FACULTY OF PSYCHOLOGY
AND EDUCATIONAL SCIENCES

Effects of using Research Based Learning on the development of academic competences of graduate students

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"Every journey starts with a dream, and your faith and belief in your dream will pave the way" G.M. Rao

My personal journey started around 6 years ago when I decided to take a step further in my professional career. Back then, I was already a passionate university English teacher but aimed to go beyond the existing knowledge that surrounded and explore the uncertain world of research.

After a long application process, I managed to get a scholarship from the Ecuadorian Government and took the risk to study in a first class university far from my home country.

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Table of Contents

Chapter 1

General Introduction 8

Chapter 2

Research-based Learning in Engineering and Science Education: A Scoping Review 108

Chapter 3

Impact of a Research-based Learning redesign of an engineering course on students' intention to do research 196

Chapter 4 218

Research-Based Learning in a Transversal Entrepreneurship and Innovation undergraduate course

Chapter 5 299

Research-based Learning in a Rural Development graduate course

Chapter 6 381

General Discussion and Conclusions

English Summary 462

Nederlandstalige samenvatting - Dutch Summary 525

Academic Output 588

Appendices 590

Data storage fact sheets 609

Chapter 1
General Introduction

Chapter 1

General Introduction

Abstract

The present chapter provides a general overview of the research topic of this dissertation. The first section starts by describing the research problem supported by stimulating examples that help the reader to understand our main research focus.

The second section summarized the conceptual and theoretical framework, which explore different ways of teaching and research integration in the higher education context and presents available evidence of RBL practices. The third section concentrates on the research variables to be studied: intention to do research and research competences through the Theory of Planned Behavior, autonomous motivation, and research self-efficacy. The fourth section focuses on the theoretical model used to explain our RBL intervention, explaining the role of intention predictors: perceived behavioral control, behavioral beliefs and subjective norms. It also explains the interplay of RBL with autonomous motivation and research self-efficacy. The fifth section deals with the design of our RBL intervention and research model along with the challenge to implement RBL in a university setting. The sixth section centres on the main research aims and objectives, followed by the elaboration of the overall research design of this dissertation. Finally, the last section presents the overview of the present dissertation and explains its structure in detail.

I. General Research Problem

At present, there is growing attention on the crucial role of higher education worldwide (Stein, Andreotti, & Suša, 2019). However, understanding this role might be problematic due to the plentiful interpretations, opportunities and changes that have arisen in the last decade (Altbach, Reisberg, & Rumbley, 2010; Manning, 2018; DePauw, 2019). In this regard, diverse opinions have been expressed.

On the one hand, the role of higher education is associated to current society demands; for instance, manpower and economic progress (Pegkas & Tsamadias, 2014). On the other hand, it is linked to the transmission of scientific and technical knowledge, aiming to solve global problems (Lilles & Rõigas, 2017; Pastor, Peraita, Serrano, & Soler, 2018) such as food and energy shortage, overpopulation, environment conservation (Duckworth, Andrews, Cubeta, Grunden, & Ojiambo, 2017) and sustainable development (Aleixo, Leal, & Azeiteiro, 2018).

In this context, the challenge for universities is to educate professionals who are able to offer solutions and contribute to the Millennium Development Goals, recently adopted as Sustainable Development Goals (Fukuda-Parr, 2016). These underline the role of higher education as a vehicle to attain goals related to quality education (Owens, 2017). They also involve other world issues such as poverty, hunger, inequality, climate change, health and sanitation, among others (Kumar, Kumar, & Vivekadhish, 2016) which require urgent attention (Briant Carant, 2017).

Therefore, universities intend to move away from a focus on the transmission of existing knowledge to the production of new knowledge through research (van der Rijst, 2017). This is why, universities are expected to produce the highest quality, state-of-the-art, cutting-edge research to meet the necessities of learners and ever-changing society (Oosterlinck, 2013). Moreover, they emphasize the development of students' research competences not only to improve higher education learning outcomes but mainly to address the aforementioned problems effectively (Zlatkin-Troitschanskaia, Pant, & Coates, 2016). At the same time, there is increasing interest from students to assume a more participating role in the construction of knowledge within higher education (Dollinger, Lodge, & Coates, 2018). It seems that producing knowledge rather than only consuming it, gives students a sense of ownership over their learning (Hay & Pitchford, 2016) and increases possibilities to be adequately immersed in the labor market (Tavares, 2017). Furthermore, by developing research competences, students are able to identify key matters, define problems and devise

solutions that can be scientifically supported (Huet & Woodfield, 2017); thus contributing to confront the existing societal problems. This leads to the conclusion that the role of higher education is to act in response to what learners demand, which at the same time is a reflection of the world needs (Ennis, 201; Tang, Wang, Zhu, & Liu, 2018).

However, meeting the above-mentioned challenges reintroduces an earlier debate about the way universities organize their curricula concerning teaching and research, known as the teaching-research nexus (Mägi & Beerkens, 2016).

To inspire the reader, we move forward in a somewhat different way as it is normally done in traditional introductory chapters.

In the following lines, we provide some stimulating examples of what the focus is in our studies. This might help the reader to better understand how different other approaches to the TRN can be. Figure 1 displays a view of the research work developed by Walkington (2015), which we present as our first example.

Figure 1. A view of the report "Students as researchers" developed by Walkington (2015)

In this example, we refer to the "students as researchers" methodology suggested by Walkington (2015) as a way to improve learning by allowing undergraduate students to experience all stages of the research cycle, with particular emphasis on communicating research findings. Interestingly, this approach can fit in different frameworks where research practices are incorporated into the curriculum and focused on actual students' participation. Teaching and research connections are promoted in the classroom through authentic students' experiences such as research projects or assignments that

involve inquiry, handling data, interpretation, judgement, research replication and other high-order thinking skills.

As described, this type of instruction reports numerous student benefits such as retention, skills development, increased confidence to present research findings at international conferences and publish in undergraduate research journals. Most students engaged in this practice, state that being undergraduate researchers allows them to approach a topic from various different angles, deal with uncertainty and be able to develop alternative plans (Walkington, 2015). Furthermore, they perceive to have acquired core skills such as research and critical thinking which enable them to undertake challenging endeavors. Therefore, those involved in this methodology seem to find it valuable for their professional careers in terms of competence development and employability benefits.

Figure 2 displays a view of the research work developed by Sorensen, Corral, Dauer, & Fontaine, (2018), which we present as our second example.

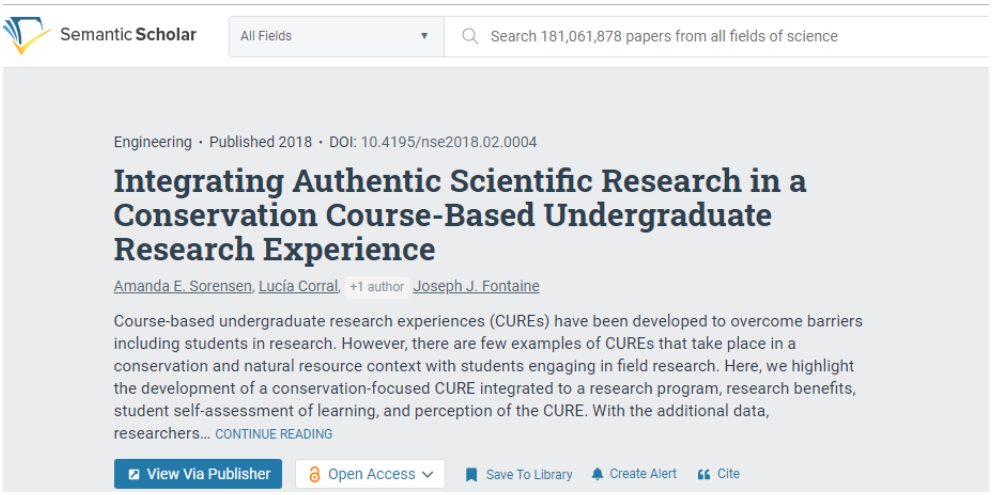

Figure 2. A view of the research paper developed by Sorensen et al. (2018)

Moving to our second example, we invoke an undergraduate research practice that takes place in a conservation and natural resource course within a 16-week semester.

In this experience presented by Sorensen, Corral, Dauer, & Fontaine (2018), students also explore the research cycle, starting with the generation of preliminary research questions and hypotheses based on their own models, research methods design, data collection and statistical analysis guided by experienced researchers. Students are oriented towards scientific communication in conferences and even rehearsed presenting their own research findings to a panel of experts in the field. Besides

students' perceived learning gains in terms of the study subject and research competences, they experienced an actual involvement in research "as if they belonged to a larger scientific community".

What is most remarkable in Sorensen et al.'s practice is the way students report to have been influenced to participate in further research (2018). As described in students' reflections, this research experience shed light on their intentions regarding potential enrollments in graduate programs and pursue jobs related to science.

The above examples show how different higher education can become when looking at a different and more innovating way to deal with research at undergraduate level. Besides, both examples show how this change takes place at undergraduate level (Hess, Fortner, & Chowdhury, 2017; Cirino et al., 2017; Shuster et al., 2019) suggesting that this ground-breaking approach requires a long-term trajectory (Emery et al., 2019).

The examples also help us to state the central problem of this PhD dissertation, which is linked to the way we manage the teaching-research nexus. In particular, we study how a pedagogical shift in our approach towards this nexus might have a beneficial impact on students' competences to be better prepared for their future role in society (John & Creighton, 2011; Zimbardi & Myatt, 2014).

In the next section, we first explain what authors state in regard to the nature of the teaching-research nexus. Next, we provide theoretical framework that help us understand different ways of teaching and research integration in the higher education context.

II. Conceptual and Theoretical Framework

2.1 Teaching-Research Nexus (TRN)

Since teaching and research are two core entities in higher education, their combination appears to be advantageous for institutions, academics and students (Healey, 2005; Brew, 2010; Boyd, O'Reilly, Bucher, Fisher, & Morton, 2010). Therefore, the teaching-research nexus (TRN) emerges as a collaborative approach where research informs teaching and teaching informs research (Casanovas, Ahearn, Ramos, & Popo, 2016); and do not compete with each other (Light & Calkins, 2015).

In the last years, growing attention has been placed on TRN (T Clark & Hordosy, 2019). Although most universities have intended to incorporate this TRN (Geschwind

& Broström, 2015), it seems to be open to incessant discussion (Zhang & Shin, 2015; Lubbe, 2015; Cadez, Dimovski, & Zaman, 2017).

On the one hand, TRN has gained increasing significance in recent decades (Tight, 2016) as it appears to contribute to the development of competences that reciprocally improve teaching performance and research outputs (Gilmore, Lewis, Maher, Feldon, & Timmerman, 2014).

Besides, the enhancement of teaching (Mägi & Beerkens, 2016), TRN stimulates learning (T Clark & Hordosy, 2019) by providing students with an initial foundation in the research arena (Eley & Wilkinson, 2015). Therefore, they perceive explicit learning gains from their participation in research activities along with faculty's engagement in institutional research (Jusoh & Abidin, 2012). This seems to encourage interactions with high quality teachers who are also researchers (Healey, Jordan, Pell, & Short, 2010). In this regard, TRN is a tool that allows academics to use existing research in the subject field leading to scholarly interactions and development of research competences (M Limniou & Mansfield, 2019).

On the other hand, TRN has been subject for discussion (Robertson, 2007) due to its intricate nature (Healey, 2005) that appears to turn it into something unreliable (L. Zhang & Shin, 2015) or impractical given the high demands and requirements of students and institutions (Tight, 2016). Its apparent predisposition to prioritize research over teaching (C. Buckley, 2011) may cause damage to the quality of university teaching (Bak & Kim, 2015) and expectations from academics (Cheol, Cummings, & Akira, 2014) when aiming for distinction (Hu, Ching, & Hung, 2018). This could lead to an apparently meaningless value for students in view that both teaching and research involve time and resources that may be insufficient (Stappenbelt, 2013). Furthermore, concentrating too much on research and reducing the value of teaching or vice versa (Duff & Marriott, 2017a); plus a cumbersome distribution of teaching and research workloads for university academics could also conduce to weak TRN practices (Hajdarpasic, Brew, & Popenici, 2015; Leišytė, 2016).

Additionally, TRN might be considered too demanding for students and academics (M Daumiller & Dresel, 2018) or seen as an antithesis that can hardly merge in view that teaching is perceived as a cooperative task which mismatches the singleness of research (Kinchin & Howson, 2019).

Despite the unquestionable pressures concerning TRN and the requirements of higher education institutions (Lewicki & Bailey, 2009), lately we observe plentiful attempts to bring teaching and research together (López, 2015; Xia, Caulfield, & Ferns, 2015; Yueh-Leun, Hung, & Ching, 2016), from understanding their connection (Brew, 2010) to the actual development of a nexus (Quinn, 2016; Farcas, Bernardes, & Matos, 2017). Nevertheless, a lot more efforts are required to completely understand the TRN (Lightfoot & Piotukh, 2015).

To make this integration effective, it is fundamental to explore ways to understand the TRN based on academics' interpretations of teaching and research (Brew, 2012) in order to harmonize their connection (Xia et al., 2015). At the same time, it is necessary to foster methodologies and institutional guidelines to strengthen the TRN (Brennan, Cusack, Delahunt, Kuznesof, & Donnelly, 2019b).

Considering the aforementioned, institutional developments to promote TRN are desirable as suggested in the Humboldtian Model of Higher Education, where teaching and research are shared in a comprehensive way despite the potential difficulties to maintain it (Mägi & Beerkens, 2016). TRN must be expressly integrated in the curriculum (Healey & Jenkins, 2009a) and supported at a program or institutional level (Boyd et al. 2010; Willison, 2012) with an instructional design aimed to enhance teaching and research and reduce tensions within the process (Harland, 2016).

In this regard, Research-Based Learning (RBL) is the suggested methodology oriented to improve instruction quality and develop student's competences; thus contributing to accomplish higher education objectives (F. Klauser & Schlicht, 2014) concerning the suitable integration of research in study programs around the world (Tight, 2016). Also, RBL seems to be the most appropriate way to manage TRN in which the integration of both teaching and research equip learners with competences that enable them to deal with the burdens of the labor market (Dekker & Walsarie, 2016).

2.2 Approaches to Teaching and Research Integration

To understand the relationship between teaching and research, different authors have presented explanations of TRN. For example, Griffiths (2004) highlighted research production from the point of view of specific subject fields aiming at students' learning. In this connection, a framework was developed identifying three approaches to link teaching to research:

- Research-led: where the focus is to learn about disciplinary findings.

