, F. (2014). The research-teaching nexus in nurse and teacher education: contributions of an ecological approach to academic identities in professional fields. *Higher Education, 68*, 167-183.

*Malcolm, M. (2014). A critical evaluation of recent progress in understanding the role of the research-teaching link in higher education. *Higher Education, 67*, 289-301.

McCallin, A., & Nayar, S. (2012). Postgraduate research supervision: A critical review of current practice. *Teaching in Higher Education, 17*, 63-74.

*McLean, M., & Barker, H. (2004). Students making progress and the 'research-teaching nexus' debate. *Teaching in Higher Education, 9*, 407-419.

Melles, M. (2011). Art, media and design research and practice: Views of educators in a 'new' Australian university. *Research in Post-Compulsory Education, 16*(4), 451-463.

Merrill, M. D. (2002). First Principles of Instruction. *Educational Technology Research & Development, 50*, 43–59.

Miller, F. (1981). *Daredevil #168*. New York: Marvel Worldwide Inc.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction—what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching, 47*, 474–496.

National Research Council (2007). *How people learn: Brain, mind, experience, and school*. Washington DC: National Academy Press.

Neave, G. (1979). Academic drift: Some views from Europe. *Studies in Higher Education, 4*, 143-159.

*Neumann, R. (1994). The teaching-research nexus: Applying a framework to university students' learning experiences. *European Journal of Education, 29*, 323-338.

*Ng, L. L., & Pemberton, J. (2013). Research-based communities of practice in UK higher education. *Studies in Higher Education, 38*, 1522-1539.

*Robertson, J., & Blackler, G. (2006). Students' experiences of learning in a research environment. *Higher Education Research & Development, 25*, 215-229.

*Seymour, E., Hunter, A. B., Laursen, S. L., & Deantoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education, 88*, 493-534.

*Simons, M., & Elen, J. (2007). The 'research-teaching nexus' and 'education through research': An exploration of ambivalence. *Studies in Higher Education, 32*, 617-631.

*Smith, P., & Rust, C. (2011). The potential of research-based learning for the creation of truly inclusive academic communities of practice. *Innovations in Education & Teaching International, 48*, 115-125.

*Spiller, D., Byrnes, G., & Ferguson, P. B.(2013). Enhancing postgraduate supervision through a process of conversational inquiry. *Higher Education Research & Development, 32*, 833-845.

*Spronken-Smith, R., Mirosa, R., & Darrou, M. (2014). Learning is an endless journey for anyone: Undergraduate awareness, experiences and perceptions of the research culture in a research-intensive university. *Higher Education Research & Development, 33*, 355–371.

*Spronken-Smith, R., Walker, R., Batchelor, J., O'Steen, B., & Angelo, T. (2012). Evaluating student perceptions of learning processes and intended learning outcomes under inquiry approaches. *Assessment & Evaluation in Higher Education, 37*, 57–72.

*Taylor, J. (2007). The teaching : research nexus: a model for institutional management. *Higher Education, 54*, 867-884.

Todd, M., Smith, K., & Bannister, P. (2006). Supervising a social science undergraduate dissertation: Staff experiences and perceptions. *Teaching in Higher Education 11*, 161–73.

Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples. *Human Resource Development Review, 4*, 356-367.

*Turner, N., Wuetherick, B., & Healey, M. (2008). International perspectives on student awareness, experience and perceptions of research: Implications for academic developers in implementing research-based teaching and learning. *International Journal for Academic Development, 13*, 199-211.

van der Rijst, R. M. (2009). *The research-teaching nexus in the sciences: Scientific research dispositions and teaching practice*. Academic dissertation. Leiden: Leiden University.

*van der Rijst, R. M., Visser-Wijnveen, G. J., Verloop, N., & van Driel, J. H. (2013). Undergraduate science coursework: Teachers' goal statements and how students experience research. *Innovations in Education & Teaching International, 50*, 178-190.

*van der Rijst, R. M., Visser-Wijnveen, G. J., Verstelle, T., & van Driel, J. H. (2009). Studentbeleving van de onderzoeksintensiviteit van universitaire onderwijsomgevingen [In Dutch: Student experience of the research intensiveness of learning environments at universities]. *Pedagogische Studiën, 86*, 214-229.

Van Merrienboer, J. J. G., & Kirschner, P. A. (2013). *Ten steps to complex learning* (2nd Rev. Ed.). New York: Routledge.

van Winkel, M. A., Poell, R. F., van der Rijst, R. M., & Jurriëns, J. A. (2011). Lecturers' transition into novel researcher roles at new universities: A conceptual framework and a research agenda. *HAN Business Publications, 7*, 63-78.