- Research-oriented: where the central emphasis is on processes or techniques of knowledge production.
- Research-based: where an inquiry-based approach is adopted, and students actually conduct research activities.

This framework was later supplemented by Healey (2005) who included a fourth approach labelled as research-tutored and which underlines scientific discussions between teacher and students. Based on the above, an influential model was developed by Healey (2005) to frame the teaching-research nexus.

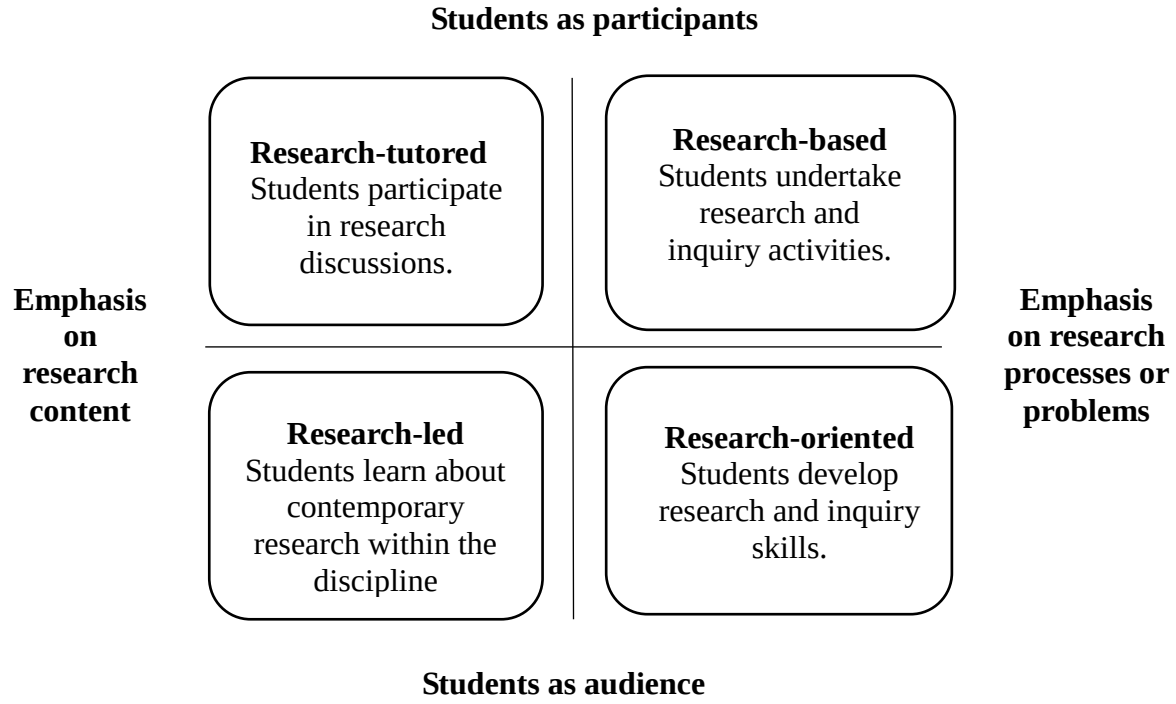

Figure 3. TRN framework based on Healey (2005, p.70)

Figure 3 depicts a diagram of two axis developed by Healey (2005) demonstrating the TRN. The vertical axis classifies teaching and research approaches from student-centered activities with students as participants to teacher-centered activities with students as audience. The horizontal axis runs from a focus on subject content to a focus on research processes and techniques.

According to Dekker & Wolff (2016) the above model is considered appropriate to label the curriculum components but not quite effective to recognize students' sorts of involvement in research-based activities. In this regard, Levy & Petrulis (2012) also contributed to the model by stressing research based on students' current knowledge and new discoveries guided by teachers' and by their own queries and concerns.

According to Jenkins & Healey (2010), all four ways of engaging students in research appear to be valuable and well-founded at some point in the curricula. However, it seems that most of the teaching and learning currently taking place in universities comes from the bottom half of the diagram. It appears that many more students could benefit to a larger extent from activities framed in the top half (Healey & Jenkins, 2009a).

In the current dissertation, we aim to move away from the type of research focused on content and move towards the approach in the upper right corner, in which students are engaged in different phases of research labelled as Research Based Learning (RBL).

Additionally, we will contrast RBL with other TRN approaches that deal with research-tutored, research-oriented and research-led learning (Healey, 2005).

2.3 Empirical evidence about the impact of RBL

Based on our literature review (see chapter 2), a large number of benefits linked to the introduction of RBL have been reported. In the following lines, we provide a description in this regard.

Recent findings reveal that RBL can help students to eventually be more research-oriented and conduct genuine research effectively by generating their own research questions (Blume et al., 2015) and making decisions on what research methods to use and how to analyze data (Marks & Van der Meer, 2016) compared to students who are not exposed to research (Hernandezm, Woodcock, Estrada, & Schultz, 2018). Furthermore, students' immersion in RBL environments has proved to increase motivation and confidence to conduct research independently (Knutson, Smith, Nichols, Wallert, & Provost, 2010b) as well as to enhance the way they perceive science (Christine W. Miller, Hamel, Holmes, Helmey-Hartman, & Lopatto, 2013).

Beyond the development of research competences (Christe, Shah, Bhatt, & Powell, 2015) and critical thinking skills (Crist, Duncan, & Bianchi, 2017), RBL seems to inspire students' interest in the subject (Fuller, Mellor, & Entwistle, 2014), develop employability competences and increase intentions to be involved in research by pursuing postgraduate studies (Hajdarpasic et al., 2015), boosting the thorough educational quality (Szteinberg et al., 2014).

Similar studies prove that RBL has been successfully integrated at undergraduate level where students go from receivers to dynamic creators of knowledge (Harvey, Bertolo,

& Byrne, 2017) in different science-related disciplines such as Biology (Shortlidge, Bangera, & Brownell, 2016), Chemistry (Heemstra et al., 2017) and others, for instance Psychology (M Limniou, Mansfield, & Petichakis, 2019). Similarly, positive results at graduate level have also been reported (Wallace, Lennon, King, & Doran, 2018) for students in medicine (Y Chang & Ramnanan, 2015) and engineering (Wallin, Adawi, & Gold, 2017).

A remarkable observation is that despite literature stating RBL is beneficial, the number of studies actually presenting empirical evidence is smaller than expected. This explains the need to reiterate these studies in an explicit way regarding anticipated RBL effects. Building on the available evidence described above, we make a selection of specific variables to be undertaken in our research studies, as explained in the next section of this chapter.

III. Variables involved in RBL studies

We select the following variables to be tackled in the present PhD dissertation. First of all, we want to go beyond the regular way of studying an impact on research competences through the adoption of self-reported measures, instead observational measures will be adopted next to research self-efficacy and autonomous motivation scales. Also, other variables that are assumed to interact in the relation between the RBL intervention and research competences are selected, such as self-efficacy and students' autonomous motivation.

Below we give a short overview to introduce the key variables that are studied in the present PhD dissertation. Table 1 outlines the variables involved in our RBL interventions within our three research studies.

Dependent Variables	Interaction Variables
Intention to do research	Research Self-efficacy
Research competences	Autonomous Motivation

Due to the interplay between RBL and the variety of dependent variables, a model is needed to structure this relationship. This is explained in detail later in this chapter.

To explain the impact of RBL on student variables in the present dissertation, we build on a number of theoretical frameworks that help linking RBL implementations to dependent and interaction variables.

We center on the dependent variables “students’ intention to do research” and “research competences” through the Theory of Planned Behavior, TPB (Ajzen, 1991) as the foundation of our assumptions. To explain how the variable “research self-efficacy” interplays with RBL, we rely on the Self-efficacy theory proposed by Bandura (1993). To determine the relationship of autonomous motivation with RBL, the Self-determination Theory (SDT) of Ryan & Deci (2000) serves as a framework to explain its interaction in connection with the three basic psychological needs: autonomy, competence and relatedness.

In the following section, we provide information about the Theory of Planned Behaviour as a framework to explain the expected impact of RBL on our dependent variables: students’ intention to do research and their actual behaviour; which is reflected in their research competences.

3.1 Intention and Behavior defined by the Theory of Planned Behavior

Given that, one of the main aims of the present dissertation is to explore the use of RBL in relation to students’ intentions to do research and the actual development of their research competences; we build on the Theory of Planned Behavior (TPB), which serves as a framework to define the nature of the precursors of human intention. In earlier studies, TPB has been widely used to predict and describe individuals’ intention to adopt certain behaviors in different domains such as agriculture (Rossi, Oude, Marques, & Lutke, 2014); entrepreneurship (Kautonen, Van Gelderen, & Fink, 2015); environment (de Leeuw, Valois, Ajzen, & Schmidt, 2015); exercise and sport (Rhodes, Jones, & Courneya, 2002); and nursing (Vincent, Riley, & Wilkie, 2015), among others.

The TPB pinpoints hypothetical concepts related to motivational elements that may influence the probability to carry out particular behaviors, assuming that they can be predicted by intentions (Montaño & Kasprzyk, 2015). In this context, intentions are supposed to precede behaviors (Ajzen, 1985a). Led by motivational influences such as achievement, growth, recognition, etc., intentions indicate the degree of determination and efforts that individuals are eager to do with the purpose to perform a behavior.

Consequently, the more robust the intention, the more likely to be executed, given that it is under free choice (Ajzen, 1991).

Based on experiential evidence, people's intentions to perform certain actions can generally be anticipated from behavioral beliefs, subjective norms and perceived behavioral control (Ajzen, 2011). These predictors of intention are explained in detail in the next section of this chapter.

Figure 4 shows how behavioral beliefs, subjective norms and perceived behavioral control have an effect on individuals' intention and as a result, on behavior.

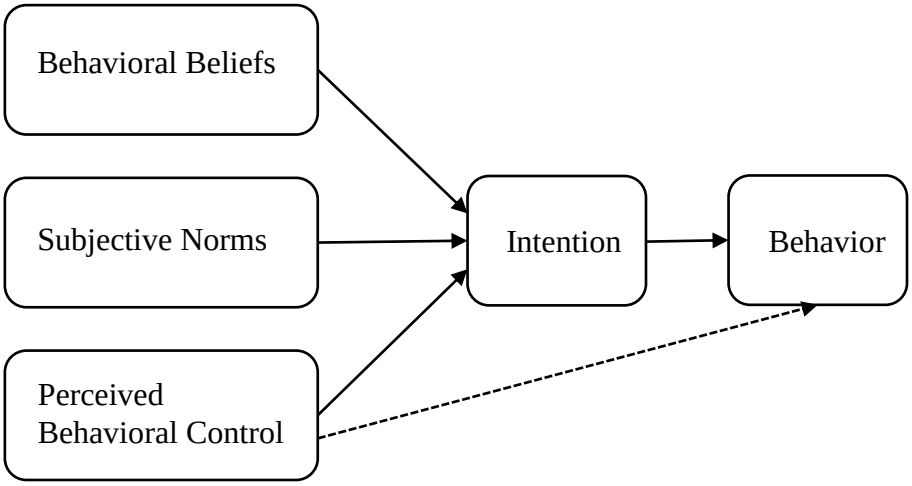

Figure 4. Visual representation of the Theory of Planned Behavior (Ajzen, 1991)

3.2 Expected Behavior: Research Competences

As explained earlier, the Theory of Planned Behavior states that intentions are expected to lead to actual behaviors (Ajzen, 1991). In this context, we assume that students' intentions to do research would result in the development of their research competences, as an anticipated behavior.

Mills & Gay (2019) define research competences as skills needed to appropriately carry out and assess research. The relevance of developing research competences seems to go beyond academic contexts and has a clear connection with more holistic goals (Albareda-Tiana, Vidal-Raméntol, Pujol-Valls, & Fernández-Morilla, 2018).

In this regard, RBL emerges as an innovative approach that can provide students with an adequate learning environment where they can develop their research competences, among other benefits (Gray et al., 2015; Soltano, Meyer, & Larrivee, 2016; Jungmann, 2019).

IV. Defining a Theoretical Model to explain our RBL intervention

TPB has proved to accurately predict people's intentions and actual actions (Kautonen, Van Gelderen, & Fink, 2015; de Leeuw, Valois, Ajzen, & Schmidt, 2015; Han, 2015; Paul, Modi, & Patel, 2016). Therefore, we rely on TPB to develop a theoretical model that allows us to measure students' intention to do research and their research competences within an RBL experience in undergraduate and graduate courses.

Figure 5 depicts the interplay of the three predictors of intention (perceived behavioral controlled also labelled as self-efficacy, subjective norm and behavioral beliefs) with students' intention to do research and its latter impact on their research competences. Also, we see the potential interaction of students' autonomous motivation with the expected impact of the RBL intervention.

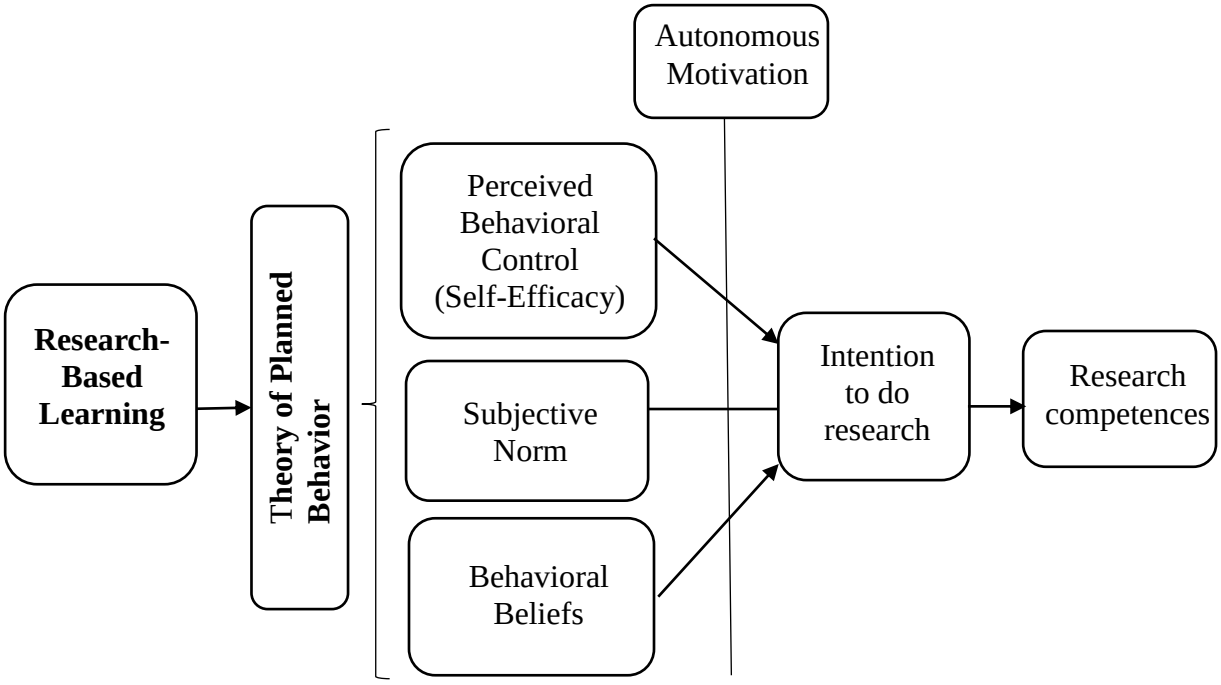

Figure 5. Interplay of dependent and interaction variables with RBL

4.1 The role of intention predictors to explain RBL

Behavioral Beliefs or attitudes towards behaviors (Ajzen, 1991), are defined as one's opinions regarding the possible outcomes of a behavior, which produce encouraging or hostile attitudes towards it (Ajzen, 1985). These positive or negative beliefs concerning the performance of particular behaviors and their consequences determine people's intention to act (Ajzen, 1985). In this regard, we assume that students' exposure to an RBL approach will develop positive attitudes towards research; and thus, lead to

intentions' to be involved in research-related activities. This is supported in available literature reporting that attitudes, intentions and behaviors are highly related to each other within different domains such as research (Armitage, Christian, & Christian, 2017). Furthermore, being acquainted with research practices seems to positively influence research attitudes, intentions and actual performance (Habineza, 2017; Hussain, Kyriazi, & Hyland, 2018; Coetzee & Kruger, 2018; Kakupa & Xue, 2019).

Subjective norms refer to people's perception of pressure from the society in regards to accomplish or not certain behaviours (Ajzen, 1991). These norms have to do with personal awareness of how important it is for others that one executes or not a certain behaviour (Rhodes et al., 2002). In this regard, people are inclined to execute a behaviour when they consider it relevant or when significant others give them approval (Ajzen, 1985).

Along with behavioural beliefs or attitudes, subjective norms have proved to be strong predictors of individuals' intention to achieve specific purposes (M. Hill, Mann, & Wearing, 1996). This is why, we hypothesize that students' engagement in RBL settings might have an impact on their subjective norms; and consequently, boost their intentions to do research. This is supported by Mueller, Barrett, Wildermuth, Ferich, & Graefe (2018) when they state that students' intentions to participate in research learning contexts, might be influenced by pressure from others. In the context of this dissertation concerning intentions to do research and research competences, subjective norms reflect students' perceptions of whether their research involvement is appreciated or anticipated by valuable people (Abd Mutalib, Jamil, Zuriana, Mohamed, & Ismail, 2017) such as teachers, researchers, relatives or peers.

Perceived Behavioural Control (PBC) is in the same way considered a robust precursor of intention (Shin & Hancer, 2016; Shabbir, Shariff, & Shahzad, 2016) which denotes people's perception of the simplicity or complexity of performing specific behaviours (Ajzen, 1991). PBC was introduced by TPB to explain situations where people's intentions to carry out certain behaviours are hypothetically restricted and do not only depend on their own volition. In this sense, PBC delimits or regulates concrete actions as a response to the behavioural intention someone has when the chances appear (Greene & Brush, 2018).

TPB relates the construct PBC to Bandura's definition of perceived self-efficacy (SE), which refers to individuals' levels of confidence in their own abilities (Ajzen, 1991).

Existing literature provides evidence that RBL instruction may have a positive effect on PBC or research self-efficacy, which pushes students' intentions to conduct further research confidently and their concrete performance (Phillips & Russell, 1994; Swan, Inkelas, Jones, Pretlow, & Keller, 2018; Butz, Branchaw, Pfund, Byars-Winston, & Leverett, 2018; Maton et al., 2016). This is why we assume an interaction effect of the variable research self-efficacy on the impact of RBL in our empirical studies.

The concept of research self-efficacy and its connection to RBL is explained in the next section.

4.2 The role of Research Self-efficacy (SE) in our RBL setting

In the present dissertation, we build in the Self-efficacy theory proposed by Bandura (1993) to assess the interplay of "perceived behavioral control" operationalized as "research self-efficacy" in our RBL interventions. In view of its congruence when explaining intentions to attain something (Ajzen, 1991) and its reliable and undeviating relation with students' academic achievement (Bradley, Browne, & Kelley, 2017; Stajkovic, Bandura, Locke, Lee, & Sergent, 2018), we anticipate a positive interaction effect on the overall impact of RBL

It appears no to be other aspect more steadily linked to human attainment than self-efficacy (R Bruning & Kauffman, 2006). Bandura (1977) defines perceived self-efficacy as individual awareness of one's competences to shape and accomplish actions in order to achieve chosen objectives. Therefore, SE has demonstrated to be a very powerful predictor of intention to engage in particular behaviours (Shamblen et al., 2018; Lee & Lina Kim, 2018).

In the context of this dissertation, we hypothesize that students who are exposed to RBL instruction may reflect higher intentions to do research and better research competences in comparison with students following research oriented, research led or research-tutored approaches, due to greater levels of research self-efficacy. This is in line with assumptions concerning higher levels of research self-efficacy in students who are involved in RBL contexts compared to those who are not. Similarly, this is stressed by Bruning & Kauffman (2006) when they state that self-efficacy may vary for the same task when performed in a type of setting contrasted with another.

The expected interaction of research self-efficacy with the impact of RBL on students' research intentions and competences is also supported by authors who state that those who perceived themselves as more efficacious in regards to their learning, demonstrate great confidence when involved in challenging tasks and set ambitious

goals which they firmly believe they can achieve. Therefore, they produce appropriate learning conditions and select suitable working partners (Dale & DiBenedetto, 2016; Maddux, 2016). Such confidence that one can succeed in the proposed endeavours, such as research activities, provides incentives to carry out tasks in spite of complications (Bandura, 2010). As a result, those owning a robust sense of self-efficacy are willing to approach demanding circumstances with the conviction that they can be managed effectively (Bandura, 1993). The fruitful accomplishment of behaviours not only demonstrate one's higher capabilities but increased confidence to perform tasks in specific fields and contexts (Bandura, 1977)

As displayed in figure 6, research self-efficacy may be acquired from four main sources: mastery of experiences, vicarious experiences, verbal persuasion and emotional and physiological states. In this way, personal efficacy processes are incited by elements related to performance achievement, empathy, advice and affection (Bandura, 1977).

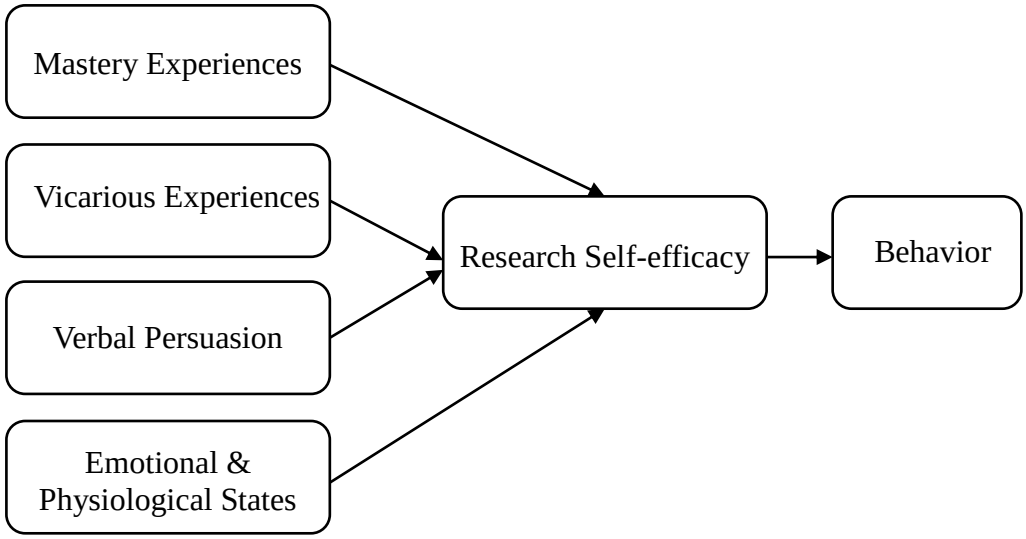

Figure 6. Sources of Research Self-efficacy. Adapter from Bandura (1977)

In the context of our dissertation, we rely on the above theoretical sources as they have proved to promote students' research self-efficacy beliefs and thus, achievement of academic tasks (Thompson & Graham, 2015; Phan, & Locke, 2015; Hendricks, 2016). Therefore, the four sources contribute to the creation of self-efficacy beliefs (Barabadi, Barabadi, Golparvar, & Bayat, 2018).

Mastery experiences is considered the most reported source of self-efficacy among students (Butz & Usher, 2015; Bjerke & Solomon, 2019) and probably the one with the greatest impact on learning (Phan & Ngu, 2016; Martins, Costa, & Onofre, 2015). It

seems that a positive performance is the most reliable evidence someone can have regarding his competences (Bandura, 1977).

Pajares (2005) describes a “mastery experience” as the elucidated outcome of former performances that allow individuals to create beliefs regarding their competences to participate in consecutive tasks. Normally, positive outcomes boost self-efficacy whereas negative ones produce the opposite effect. Repeated effective performances are potential signals that a person has mastered certain skills or activities and gained confidence, leading to more attainments (Thomson, DiFrancesca, Carrier, & Lee, 2017).

This SE source explains our hypotheses concerning students’ higher research intention and research competences due to increased self-efficacy in RBL experiences. This is supported in available literature referring to improvements in students’ learning outcomes as they work in tasks and become skilled at them, which boosts their research self-efficacy (Schunk & Bursuck, 2016; Carpi, Ronan, Falconer, & Lents, 2017; Kuo, Woo, & Bang, 2017). Even though research tasks might have an increase in complexity, students who have developed research self-efficacy are likely to succeed. As confirmed by Bandura (1981), once self-efficacy has been settled through reiterated attainments, sporadic failures are not likely to have a significant negative effective on one’s perceived competences

Concerning vicarious experiences from role models, available literature states that they are possibly powerless compared to mastery experiences but still relevant as an actual source of self-efficacy Vicarious experiences are effective when one can positively identify with the person acting as a model (Lunenburg, 2011). Similarly, people who are vicariously convinced that do not possess the expected competences to execute a particular task, are often predisposed to perform poorly (Bandura, 1981).

In the context of our dissertation, the aim is to find out whether vicarious experiences from role models such as students with advanced research competences or who intend to pursue research careers can influence others and vice versa within the RBL intervention. Our aim is in accordance with the idea that proficient learners can provide expertise on how to develop abilities and succeed in particular settings as well as to go through learning obstacles (Bandura, 1977). This is also supported by Pajares (2005) when he states that a person can build self-efficacy beliefs by paying attention to the way others perform. This may have effects especially on people who do not feel

confident about their own skills or have insufficient prior knowledge related to the particular task, which is probable the case of some students involved in RBL practices.

In regards to social persuasion, Pajares (2005) defines it as another source of self-efficacy through which individuals create beliefs concerning their abilities when being influenced by others. These constructive persuasions encourage people's own perception of their abilities and vice versa. People are socially persuaded by others through feedback on one's performance, recommendations and reinforcement (Bandura, 1977). For instance, when someone perceives that others trust in his capabilities to perform successfully, it is more likely that he can actually accomplish the proposed tasks (Lunenburg, 2011). This matches the purposes of the present dissertation in regards to the assumption that students who are positively persuaded by others such as tutors, peers or experts will eventually show higher levels of research self-efficacy in the RBL experience. As pointed out by Bandura, (1977), when tutors constantly reassure their confidence in learner's capabilities to perform well, their perceived self-efficacy grows.

Correspondingly, those who are persuaded of their low efficacy to accomplish tasks, are inclined to avoid demanding tasks and surrender easily when confronted with adversity (Bandura, 1981). The former statement may justify the fact that learners who are negatively persuaded regarding their research competences could tentatively perform below the expected level in our RBL intervention.

In connection to emotional and physiological states, Pajares (2005) refers to them as human and affectional circumstances that may also influence the creation of self-efficacy beliefs. People can measure how confident they feel regarding a particular behaviour based on the emotional events they go through. This tendency to depend on emotions and physical personal conditions can undermine the judgement of one's perceived competences to perform successfully (Bandura, 1981).

This source of SE is connected to our dissertation by helping to explain whether students are influenced by emotional and physiological factors when conducting research-related activities. It appears that learners who feel concerned about their abilities to accomplish complex tasks within a study field might reflect low levels of self-efficacy (Bandura, 1977). Based on our assumptions, students involved in our RBL intervention who are emotionally affected by certain personal or academic situations might reflect decreased research self-efficacy, which could be reflected in their research competences.

4.3 The Role of Autonomous Motivation to explain RBL

We build on the Self-Determination Theory SDT (Deci & Ryan, 2000) to explain the role of autonomous motivation in an RBL setting. In the present dissertation, we intend to find out if a positive impact of RBL on students' research competences is related to higher levels of autonomous motivation in research.

In the following lines, we begin by explaining the concept of motivation and its different types. According to Ryan & Deci (2017) motivation has to do with the kind of energy that stimulate people to action and direct the way they act.

Across history, several theories have studied motivation as a single aspect, which strives to influence achievement, learning and attitudes. Throughout time, other approaches to motivation have emerged and highlighted not only different types of motivation but also sources that have effect on the way people behave. Controversy on these issues have aroused disputes regarding the types of variables intervening in the origination of behaviours (Deci & Ryan, 1980).

In this regard, the Self-Determination Theory emerges as a broad framework for the study of human behaviour and personality that focuses on different types of motivation and not only one (Deci & Ryan, 2008). Ryan & Deci (2017) make an important distinction between extrinsic and intrinsic motivation as contrasting forces that determine the way people are and act. However, there is a strong emphasis on other types of motivation identified as controlled and autonomous, that actually emerge from both extrinsic and intrinsic motivation, respectively.

Autonomous motivation (AM) derives from inner sources including motivation that arises due to outer factors when individuals feel identified with values or emotional states aligned to themselves (Deci & Ryan, 2008). AM is attained when spontaneously people desire to get involved in tasks because of internal motives such as they finding them gratifying or personally worthwhile (Greguras, Diefendorff, Carpenter, & Troster, 2014). This is why, autonomously motivated individuals have an entirely sense of willingness to participate in activities that they freely choose based on their pursuits, ideals and other personal drives (Ryan & Deci, 2017). It seems that there is a natural aspiration in humans to be autonomous in different life contexts and strive for goals they consider intrinsically gratifying (Cook & Artino, 2016).