*Verburgh, A., & Elen, J. (2011). The role of experienced research integration into teaching upon students' appreciation of research aspects in the learning environment. *International Journal of University Teaching and Faculty Development, 1*(4), 1-14.

*Verburgh, A., Elen, J., & Lindblom-Ylänne, S. (2007). Investigating the myth of the relationship between teaching and research in higher education: A review of empirical research. *Studies in Philosophy & Education, 26*, 449-465.

Vereijken, M. W. C., van der Rijst, R. M., de Beaufort, A. J., & Dekker, F. W. (in press). Fostering desirable learning outcomes of research integration: student perceptions, beliefs about the value of research in learning and student achievement. *Innovations in Education & Teaching International.*

Vereijken, M. W. C., van der Rijst, R. M., Dekker, F. W., & van Driel, J. H. (2015, December). *By all means: Unravelling undergraduate research supervision strategies using stimulated recall*. Poster presentation at the annual meeting of the SRHE. Newport, UK.

Vermunt, J. D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning & Instruction, 9*, 257-280.

Visser-Wijnveen, G. J., van der Rijst, R. M., & van Driel, J. H. (in press). A questionnaire to capture students' perceptions of research integration in their courses. *Higher Education*.

*Visser-Wijnveen, G. J., van Driel, J. H., van der Rijst, R. M., Verloop, N., & Visser, A. (2009). The relationship between academics' conceptions of knowledge, research and teaching: A metaphor study. *Teaching in Higher Education, 14*, 673-686.

*Visser-Wijnveen, G. J., van Driel, J. H., van der Rijst, R. M., Verloop, N., & Visser, A. (2010). The ideal research-teaching nexus in the eyes of academics: Building profiles. *Higher Education Research & Development, 29*, 195-210.

*Visser-Wijnveen, G. J., van Driel, J. H., van der Rijst, R. M., Visser, A., & Verloop, N. (2012). Relating academics' ways of integrating research and teaching to their students' perceptions. *Studies in Higher Education, 37*, 219-234.

Visser-Wijnveen, G. J. (2013). Vormen van de integratie van onderzoek en onderwijs [In Dutch: Forms of the integration of research and teaching]. In D. M. E. Griffioen, G. J. Visser-Wijnveen, & J. M. H. M. Willems (eds), *Integratie van onderzoek in het hoger onderwijs: Effectieve inbedding van onderzoek in curricula* (pp. 61-74). Groningen: Noordhoff Uitgevers.

Case descriptions

Case 1: Creative researcher

Programme: Media Technology

Academic year: 1 MA; ECTS 4

General description: The Media Technology programme recognises creativity as an important factor in scientific innovation. In this course, principles of scientific research are explained and illustrated with examples of "creative research practices" – unconventional ways to conduct scientific research. Due to the far-reaching specialisation within the sciences and increasingly sophisticated methodologies, it seems as if science is per definition impenetrable. However, this is not the case, for the principles of science are clear and distinct. There are examples of good science on questions which are directly imaginable for everyone. And there are examples of good studies on the basis of clearly understandable methods to anyone. Topics covered in the course are ‘principles of science’, organisation of the scientific world, scientific publications, creative and unconventional research. Student participation is high, with many activating tasks and a research project. Seven lectures are combined with student presentations and projects. Participants must conduct a research project and write a scientific paper.

Case 2: Inquiry based learning

Programme: Molecular science & technology

Academic Year: 1 BA; ECTS 6

General description: The course is part of the programme Molecular Science & Technology. This is a collaboration between Leiden university and Delft University of Technology. Under the supervision of a researcher (often a postdoc) students take part of the ongoing research in the faculty. They participate in carrying out experiments in small groups in the research institutes in Leiden and Delft. They gain an overview of what scientific research is and who are involved. The course is completed with a poster presentation at a local conference specially organised around this course in which the results are exchanged among students and staff. Already in their first year students are spread over research teams. Each group will receive approximately eight undergraduate students. In Fall students follow an introductory research practical in order to prepare them for participation in the research groups. During Winter and Spring, the work in the institutes takes place for two days a week.

Case 3: Approaches to Diversity

Programme: Linguistics (two year Research Master)

Academic Year 1 MA; ECTS 10

General description: Twelve experts from different domains of linguistic research give an introduction to their topic based on their studies and applied methodologies. Examples of this are: dialectical perspective, sociolinguistics perspective to language change operation, phonological differences between languages, the transposition of (natural) languages and the shaping of language with the computer. Each week a different researcher gives an introduction according to the same schedule: Each Monday there is a 'keynote' in the main lecture hall, and afterwards students receive a homework assignment. On Friday the researcher leads a discussion group about the topic and all assignments are handed in. In order to finish the course, students have to complete at least nine assignments.