On the contrary, controlled motivation occurs when people behave in a certain way in hoping to get rewards or to avoid punishment. While autonomously motivated individuals have free choice to act independently, those who are guided by controlled

motivation are pushed to follow certain patterns of behaviour with no independence (Deci & Ryan, 2008).

Both controlled and autonomous motivations are considered precursors of performance, social outcomes and wellness (Deci & Ryan, 2008). However, autonomous types if motivation seem to be more advantageous in terms of the enhancement of student learning outcomes and welfare, compared to controlled forms of motivation (Legault & Inzlicht, 2013; Orsini, Evans, & Jerez, 2015; Liu, Wang, Reeve, Kee, & Chian, 2019).

Based on the above, we decide to study the role of the variable "autonomous motivation" in our intervention to find out whether it interacts with the overall impact of RBL on students' intention to do research and research competences. This is in line with earlier studies that demonstrate that individuals can perform better due to high levels of autonomous motivation (Strauss & Parker, 2014) since it appears to be more effective to encourage behaviours and enhance achievement compared to controlled motivation (J. Howard, Gagné, Morin, & Van den Broeck, 2016).

In this regard, it is assumed that students' intention to do research in our RBL intervention can be boosted by their autonomous motivation as it can drive students in their academic efforts (León, Núñez, & Liew, 2015), strengthen interest in any learning task and help students satisfy their instinctive psychological needs (Reeve, Ryan, & Deci, 2018). Therefore, a behaviour such as students' growing intention to do research, may become an enjoyable habit, given that it is autonomously motivated and thus, fulfils their essential human needs (France et al., 2017).

These basic psychological needs in connection with RBL in this dissertation, are explained in the next section.

4.3.1 The Role of the Basic Psychological Needs to explain RBL

Again, we build on the Self-Determination Theory to explain the interplay of the three basic psychological needs: competence, autonomy and relatedness with the impact of RBL on students' research competences within our intervention.

Figure 7 depicts the three basic psychological needs in connection with different types of motivation once they are satisfied.

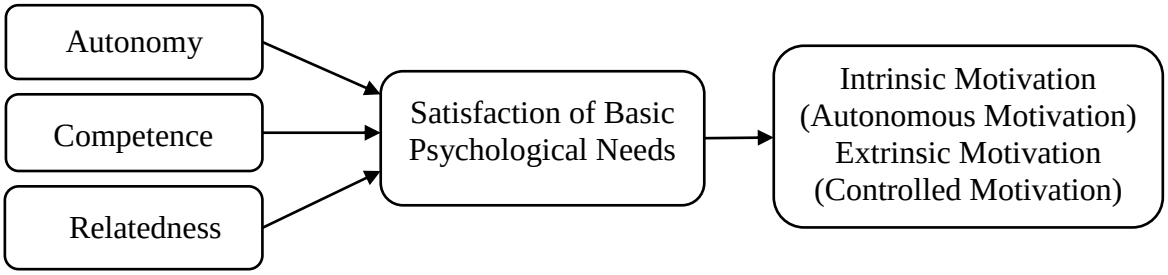

Figure 7. Basic Psychological Needs in relation to Autonomous Motivation (Deci & Ryan, 2000)

It seems that the satisfaction of such needs leads to personal welfare, increasing autonomous motivation (Deci & Ryan, 2000) and life accomplishment (Sheldon, Abad, & Omoile, 2009). Similarly, the detriment of these needs appears to also have a quantifiable impact related to noticeable decrement of contentment, success (Ryan & Deci, 2017) and increasing levels of stress and frustration (Olafsen, Niemiec, Halvari, Deci, & Williams, 2017).

The above findings are linked the research aims of the present dissertation. We anticipate that students will reflect higher research intentions and competences when they are autonomously motivated to do research and their basic psychological needs are properly fulfilled. This assumption may be supported by earlier studies which confirm that the suitable satisfaction of these needs may have a beneficial impact on students' intentions to perform certain behaviours (Khan et al., 2018), increase their autonomous motivation (Black & Deci, 2000; Ryan & Deci, 2017) related to academic tasks (Orsini, Evans, Binnie, Ledezma, & Fuentes, 2016) and interact with the development of competences (DeHaan, Hirai, & Ryan, 2016).

We expect that an adequate satisfaction of the basic psychological needs allow students increase their autonomous motivation; and consequently, improve their research competences. This is congruent with ideas from Wang, Chen, Duan, & Du (2018) and Koole, Schlinkert, Maldei, & Baumann (2019) stating that people are instinctively prone to cultivate their promising abilities when the conditions permit them to gratify their basic psychological needs. This is why, it seems to be essential that these needs are satisfied so that individuals can increase their autonomous motivation (Liu, Wang, Reeve, Kee, & Chian, 2019) and consequently, perform at their best in any area of expertise (Deci & Ryan, 2008).

We will now describe the role of each of the basic psychological needs within our RBL interventions in the present dissertation.

Autonomy is probably the most fundamental need in SDT (Diefendorff, Houlfort, Vallerant, & Krantz, 2018). It refers to one's need to control his own events and performances. This means that personal actions are supported and compatible with one's genuine pursuits and ethics (Ryan & Deci, 2017) and not due to extrinsic demands (Núñez & León, 2015). It is achieved when people perform behaviours as

the result of individual choices driven by their own interests and beliefs. Even though these choices may be affected by external factors, individuals agree with them as if they come from their own enterprise (Deci & Ryan, 2002).

The fact that others; for instance tutors, support students' autonomy may contribute to the fulfilment of this need whereas the opposite situation may lead to lack of commitment and frustration (Jang, Kim, & Reeve, 2016). Hence, promoting students' autonomy can result in considerable benefits with regard to learning gains (Deci & Ryan, 2016) and academic performance (Black & Deci, 2000).

The need for autonomy interplays with our intervention given that RBL may have an impact on students' research competences when they have a voice regarding their needs, wants, favourite ways of learning (Jang, Reeve, & Halusic, 2016). These choices, even if they are limited must be directly significant for students (B. Chen et al., 2015). For instance, students may choose research topics of their interest or related to their study degrees. This is supported by Deci & Ryan (2002) when they state that autonomy is achieved when people perform behaviours as the result of individual choices driven by their own interests and beliefs. Even though these choices may be affected by external factors, individuals agree with them as if they come from their own enterprise.

Teachers, tutors and peers can also help to increase students' autonomy. This is confirmed by Jang, Kim, & Reeve (2016) when they state that tutors who support students' autonomy may contribute to the fulfilment of this need whereas the opposite situation may lead to lack of commitment and frustration. Hence, promoting students' autonomy can result in considerable benefits with regard to learning gains (Deci & Ryan, 2016) and academic performance (Black & Deci, 2000).

Regarding competence, Klein (2019) describes it as one's ability to resolve problems successfully. It also refers to people's need of being proficient and effective when carrying out different tasks (Ryan & Deci, 2017) in life settings that matter to them (Deci & Ryan, 2008). Competence is achieved when one's abilities are in line with the demands of the required tasks (Diefendorff et al., 2018).

In the present dissertation, we intend to explain the role of competence in our RBL intervention. We aim to determine whether students who feel competent when conducting research-related tasks, may demonstrate improved research competences (Chiang, Baley, Ponder, & Padilla, 2016).

Earlier studies state that students who perceive themselves as competent are powerfully inclined to get engaged in stimulating tasks (Black & Deci, 2000) and can potentially perform expected behaviours (Williams et al., 2006; Chiniara & Bentein, 2016) in this case, competency to carry out research tasks. Therefore, individuals who are involved in challenging activities that stimulate and develop their capabilities can satisfy their need for competence (Chiang, Baley, Ponder, & Padilla, 2016; Reeve et al., 2018). Similarly, we believe that students who are negatively criticized or discouraged in their research attempts, may feel less competent to conduct research. This is supported by Ryan & Deci (2017) when they explain that feelings of competence or mastery can easily be hindered when one is exposed to puzzling situations, harmful criticism or negative discrimination

In connection to relatedness, it refers to feeling linked, related or meaningful to others (Ryan & Deci, 2017). It is considered as a strong predictor of enhanced learning results at university level as it clearly improves students' performance and autonomous motivation (Beachboard, Beachboard, Li, & Adkison, 2011).

In this dissertation, we rely on the concept of relatedness to explain the expected positive impact of RBL on students' research competences when they feel positively related to one another. This is in line with the notion that high levels of relatedness may certainly influence individuals' tendency to get involved in specific activities (Jang, Reeve, et al., 2016), such research-related tasks. Moreover, as emphasized by Butz & Stupnisky (2017), feeling attached to others is a key factor in order to attain the expected outcomes.

We investigate whether students involved in our RBL intervention feel connected or attached to others such as class peers; and consequently, reflect enhanced research competences. Our aim is supported by Koole et al. (2019) when they claim that relatedness can be satisfied when people perceive that their actions or efforts are appreciated by peers. Relatedness can be experienced through significant interactions or perceived feelings of recognition of one's values or capabilities (H. T. Reis et al., 2018). Being positively related to others may also imply behaving in a certain way or carrying out tasks that significant others consider worthy; with the purpose to shape positive connections (Diefendorff et al., 2018).

V. Designing our RBL intervention

In this section, we firstly describe the challenges to implement RBL in a university setting. Then, we explain the research model to be used in our RBL intervention within

the present dissertation. Also, we refer to the nature of our intervention through the adoption of a holistic model for research integration

5.1 The challenge to implement RBL in a university setting

As stated earlier in this chapter, the idea of developing a TRN has been promoted worldwide given that most higher education institutions encourage research as one of their main aims among academics and students. However, its actual application is still conflictive (Arimoto, 2015; Quinn, 2016) due to the existing academic burden, dealing with lack of structure, organization and clearly-defined objectives (Leišytė, 2016). This is the case of the Ecuadorian context, where the Ministry of Education plays a major role in the renovation of university graduate programs to become more research-oriented. This educational reorientation pushes interest in adopting innovative approaches towards the teaching-research nexus (TRN). Nevertheless, as mentioned earlier in this chapter, practical approaches to put TRN into practice may need to be strengthened as they are still insufficient or inconsistent (Brew, 2010; Lubbe, 2015).

Considering the above, we focus on a particular Ecuadorian public university that promotes research through the development of research-oriented master and doctorate programs, which constitute a major breakthrough for the academia in Ecuador.

In this regard, RBL emerges as an innovative methodology, which seems to actually engage students in phases of the research cycle (Griffiths, 2004) such as observation, developing research instruments, examining information sources, identifying literature gaps, collecting, analyzing data, interpreting and communicating results (Brew, 2013; Maaß & Artigue, 2013).

Due to the many RBL benefits reported in previous sections of this chapter, the aim of this dissertation is to set up a 4-year research project to redesign existing curricula in an Ecuadorian public university and move towards RBL. We anticipate that the adoption of RBL methodology may contribute to develop students' intention to do research and develop their research competences (Tungkasamit, 2019). This expected RBL impact is measured in three empirical studies that we describe in detail in the following sections.

However, we deal with several challenges. On the one hand, attempting to implement RBL practices in undergraduate courses where most students are novices in the research field, require hard work and collaboration from the participants.

On the other hand, adopting RBL in research-oriented graduate courses is also complex given that most of them might be at an initial stage of their research aims towards a more innovative curriculum. Moreover, the role of participants might be unclear as they probably lack experience, structure or willingness to be involved in RBL.

Another challenge is in fact, to create an appropriate RBL setting in a single course within a degree program which has not used the RBL approach before. This absence of sequence may certainly limit students research competences because they are not continuously trained at different stages of the research cycle.

5.2 Defining an RBL research model

Building on the theoretical model based on the Theory of Planned Behaviour, Self-Determination Theory and Self-Efficacy Theory (see fig. 3) to explain the interplay of RBL with dependent and interaction variables, we develop the research model for our intervention.

Figure 8 depicts our research model which explains how RBL is expected to affect dependent variables: intention to do research and research competences. Also, it shows the expected interaction with other variables such as autonomous motivation, self-efficacy (perceived behavioural control), behavioural beliefs and subjective norms.

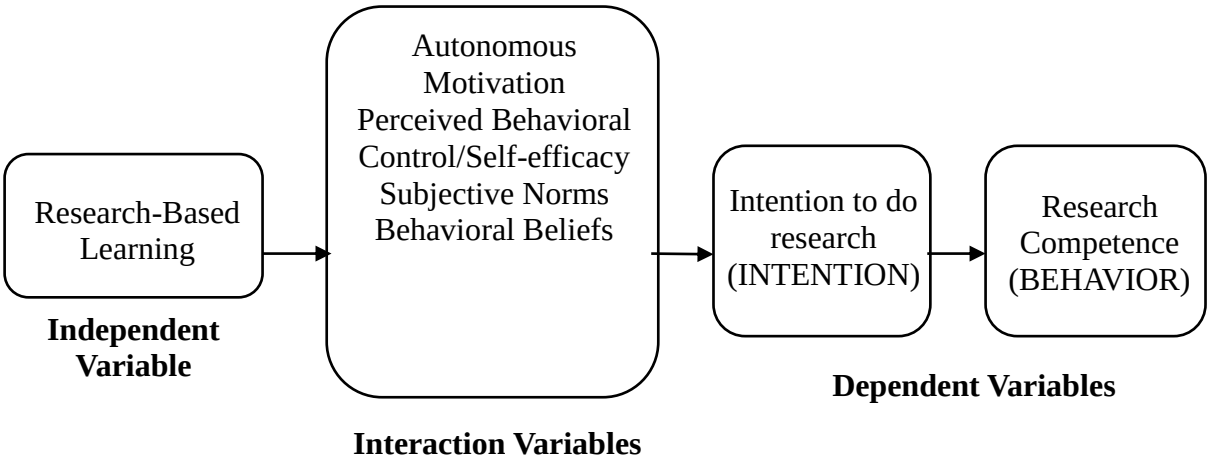

Figure 8. Research model explaining the interplay of RBL with research variables

To define the nature of RBL in the present dissertation, we adopt Brew's holistic model for research decision integration (2013) as we consider it appropriate to explain decisions made in the design of our RBL intervention.

Brew's model (2013) places “students” as the essential focus. Particularities such as their prior knowledge, study course, research abilities, etc. must be taken into consideration before making curricular and instructional decisions.

In regard to “context”, it should contemplate the institution, department, teaching, learning, research policies and society. It seems to be important to be conscious of such contexts so that it can be defined who leads specific tasks.

Concerning “learning outcomes”, it is required to determine what knowledge and skills students would attain because of research involvement. In addition, it is important to anticipate constraints that may appear throughout the process.

Figure 9 shows the above mentioned framework involving three key elements: students, contexts and learning outcomes. It emphasizes pedagogical decisions or choices within a course or program regarding initial knowledge, inquiry, research topics, questions, structure of tasks, audience and assessment along with learning products. Such decisions are either fixed by the teacher, negotiated between teacher and students or controlled by the student.

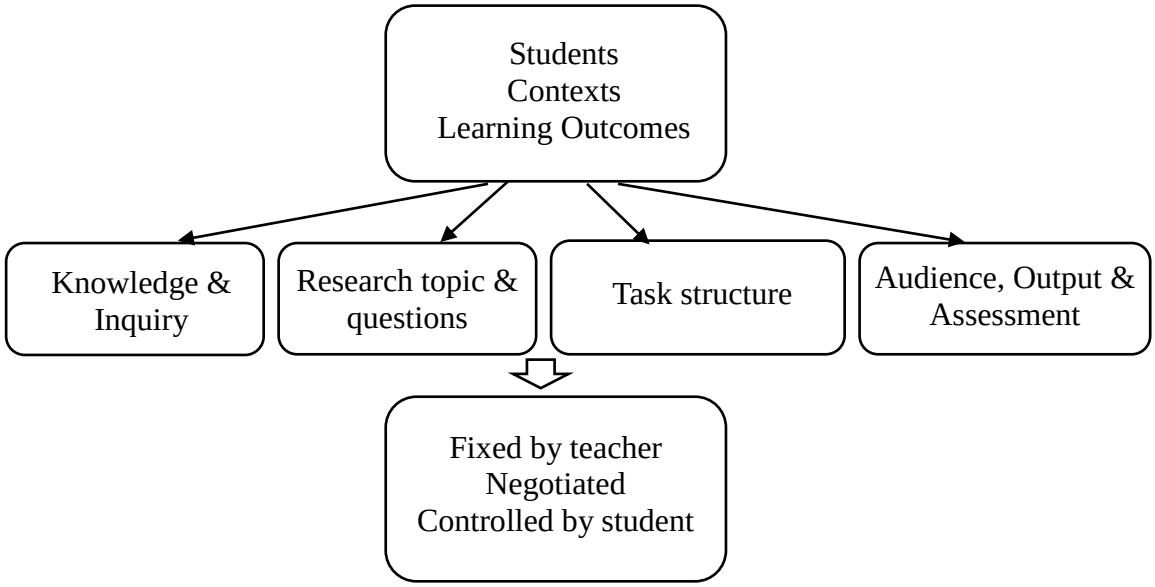

Figure 9. Research-based learning holistic model. Adapted from Brew (2013)

Decisions regarding students, context and learning outcomes respond to different levels of autonomy (Willison, 2012) in which choices are managed by teachers or researchers, students or negotiated among them considering the requirements and aims of the course or program (Brew, 2013). The model is active, as it is possible to

mix choices. At first, the teacher could mostly define the research domain, followed by teacher-student negotiations in regards of the research methodology, leading to students' freedom to present research products, for instance. As students gain more research experience, they may become more autonomous in relation to their research competences (Willison, 2012), in which for example, students could follow a fixed structure but have a choice in regards of research topics of their interest or study fields (Brew, 2013).

The above helps us to distinguish a structured and semi-structured version of RBL within our intervention. This reflects different levels of control as shown in fig. 6. For instance, a structured RBL version implies a clearly organized instruction with sufficient initial knowledge and guidance throughout the research process whereas semi-structure RBL suggests less controlled and guided instruction pushing students to be more autonomous in their learning.

In the present dissertation, we rely Brew's holistic model for research integration (2013) for analyzing earlier empirical studies and as a baseline to build our own, which are explained in detail further in this chapter.

VI. Research Objectives

In accordance to the research context, theoretical and conceptual frameworks and research challenges described in the previous sections, the general aim of the present dissertation is to gain insights about the nature of Research-Based Learning and its specific impact on university students' intention to do and research competences. This aim leads to the following research objectives, hypotheses and research questions:

Research Objective 1 (RO1): Build an RBL scoping review in engineering and science education.

To accomplish research objective 1, the following research questions are formulated:

RQ1: What research competences are being developed in the Engineering and Science students?

RQ2: Building on Brew's framework for research integration, what is the nature of the RBL implementations described in the reviewed studies?

RQ3: What are the reported benefits of adopting RBL in Engineering and Science programs/courses?

RQ4: What are the reported challenges of adopting RBL in the included Engineering and Science programs/courses?

RQ5: What actions have been suggested to enhance future RBL implementations?

Research objective 2 (RO2): Evaluate the impact of RBL on students' intention to do research.
To accomplish research objective 2, the following hypotheses are formulated:

H1: Students involved in the RBL version of a course will reflect a higher intention to do research as compared to students involved in the control condition version of the same course.

H2: Students involved in the RBL version of a course will reflect a higher intention to do research as compared to students involved in the control condition version of the same course, considering the different course contexts, the changes in autonomous motivation, perceived behavioral control, behavioral beliefs and subjective norms; and the interaction with co-variables (age and gender).

H3: Studying in a structured RBL condition will result in higher intentions to do research as compared to studying in a semi-structured RBL or control condition.

H4: Changes in autonomous motivation, perceived behavioral control, behavioral beliefs and subjective norms will interact with the impact of studying in a structured RBL, semi-structured RBL or control condition on intentions to do research.

Research Objective 3 (RO3): Evaluate the impact of RBL on students' research competences.
To reach this research objective, the following hypotheses and research questions are presented:

H1: Studying in a structured RBL condition will improve students' research competences as compared to studying in a semi-structured RBL or control condition.

H2: Changes in autonomous motivation, perceived behavioral control, behavioral beliefs and subjective norm will interact with the impact of studying in a structured RBL, semi-structured RBL or control condition on research competences.

RQ1: What is the specific effect of engaging students in an RBL graduate course on their actual research competences?

RQ2: What is the effect of engaging students in an RBL graduate course on their actual research competences considering changes in autonomous motivation?

RQ3: What is the effect of engaging students in an RBL graduate course on their actual research competences considering changes in self-efficacy?

6.1. Research Design

In order to achieve the general research aim, specific research objectives, test hypotheses and provide an answer to the research questions proposed in the present dissertation, three empirical studies are conducted where both quantitative and qualitative approaches are applied.

To achieve RO1, a systematic literature review is developed following the five-stage framework of Arksey and O'Malley (2005) to gain insights regarding the nature of RBL instruction and earlier practices in undergraduate and graduate courses. Five research questions emerge from the literature and practical experience of other researchers already using RBL. The aim of this review is to provide answers to these questions which involve research competences mostly developed through RBL, and the nature of its implementation following the framework from Brew (2013). Also, reported RBL benefits, challenges and suggested action plans to make this approach more effective. Data was obtained from 4 electronic databases, where 5,607 studies were initially identified, from which only 47 studies met the inclusion criteria.

This literature review, contained in chapter 2 of this dissertation, is relevant in view of the lack of available studies concerning RBL in engineering and science contexts (Edwin Peraza, Das, & Lagoudas, 2012) and the need to implement RBL in these areas given that this approach has proved to contribute to students' learning (Wallin et al., 2017). This review provides avenues for further studies in consonance with the reported findings.

RO2 encompasses study 1 involving graduate engineering and science students (chapter 3) and study 2 involving undergraduate Entrepreneurship and Innovation students (chapter 4). Both studies build on a quantitative approach and were set up to test an expected increase of students' intention to do research when involved in RBL settings. Study 1 considers two research conditions: experimental (RBL) and control;

whereas study 2 contemplates three conditions: structured RBL, semi-structured RBL and control. The latter distinctions in RBL conditions are in congruence with Brew's holistic model for research integration (2013).

In study 1, we also hypothesize that other variables such as autonomous motivation, gender and age along with constructs from the Theory of Planned Behaviour (TPB), labelled as precursors of human behaviour (Ajzen, 1991) may interact with the effect of RBL on students' intention to do research. The latter has been reiterated by several authors when referring to these predictors: perceived behavioural control, subjective norms and behavioural beliefs of attitudes as determinant to produce intentions and; consequently, behaviours (Abd Mutalib et al., 2017; Armitage et al., 2017).

Research instruments such as scales, were developed under the framework of TPB (Ajzen, 1985), SDT (Ryan & Deci, 2000) and Self-efficacy (Bandura, 1977) and adapted to the context of the research. Scales to measure intention, autonomous motivation, self-efficacy and TPB variables were administered before and after the intervention. For research purposes, explicit research instruments were designed, matching students' knowledge fields, in view that for instance, SE must be measured according to specific domains (Jackson, 2018).

In both study 1 and 2, an increased students' intention to do research and interactions with other variables could not be confirmed. Results from these studies put forward the need to consider other variables related to RBL, aside from students' intention to do research. Also, explore students' insights and perceptions about RBL by using a qualitative approach. These findings led to the concluding research study, labelled as study 3 that is described in the next lines.

To achieve RO3, we rely on our study 2 and 3 following quantitative and qualitative approaches, respectively. Study 2 deals with the anticipated positive impact of RBL on students' research competences. In this study, it is also hypothesized that students involved in RBL conditions will reflect positive changes in autonomous motivation, self-efficacy and in other variables belonging to the Theory of Plan Behaviour (Ajzen, 1991). Additionally, it is expected that the latter variables interact with the effect of RBL on students' research competences. Research instruments designed for study 1 were adapted to the new context of the research in study 2. This is justified in earlier literature stating that explicit research instruments should match students' knowledge fields, in view that they must be measured according to specific domains (Jackson, 2018).

To measure students' research competences, 10 weekly assignments were designed involving stages of the research cycle proposed by Jungmann & Ossenberg (2014) and the entrepreneurial cycle suggested by Brush et al., (2003). Results indicate that there was a significant RBL effect on students' overall research competences and specific research competence clusters. This is in line with ideas from Zimbardi & Myatt (2014) concerning the link between research experiences and RBL.

Concerning study 3, a qualitative research study involving the total population of 6 graduate students from a Sociology and Rural Development course, was set up. A qualitative approach is adopted in consonance with earlier research emphasizing the importance of exploring students' participation in research (C. Buckley, 2011) and their perceptions of the implemented RBL courses (Visser-Wijnveen, Van der Rijst, & Van Driel, 2016).

The aim of study 3 is to answer the proposed research questions related to the impact of RBL on students' research competences and its interaction with other variables such as autonomous motivation and self-efficacy. Theoretical frameworks such as Self-Determination Theory (Ryan & Deci, 2017) and Self-efficacy (Bandura, 1977) helped to support the assumptions stated in the present dissertation.

Data was collected from 3 rounds of interviews designed to explore students' views concerning their research competences, levels of confidence and motivation to do research. This interview intended to comprise questions which focused on elements from Bandura's Self-efficacy Theory, (1977) such as the four sources of self-efficacy and the three basic psychological needs (Ryan & Deci, 2017). This study, contained in chapter 5, is particularly relevant to this dissertation for two reasons: Firstly, it contributes to fill a gap in the existing literature regarding inconclusive RBL findings on the base of quantitative data. Secondly, it complements the previous findings reported in chapters 3 and 4, also from quantitative approaches.

In general, results from this study reflect a clear positive impact of the RBL intervention and surely opens avenues for future implementations involving mixed-method designs and larger populations.

To better comprehend the structure of the present dissertation, table 2 outlines each of the chapters, research objectives, methodology used to accomplish these objectives, study participants, data collection methods and the way they were analysed.

Table 2: Outline of the dissertation including chapters, research objectives, methodology, study participants, data collection methods and ype of analysis.

Chapter	Research Objective	Methodology	Participants	Data collection	Type of analysis
1	Introduction, problem statement, conceptual and theoretical framework, research challenges, research objectives, research design, structure and overview of the dissertation, relevance of the dissertation				
2	1	the five-stage criteria framework	47 studies	4 online databases	inclusion-exclusion
3	2	Quantitative	52 graduate engineering and science students	Paper and pencil scales	Descriptive analysis Analysis of covariance (ANCOVA)
4	2	Quantitative	107 undergraduate Entrepreneurship & Innovation students	Paper and pencil scales 10 graded weekly assignments	Descriptive analysis Analysis of covariance (ANCOVA)
5	3	Qualitative	6 graduate Sociology and Rural Development students	3 rounds of interviews with all 6 participants	Descriptive analysis Content analysis (NVivo)
6	General discussion Overview of the main findings, limitations, directions for future research and implications				

6.2. Structure of the Dissertation

The present dissertation is structured into 6 chapters (see Fig 7) of which three are based on empirical research studies (chapters 3, 4 and 5) submitted for publication or published in international peer-reviewed journals listed in the ISI Web of Knowledge. Due to their nature, all of them follow a similar structure: introduction, theoretical framework, methodology, results, discussion and conclusion. These chapters are preceded by a general introduction (chapter 1) and completed with a discussion and conclusion (chapter 6). Fig 10 displays and schematic overview of the chapters contained in this dissertation.