Case 4: Dutch history

Programme: History

Academic Year: 2 BA; ECTS 6

General description: In their first year students start their methodical training in the conduct of historical research in the course Historical Practice. Emphasis is put on the critical use of different types of source materials. Students' research skills are further developed in their sophomore year by conducting small scale studies. The historical issues and debates in the studies of the sophomores are closely linked with the research of the staff. The interaction between staff and students, research and learning, and the emphasis on historiographical positioning of issues and debates in the student papers, ensures that the students peruse the recent developments in the different research areas. The ongoing research of teachers is made visible in thematic lectures.

Figures

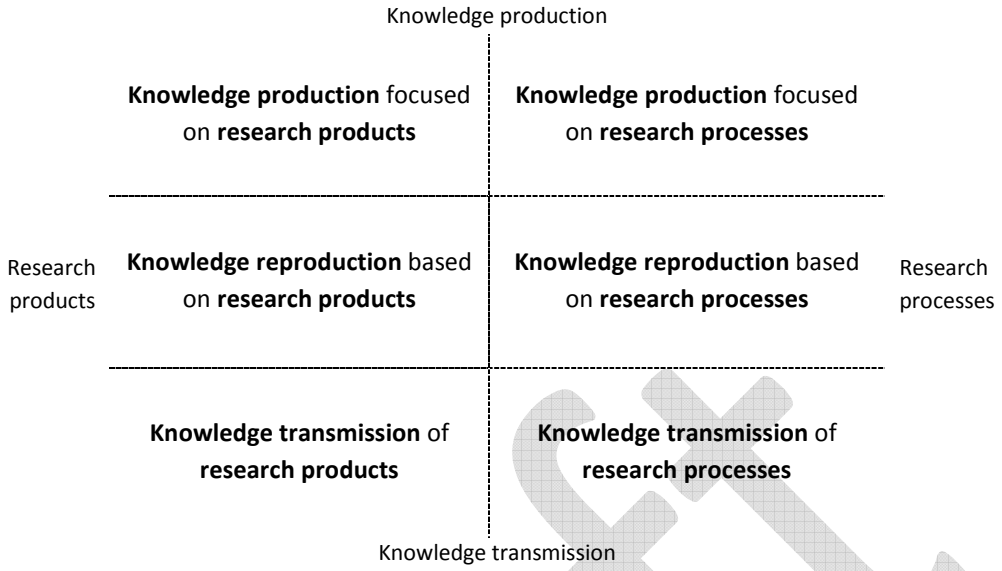

Figure 1. Knowledge model of the research-teaching nexus (Visser-Wijnveen, 2013)

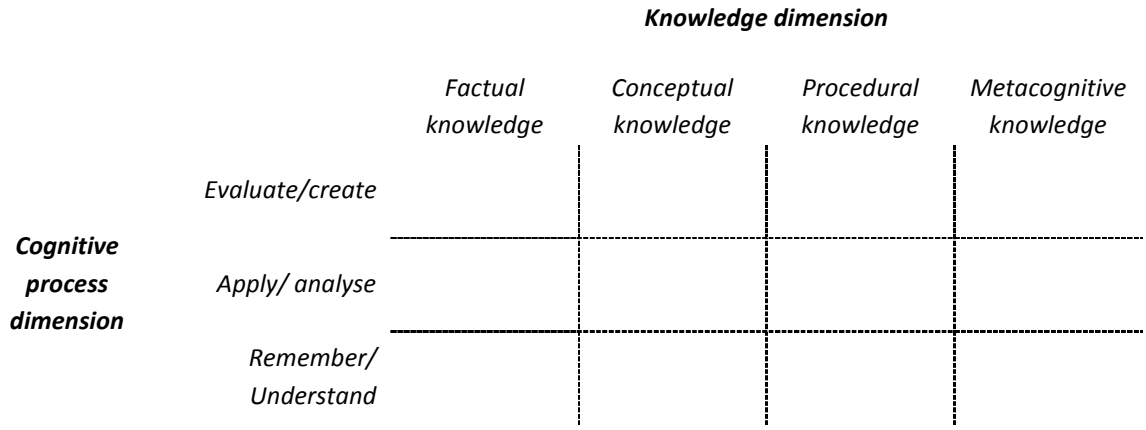

Figure 2. Taxonomy of learning goals (based on Krathwohl, 2002)

Tables

Table 1.
Overview of the search terms and inclusion criteria

Primary	*Secondary*	*Inclusion criteria*
Research based	Higher education	Journal included in the SSCI
Research informed	Undergraduate education	English language
Research led	Post-secondary education	Peer reviewed
Research oriented		All years
Teaching-research nexus		
Research-teaching nexus		
Undergraduate research		

Note: Search terms were collected at the start of the review process during pilot searches.