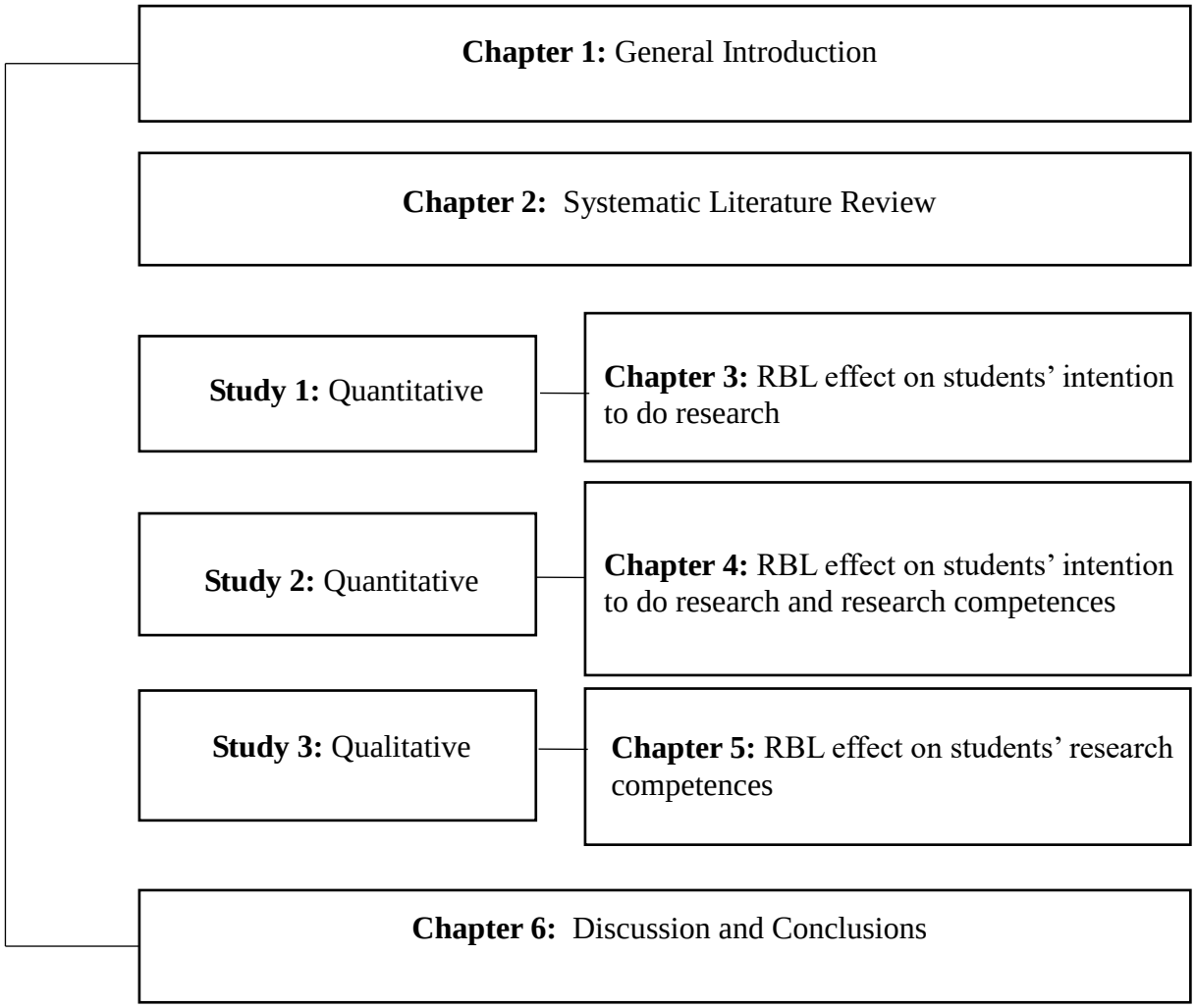

Fig 10: Schematic overview of the chapters in this dissertation.

Chapter 1 provides a general introduction to the present dissertation. It starts describing the role of higher education worldwide considering the need to educate

future professionals who could deal with main global problems and current demands of our society. It emphasizes universities attempts to incorporate a teaching and research nexus into their institutional objectives. Two examples dealing with an innovative integration of research into teaching are explained. Attention is paid to the increasing importance of TRN in universities due to its numerous advantages, constraints for its suitable implementation and the need to appropriately integrate it in the curriculum. This is brought into focus as a broad framework that helps to understand the current situation of higher education concerning its aims to link teaching and learning with research. This is followed by the research context in which the present dissertation is positioned as well as the statement of the research problem.

Next, an outline of the conceptual and theoretical framework is presented in which key concepts and frameworks that support the assumptions of this dissertation are explained. This includes literature on the Teaching-Research Nexus, Research-Based Learning, RBL models, Theory of Planned Behavior, Self-efficacy and Self-Determination Theory. Also, a theoretical model is developed and the main research variables identified in the literature as having impact or interacting with RBL, are described.

Furthermore, the challenge of implementing RBL in a university setting is explained along with the research model to be use in our intervention. Furthermore, it includes a detailed overview of the research objectives (including hypotheses, questions and design of the study) and the general structure of the dissertation are provided.

Chapter 2 provides a scoping review of empirical work concerning RBL in engineering and science education between 2000 and 2017. Following the five-stage framework of Arksey and O'Malley (2005), it presents research outcomes from earlier RBL practices in regards to graduate and undergraduate students' research competences, nature of RBL instruction, benefits, challenges and actions for improvement. Data were collected from 4 electronic databases that originally included 5,607 studies. After applying exclusion criteria, only 47 studies were subject to analysis in this study.

Findings in this chapter are in general positive, with the use of a great variety of research activities connected to the research cycle where in most cases decisions are negotiated between student are teacher. Several benefits are reported such as the development of students' research competences, improved achievement and increased self-efficacy. Such student variables are tackled in chapters 3, 4 and 5 with

empirical studies addressing the potential impact of RBL and interactions with these variables.

Notably, this chapter fills in an existing gap in the literature regarding the outcomes of RBL implementations in the last years. Additionally, it provides a theoretical framework and state of the art which allows the identification of new gaps and further variables interacting with the impact of RBL.

Chapter 3, 4 and 5 of the present dissertation report on empirical research studies building on the available RBL literature and involving the aforementioned student variables.

In this regard, chapter 3 builds on a pretest/posttest experimental quantitative research design where 52 engineering and science graduate students from a public university were involved in an RBL version of the course compared to students in a non-RBL version. A differential impact was studied on students' intention to do research. It was also hypothesized that changes in other variables such as autonomous motivation and the precursors of intention: perceived behavioral control (self-efficacy), behavioral beliefs and subjective norm may interact with the impact of the RBL experience. In addition, the potential interaction effect of gender and age were considered.

Research instruments were built to determine students' self-efficacy (Bandura, 2010), to explain the intention to do research along with behavioural beliefs and subjective norm from the Theory of Planned Behaviour (Ajzen, 1991) and to determine autonomous motivation using the Intrinsic Motivation Inventory from Deci & Ryan (1980). These instruments were validated in a pilot study involving students not included in the formal study. The intervention lasted six weeks, requiring students to carry out specific research activities on a weekly basis. RBL students worked on activities designed on the base of stages of the research cycle whereas non-RBL students, during a comparable amount of time, simply adopted basic TRN assignments.

The results of this study demonstrated that RBL students reached higher intention to do research. Although positive trends were reported, hypotheses could not be confirmed as statistical differences were no significant neither for the variable intention to do research nor for the other student variables.

Following a similar path, chapter 4 also reports on an empirical quantitative research study that involved 107 undergraduate students from four Entrepreneurship and

Innovation courses from the same public university. Students were randomly assigned to three conditions, associated with the amounts of RBL instruction: structure RBL, semi-structured RBL and control condition. Building on the promising but at the same time inconclusive outcomes of chapter 3, the same student variables were measured in this chapter with changes in the research design that included the variable students' research competences. This study assumed that students involved in an RBL condition may reflect higher intentions to do research, improved research competences along with positive changes in autonomous motivation, perceived behavioural control, behavioural beliefs and subjective norm in comparison with students involved in a semi-structured RBL and control condition.

In this 7-week intervention, all students carried out weekly activities involving clustered research competences, linking the entrepreneurial cycle with the research cycle. Furthermore, these tasks were designed according to Brew's framework for research integration (2013) which considers different degrees of RBL instruction and pedagogical decisions about students' learning. Validated research instruments from the past study were adapted for the context of Entrepreneurship and Innovation.

Once again, it was not possible to demonstrate RBL students' increasing intention to do research. However, results were statistically significant in regard to research competences. This study provides an encouraging picture of an actual implementation of TRN operationalized as RBL.

In view of the quantitative nature of the past research studies reported in chapters 3 and 4, and the extensive number of other quantitative results in the available RBL literature, the need for a qualitative approach is clearly identified. This need can be justified by the fact that many past studies reporting RBL findings rely on quantitative data which sometimes are not as anticipated (Tomasik, Cottone, Heethuis, & Mueller, 2013; Bangera & Brownell, 2014). This brings the need to explore students' insights, perceptions and views that conducted to such outcomes.

This chapter reports on an empirical qualitative study that involved a total population of 6 graduate students from a Sociology and Rural Development master course in the target public university. An intervention was built on the basis of the regular course assignments, in connection with stages of the research cycle. Research instruments included a 35-open ended question interview that included 16 questions designed on the base of the Intrinsic Motivation Inventory proposed by Deci & Ryan (1982) addressing the three basic psychological needs: autonomy, competence and

relatedness and 19 questions built on the Self-efficacy Theory from Bandura (2010) addressing its four sources: mastery experiences, vicarious experiences from role models, social persuasion and emotional and physiological states.

Additionally, a pre/post research competency test was designed to measure students' research knowledge and skills. Given the small population in this study, the results of this test were not aimed for quantitative analysis but just to complement the qualitative outcomes

Three rounds of interviews were conducted involving all the participants. At the same time, feedback on their assignments was provided. The coding scheme focused on indicators referring to the study variables, followed by the calculation of intra-rater reliability. NVivo was used for statistical analysis. Results confirmed hypothetical assumption in regard to the RBL effect on students' research competences and the interaction of autonomous motivation and self-efficacy.

Finally, chapter 6 concludes with a synthesis of the most relevant findings from the preceding chapters in relation to the initial formulated research objectives and the review of literature presented earlier. In addition, this chapter discusses theoretical and practical limitations of the studies, research implications and directions for further research.

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Chapter 2
Research-based Learning in Engineering and Science Education: A Scoping Review

This chapter is based on:

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Chapter 2

Research-Based Learning in Engineering and Science Education: A Scoping Review

Abstract

The present study is a scoping review of empirical work from 2000 to 2017 on Research-Based Learning (RBL) in engineering and science education. It describes RBL implementations in terms of students' research competences, nature of instruction, benefits, challenges and actions suggested for improvement. The methodology involved a rigorous search in four electronic databases which initially identified 5,607 studies. After further scrutiny using inclusion/exclusion criteria, only 47 studies remained and were subject to in-depth analysis. Our findings reveal that the most developed research competences were conducting research, analyzing and interpreting results and communicating findings. Regarding the nature of RBL instruction following a defined framework, pedagogical decisions are made by teachers, students or negotiated; being the latter more remarkable in studies set up after 2012. Among RBL benefits, some are derived such as development of research skills, improved learning performance, appreciation of the course and research self-efficacy. Also, challenges such as decreased research interest due to complex course design and insufficient research training and time constraints are also reported. Studies suggest to create more coherent research courses that allow novice learners to initiate in research, allow enough time for authentic research activities and periodically assess the impact of RBL.

I. Introduction

University education differs from other types of Higher Education, due to its focus on a Teaching-Research Nexus (TRN). As widely acknowledged by the Magna Charta Universitatum, both teaching and research are pillars of a university (Oosterlinck, 2013). Therefore, higher education institutions link teaching and research as part of their objectives (R. M. Van der Rijst, Visser-Wijnveen, Verloop, & Van Driel, 2013).

Although TRN is intensely promoted, its tangible implementation is weaker, especially among academics with mainly a teaching role or a limited research background (Boyd et al. 2012). In many cases, teaching and research coexist instead of being integrated at a program or institutional level (Willison 2012). Consequently, institutional processes to support implementation of the TRN are highly needed (Boyd et al. 2010). Key demands for university teachers are associated to scientific work, while complying with teaching loads (Hajdarpasic et al., 2015).

In recent years, we observe attempts to develop the TRN in Higher Education (Brew, 2010a), by explicitly integrating teaching and research into the curriculum; thus developing students as producers of knowledge, instead of consumers (Healey & Jenkins, 2009a).

II. Theoretical background

Different authors have attempted to explain the TRN. For example, Griffiths, (2004) developed a framework identifying 3 approaches to link teaching to research where the main focus was to learn about disciplinary findings (research-led), processes, or techniques (research oriented), or by actually conducting research activities (research-based). This framework was later complemented by Healey (2005) who added another approach that emphasized scientific discussions between teacher and students (research-tutored). Also Levy & Petrulis (2012) contributed to the model and stressed research based on students' current knowledge and new discoveries.

All TRN attempts appear to provide students with research experiences. However, Research Based Learning (RBL) seems to actually engage students in phases of the research cycle to undertake inquiry (Griffiths, 2004) such as observation, developing research instruments, examining information sources, identifying literature gaps, collecting and analysing data, interpreting and communicating results (Brew, 2013; Maaß & Artigue, 2013). Beyond the development of research skills (Christe et al., 2015), RBL is also expected to inspire students' interest in the subject (Fuller, Mellor, & Entwistle, 2014), develop employability competences and increase the aspiration to

pursue postgraduate studies (Hajdarpasic et al., 2015), and raising overall educational quality (Szteinberg et al., 2014).

Building on the above, Brew (2013) developed a broader RBL model emphasizing instructional decisions regarding initial knowledge, research amounts, students' individualities, skills and learning products along with the organization of tasks and assessments. These decisions may be controlled by the teacher, the student, or negotiated among them considering the needs and purposes of the research programs or projects. In the current study, we build on this comprehensive framework.

Next, to address students' research competences as RBL outcomes, we build on the research cycle of Jungmann & Ossenberg (2014).

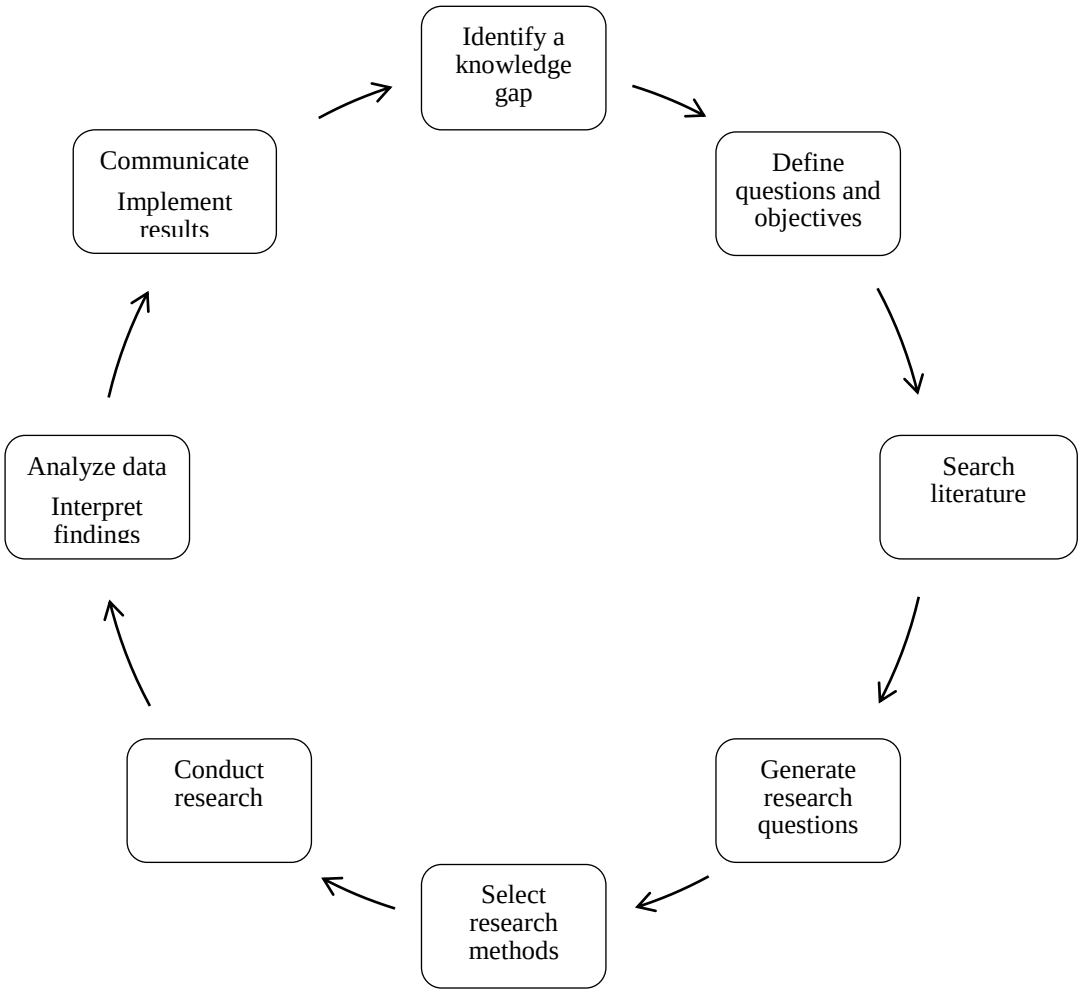

Figure 1. Research cycle for engineering and science (based on Jungmann & Ossenberg, 2014).

The above figure illustrates a typical research cycle with a process starting with a perceived knowledge gap, followed by the definition of questions and objectives,

literature search, formulation of research questions, selection of appropriate methods, the actual experimentation, analysis and interpretation of results and implementation of products or communication of results. The cycle may start over as a new research gap has been identified (Jungmann & Ossenberg, 2014a).

In the present article, we focus on an analysis of RBL in the context of science and engineering courses/programs. Available research stresses the potential of RBL to provide science students with research cycle experiences (Toledo, Pérez, & Pareja, 2015¸ Talikka, Eskelinen, & Varri, 2014). We therefore aim at studying the impact of RBL on undergraduate and graduate students (Shaw & Kennepohl, 2013), allowing students to grow into science fields (Bangera & Brownel, 2014), promoting entrance to graduate education (Giacaman & Sinnen, 2014), and building their future research capacities (Lesa, Daniel, & Harland, 2015). Next to the fact hardly review studies are available about RBL (E. Peraza, Das, & Lagoudas, 2012), the latter is especially true in the science and engineering domain when focusing on the potential of RBL or whether it is beneficial or not (Baiduc, Drane, Beitel, & Flores, 2017; Duff & Marriott, 2017; Robson and Morgan, 2012; Wilson, Howitt, & Higgins, 2016). The former inspired the current article in which we present the results of a scoping review about RBL in Engineering and Science Education.

III. Method

The scoping review followed the five-stage framework of Arksey and O'Malley (2005): (1) identifying the research questions, (2) identifying relevant studies, (3) selecting studies, (4) charting the data, (5) collating, summarizing and reporting the results.

3.1. Stage 1: Identifying the research questions

The following questions guided the review:

1. What research competences are being developed in the Engineering and Science students?
2. Building on Brew's framework, what is the nature of the RBL implementations described in reviewed studies?
3. What are the reported benefits of adopting RBL in the included Engineering and Science programs/courses?
4. What are the reported challenges of adopting RBL in the included Engineering and Science programs/courses?
5. What actions have been suggested to enhance future RBL implementations?

3.2. Stage 2: Identifying relevant studies

The literature identification and selection process took place in September 2017. Four online databases were used to identify peer-reviewed literature within the Engineering and Science domain: Web of Science (WOS), Scopus, Education Resources Information center (ERIC) and PROQUEST; limited to English language publications from 2000 to 2017 with the search terms described in table 1.

Table 1

Key search terms

Search terms in title and content
"research based learning" OR "research-based learning" OR "research based" OR "research-based" OR teaching research nexus OR teaching-research nexus" OR "research teaching nexus" OR research-teaching nexus"

3.3. Stage 3: Study Selection

Using the search terms, 5,607 articles were identified: WOS (N= 2,608), SCOPUS (N=2,549), ERIC (N=224) and PROQUEST (N=226). A review of abstracts resulted in excluding articles associated to elementary, high school, vocational settings or studies set up in non-educational contexts. Other studies were excluded as they were duplicates, access-restricted or preliminary research.

Table 2 summarizes the inclusion and exclusion criteria used in the screening process.

Table 2

Inclusion and exclusion criteria

	Inclusion criteria	Exclusion criteria
Topic	RBL as defined by Brew (2013)	Research based activities in non-educational contexts non-RBL approaches
Educational Level	Higher Education Undergraduate/Graduate	Other settings such as elementary or high school or unspecified
Participants	Students	faculty, individuals in non-educational settings
Study Focus	Empirical studies	Reviews of research, non-empirical studies, frameworks
Other	N/A	duplicate articles or not accessible

Only 47 studies did fit above criteria. Following the Preferred Reporting of Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Moher, Liberati, Tetzlaff, Altman, & Group, 2009), the process of article selection is displayed in figure 2.

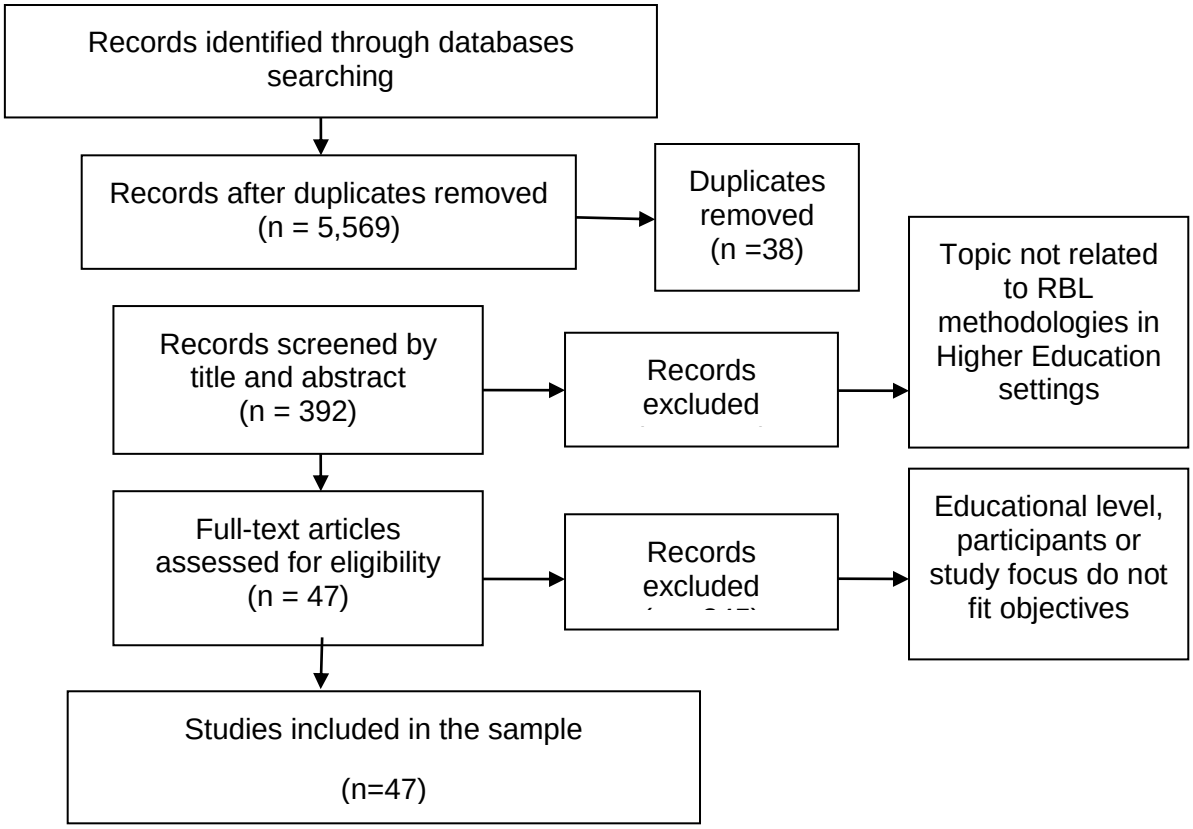

Fig. 2: PRISMA flow diagram for article selection.

3.4. Stage 4: Charting the data

Summaries of each article were developed focusing on inclusion elements explained in table 3.

To examine question 1, we linked RBL activities to the research cycle for Engineering science proposed by Jungmann & Ossenberg (2014; see table 4).

To answer question 2, we analyzed the nature of each reported RBL implementation following Brew's framework (2013). For questions 3 and 4, we reviewed the discussion and conclusion sections from the studies in order to identify RBL benefits and challenges. Concerning question 5, we reviewed the limitations and further research sections. Not all studies explicitly offered such remedial actions. Table 3 gives an overview of all included studies within the scoping review

Table 3

Overview of selected studies

Authors	**Country, education level sample, course**	**Research skills**	**Dependent Variables**	**Method** **Duration**	**Outcomes**
1. Carnahan et al., 2000	USA,N/A*, Chemistry	Search literature, conduct experiments, write a report	Development of research skills, appreciation of the course	Qualitative 1 semester	Positive Students performed well in research activities and perceived the course as stimulating.
2. Grover, 2004	USA, N=16* Biochemistry	Search literature, identify a research problem	Development of research skills, interest in research	Quantitative 1 semester	Mixed Literature search skills were reported as valuable. However, identifying research problems that match class topics was a constraint.
3. Thompson, Alford, Liao, Johnson, & Matthews, 2005	USA, N=38* Engineering	write research progress reports	Development of research skills	Mixed 2 years	Positive Students reported gains in understanding scientific material, synthesizing information and solving research problems.
4. Newton, Tracy, &	USA, N=18* Chemistry	Conduct experiments, analyze and interpret	Development of research skills, critical thinking in	Mixed 1 year	Positive Students gained confidence in their

Prudenté, 2006		findings, write a research paper	writing, self-efficacy in research, learning performance		research skills. Critical thinking and communication skills were developed.
5. Buckner et al., 2007	USA, N=60* Biology Computer Science	Search literature, communicate findings	Development of research skills, interest in research, learning performance	Quantitative 2 years	Positive High number of students pursued postgraduate studies. Development of subject expertise.
6. Brame, Pruitt, & Robinson, 2008	USA, N=50* Biology	Generate hypotheses, conduct experiments, analyze and interpret results, write a research report	Interest in research, learning performance	Quantitative 1 semester	Positive Increase in students' knowledge and skills. Lab reports showed significant improvements in quality.
7. Bahr, 2009	USA, N=32* Engineering	Search literature, communicate findings	Development of research skills, intrinsic motivation, learning performance	Mixed 1 week	Mixed Little impact on students' GPA. However, there was motivation to engage in research.
8. Parra, Osgood, & Pappas, 2010	USA, N=14* Biochemistry	Conduct experiments, analyze and interpret findings, write a research paper	Development of research skills, interest in research	Mixed 10 weeks	Positive Students co-authored peer-reviewed scientific research papers and pursued postgraduate studies.
9. Knutson, Smith, Wallert, & Provost, 2010	USA, N=24* Biochemistry	Conduct experiments, write research papers	Development of research skills, self-efficacy in research, intrinsic	Quantitative 2 semesters	Positive Students enhanced skills, motivation in science and confidence when

			motivation, attitudes towards research		carrying out research.
10. Knutson, Smith, Nichols, Wallert, & Provost, 2010	USA, N=30* Biochemistry	Search literature, generate hypothesis, design and conduct experiments, analyze and interpret findings, write a research paper	Self-efficacy in research, intrinsic motivation, course appreciation, critical thinking	Quantitative 2 semesters	Positive Students increased confidence, motivation and interest in research. Most students were competent in critical thinking.
11. Gamarra, Ironside, de Vere, Allainguillaume, & Wilkinson, 2010	UK, N=11* Biology	Conduct experiments, analyze and interpret results, present findings	Appreciation of the course, attitudes towards research	Mixed 1 semester	Mixed Students highly appreciated the course but attitudes towards research were weak.
12. Russell & Weaver, 2011	USA, N=800* Chemistry	Design and conduct experiments, analyze data, report findings	Conception of the nature of science	Qualitative 2 years	Neutral No substantial effect on students' conceptions of the nature of science but experimental students showed deeper understanding.
13. Jones, 2011	USA, N=25* Chemistry	Develop and test hypotheses, design and conduct experiments, write a research	Self-efficacy in research, critical thinking in writing	Mixed 10 weeks	Positive Students' confidence in research increased after conducting research

		paper			and writing a manuscript.
14. Makarevitch & Kralich, 2011	USA, N=80* Biology	Design and conduct experiments, write research papers	Learning performance	Qualitative 4 weeks	Positive Experimental students improved their learning performance compared to the traditional students.
15. Caccavo, 2011	USA, N=20* Biology	Search literature, generate hypotheses, write proposals, conduct experiments, analyze and interpret data, present findings	Appreciation of the course, learning performance, development of research skills	Quantitative 1 semester	Positive Most students reported advancement at personal level in the evaluated variables.
16. Peraza et al., 2012	USA, N=1* Engineering	Search literature, design and conduct experiments, write a research paper	Development of research skills, learning performance, interest in research	Qualitative 10 weeks	Positive The student developed research skills and pursued postgraduate studies.
17. Robson & Morgan, 2012	USA, N/A* Engineering	write a research paper, communicate results	Learning performance	Mixed 1 semester	Positive Students were competent to write a research paper and developed a business model.
18. Buckley et al., 2013	USA, N=53* Engineering	Design and conduct experiments, report findings	Learning performance, appreciation of the course	Mixed 1 semester	Positive Students' achieved higher grades. They managed to connect theory and practice.

19. Tomasik, Cottone, Heethuis, & Mueller, 2013	USA, N=640* Chemistry	Conduct experiments, analyze and interpret findings	Appreciation of the course, learning performance, interest in research	Mixed 3 years	Mixed Experimental students did not achieve higher grades compared to control but they found the RBL lab more stimulating.
20. Miller, Hamel, Holmes, Helmey-Hartman, & Lopatto, 2013)	USA, N=25* Chemistry, Biology	Search literature, conduct experiments, analyze data, write a research paper	Learning performance	Mixed 15 weeks	Positive Students reported learning improvements and increased understanding of science and research processes.
21. Chase, Pakhira, & Stains, 2013	USA, N=271* Chemistry	Analyze data, communicate results	Appreciation of the course, self-efficacy, learning performance	Quantitative 2 semesters	Neutral No significant impact between the experimental and control groups but, they showed positive attitudes.
22. Ribes-Zamora, Amin, Simmons-Nout, Larios-Sanz, & Rosell, 2013	USA, N/A* Biology	Generate hypothesis, conduct experiments, communicate findings	Understanding of science, learning performance, appreciation of the course	Quantitative 1 semester	Positive Students improved their conception of science and gained subject knowledge.
23. Giacaman & Sinnen, 2014	Australia, N=60* Engineering	Write research reports, give oral presentations	Appreciation of the course, interest in research	Quantitative 12 weeks	Positive About 95% students appreciated the course methodology and integrated

					research in their learning.
24. Sharma et al., 2014	Australia, N=439* Physics	Write research proposals, design and conduct experiments, analyze and interpret results, present findings	Development of research skills, appreciation of the course, perceptions of teachers	Mixed 9 weeks	Mixed About 80% students were positive about the course and research skills development. Feedback about teaching staff was negative.
25. Wemhoff, 2014)	USA, N/A*** Engineering	Write a research proposal	Interest in research	Quantitative 1 semester	Mixed Students showed high interest in subject-related research but due to the complexity of the course, it decreased.
26. Tomasik, Lecaptain, et al., 2014	USA, N=36* Chemistry	Conduct experiments, analyze and interpret results, write reports	Attitudes towards the subject, appreciation of the course, learning performance	Mixed 3 semesters	Mixed Experimental students improved perceptions and attitudes towards the subject. No effects on learning performance.
27. Wiley & Stover, 2014	USA, N=95* Biology	Conduct experiments, write research papers	Motivation in science, communication skills, attitudes towards research	Mixed 5 years	Positive Beyond 80% students were positive towards science and motivation to do research.
28. Dopico, Linde, & Garcia-	Spain & Brazil, N=55* Biology	Search literature, design and conduct experiments,	Learning performance, development of research	Quantitative 1 semester	Positive Students self-assessed their

Vazquez, 2014		analyze data, communicate results	skills		research skills as competent. Learning performance was satisfactory.
29. Rojo, Elias, Corcuera, & Eceisa, 2014	Spain, N=15* Engineering	Search literature, design and conduct experiments, analyze data, communicate results	Learning performance	Quantitative 1 semester	Positive Students succeeded in both the conceptual tasks and laboratory work.
30. Blume et al., 2015	Germany, N/A** Engineering	Formulate questions, search literature, conduct experiments, analyze and interpret results, present findings	Appreciation of the course, learning performance	Mixed 1 semester	Positive Students improved exam grades compared to previous semesters. Responses to the course set-up was positive.
31. Gray et al., 2015	USA, N=128* Biochemistry	Conduct experiments, analyze data, communicate findings	Learning performance, development of research skills, appreciation of the course, self-efficacy in research	Quantitative 1 year	Positive Students' grades improved. The course was rated as beneficial. 75% students increased research confidence.
33. Ma, 2015)	China, B=300** Chemistry	Search literature, identify a problem, formulate hypotheses, report findings	Development of research skills, learning performance	Quantitative 1 semester	Positive Students' enhanced skills related to generating hypotheses. Achievement was satisfactory.

34. Scott et al., 2015)	USA, N=38* Chemistry	Generate hypotheses, conduct experiments, analyze data	Development of research skills, motivation to do research, appreciation of the course, learning performance	Qualitative 1 semester	Positive Experimental students reported more skills development, learning increases and motivation compared to control.
35. Gao, 2015	USA, N=14* Chemistry	Search literature, identify a problem, design experiment, conduct experiments, analyze data, communicate results	Development of research skills, learning performance	Quantitative 1 semester	Mixed Students' scores were good in the research paper but still needed improvement.
36. Winkelmann et al., 2015	USA, N=500* Chemistry	Generate hypothesis, design and conduct experiments, analyze results	Self-efficacy to do research, attitudes towards research, learning performance	Quantitative 3 semesters	Mixed Students' performance and research self-efficacy improved. No enhancement of students' attitudes towards research.
37. Iyer, Smith, Kudrle, & Leon, 2015)	USA, N=199* Biotechnology, Environmental Sciences	Conduct experiments, analyze data, write a research paper	Development of research skills, learning performance, appreciation of the course	Mixed 7 semesters	Positive Students gained research abilities and subject content. Most students found the course helpful.
38. Christe, Wisner, Bhatt, & Kontsos, 2016	USA, N=14* STEM unspecified	Search literature, conduct experiments, communicate results	Development of research skills, interest in research, perceptions of teachers	Quantitative 10 weeks	Positive Students' scientific writing, willingness to pursue research and

					perceptions of mentors were positive.
39. Vernon, Goldberg, & Wolfe, 2016)	USA, N=1215* Biology, Chemistry	Conduct experiments, analyze data, write a research paper, give oral presentations	Interest in the subject, self-efficacy in research	Mixed 1 semester	Positive Experimental students showed greater confidence in research and interest in the course compared to control condition.
40. Streu, Reif, Neiles, Schech, & Mertz, 2016	USA, N=47* Biochemistry	Identify a research problem, conduct research, write a research paper	Development of research skills, self-efficacy, learning performance, appreciation of the course	Quantitative 1 semester	Mixed Students' learning, research skills and confidence improved but they lacked research training.
41. Dadach, 2016	United Arab Emirates, N/A* Chemical Engineering	Conduct experiments, interpret results, write reports	Development of research skills, appreciation of the course	Quantitative 1 semester	Positive Students' showed willingness and motivation to conduct experiments in the lab.
42. A. Fuller, 2016	USA, N=30* Chemistry	Conduct experiments, analyze and interpret results	Development of research skills, learning performance, self-efficacy	Mixed 5 weeks	Positive Students improved learning performance, research skills and confidence to do research.
43. Al-Maktoumi, Al-Ismaily, &	Oman, N=26* Agricultural Engineering	Generate research questions, design experiments, analyze and interpret findings, write	Development of research skills, learning performance, appreciation	Quantitative 3 months	Positive Students' gained knowledge and research competences. The course

Kacimov, 2016		reports	of the course		was beneficial.
44. Balint, 2016	United Arab Emirates, N/A*, Engineering	Search literature, communicate results	Development of research skills, learning performance	Quantitative 1 semester	Positive Students improved abilities to search for scientific information, synthesize and write a paper.
45. Lefurgy & Mundorff, 2017	USA, N=12* Biochemistry	Search literature, conduct research, communicate results	Development of research skills, learning performance, appreciation of the course	Quantitative 13 weeks	Positive Students provided positive course feedback, learning outcomes and possibilities for future publication.
46. Firdaus & Darmadi, 2017	USA, N=18* Biology	Write a research proposal, conduct research, analyze data, write a research paper	Attitudes towards research	Quantitative 14 weeks	Mixed RBL helped to frame students' attitudes towards science but it was not evident in all learning phases.
47. Baiduc et al., 2017	USA, N=375*. Engineering, Science	Generate research questions, search literature, design and conduct experiments, analyze data	Development of research skills, interest in research, students' retention	Mixed 3 years	Mixed Experiment students were highly involved in research activities compared to control. No effect on research interest and students' retention.

*undergraduate **graduate *** both

3.5. Stage 5: Collating, summarizing and reporting results

During this final stage, we synthesized the analytical picture emerging from the results in table 3.

IV. Results

Reviewed studies were set up in 10 different countries: United States (37), Australia (2), United Kingdom (1), United Arab Emirates (2), and Spain (1). Additionally, single studies from Germany, China, Oman and Brazil in collaboration with Spain are reported.

In 47 articles, most RBL implementations were carried out in Engineering programs (15). Chemistry (14) and Biology (12) courses were also predominant. Some practices were developed in Biochemistry (7) courses followed by unspecified Science programs (5) Physics, (1) Biotechnology (1) and general STEM contexts (1).

Forty-four out of forty-seven studies reported RBL practices in undergraduate courses, followed by graduate (2) and in both (1).

In terms of sample size, 30 studies involved 1 to 95 students, followed by 7 studies involving 128 to 500 and 3 studies ranging from 600 to 1215 students. In seven studies numbers were unspecified.

Regarding research methodologies, mostly a quantitative approach (25) was adopted, followed by mixed (17) and qualitative (5) designs.

In relation to the amount of time spent in the RBL experiment, most studies built on 1 semester (19), followed by 1 to 15 weeks (14), 2 to 7 semesters (6), 1 to 3 years (7) and longer (1).

4.1. What research competences are intended to be developed in the Engineering and Science students?

Table 4 displays students' the number of studies pursuing specific research phases. Studies were counted more than once when emphasizing multiple phases; the sum therefore exceeds the number of studies.

Table 4. Specification of research skills within the research cycle phases in the reviewed studies

Research cycle phase	Research competence	Number of studies
Identify a knowledge gap	Identify a research problem	4
Define questions and objectives	Write a research proposal	4
Search literature	Search for scientific literature	17
Generate hypothesis or research questions	Formulate hypothesis or research questions	11
Select research methods	Design research methodology	14
Conduct research	Conduct experiments, collect data	36
Analyze data and interpret findings	Analyze data, interpret research findings	25
Communicate or implement findings	Report findings through papers, reports, posters, research models	37

Results reflect a strong emphasis on nearly all research competences/phases in a research cycle; thus guaranteeing the potential development of key academic competences (Symons, Colgoni, & Harvey, 2017). One could also conclude with other authors that RBL can help installing research experiences in engineering and science students to develop their research capabilities (Winkelmann et al., 2015; Stout, 2015; Walkington, 2015).The degree of coverage is in line with the observations of Mullan, Weston, Rich, & McLennan (2014). As illustrated in table 4, key research competences are pursued in relation to “conducting research, analyzing and interpreting results and communicating and implementing findings”. The results also reflect an imbalanced development of other research competences in the research cycle. But this can be justified by the fact that attaining research competences does not progress in a linear way. For instance, students could generate research questions without pursuing a search for answers or gather information regardless of outlining specific questions (Walkington et al., 2011).

4.2. Building on Brew's framework, what is the nature of the RBL implementations described in reviewed studies?

Table 5. Studies sorted according to Brew's model to qualify the nature of RBL; numbers in italics refer to studies set up after 2012

Knowledge

Fixed by teacher	-	Not fixed, negotiable	Unspecified,
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 17, *18, 19, 20, 21, 22, 23, 24, 2, 27,6 27, 28, 29, 30, 31, 32, 33, 34, 35, 40, 41, 42, 43, 45*		13, 15, *36, 38, 39, 44*	*37, 46, 47*

Topic

Decided by teacher	Negotiated	Decided by student	Unspecified
1, 4, 5, 7, 8, 9, 11, 12, 14 , 16, 17, *19, 20, 21, 22, 23, 25, 26, 27, 29, 30, 31, 32, 33, 34, 37, 40, 41*	2, 6, 10, *24, 28, 36, 39, 43, 47*	3, 13, 15, *35, 38, 42, 44, 45*	*46*

Question

Chosen by teacher	Negotiated	Chosen by student	Unspecified
1, 4, 5, 9, 12, *20, 23, 26, 41*	10, 14, 16, *27, 28, 30, 31, 32, 37, 39, 47*	2, 3, 6, 8, 13, 15, 17, *18, 19, 22, 24, 25, 29, 33, 34, 35, 36, 38, 40, 42, 43, 44, 45, 46*	7, *21*

Task

Structured by teacher	Negotiated	Unstructured	Unspecified
1, 2, 3, 5, *20, 21, 23, 25, 26, 27*	4, 7, 8, 9, 11, 12, 14, 15, 16, *19, 24, 28, 29,*	6, 10, 13, 17, *18, 19, 22, 32, 34, 35, 36, 38, 40, 41, 42, 43, 45, 46*	

30, 31, 33, 37, 39, 44, 47

Inquiry

Close-ended	-	Open-ended	Unspecified
1, 2, 4, 5, 9, 11, 13, 16, *21, 26, 28, 31, 33, 34, 40, 41, 44*		6, 8, 10, 14, 15, 17, *18, 19, 22, 24, 29, 30, 32, 35, 36, 37, 38, 39, 42, 45*	3, 7, 12, *20, 23, 25, 27, 43, 46, 47*

Audience and Output

Fixed by teacher	Negotiated	Fixed by student	Unspecified
1, 2, 3, 4, 6, 7, 8, 9, 10, *18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 31, 34, 35, 36, 40, 41, 42, 44, 45, 46*	5, 13, 17, *43*	11, 15, 16, *30, 37, 38, 39*	12, 14, *21, 32, 33, 47*

Assessment

Controlled by teacher	Negotiated	Controlled by student	Unspecified
1, 2, 3, 4, 6, 7, 8, 9, 10, 12, 13, 14, 15, *18, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 33, 34, 35, 36, 37, 38, 40, 42, 45*			5, 11, 16, 17, *20, 32, 39, 41, 43, 44, 46, 47*

Knowledge

New to the student	-	New to discipline and society	Unspecified
1, 2, 4, 6, 7, 9, 10, 12, 14, 15, 16, *18, 19, 20, 22, 24, 25, 27, 29, 31, 32, 33, 34, 35, 41, 42, 43, 44, 47*		5, 8, 13, 17, *23, 28, 30, 36, 37, 38, 39, 45*	3, 11, *21, 26, 40, 46*

Following Brew's model (2013), we structure our findings in relation to the eight key decisions made when implementing RBL: decisions concerning initial knowledge, selecting a topic, generating research questions, carrying out research tasks, deciding on the type of inquiry, audience and output, assessment and knowledge by the end of the instruction. Table 5 displays each section focusing on decisions made either by the teacher or student, negotiated between them or not specified in the specific study. The overview list studies in chronological order helping to develop a timeline in the research emphasis in studies since 2012.

In 38 out of 47 studies, decisions regarding initial knowledge were made by the teacher. This is consistent with authors supporting that guidance is key when introducing learners to new or difficult inquiry activities (Chen, Kalyuga, & Sweller, 2015; Lehtinen & Viiri, 2017).

Interestingly, findings about the selection of research topics display a slight increase in the number of decisions made by students and negotiated between teacher and student. This is observable in studies since 2013. This suggests growing trust in students' autonomy in doing research (Willison & O'Regan, 2012) while they move from structured guidelines; for instance a list of research questions provided by the teacher (E. Peraza et al., 2012) or pre-determined tasks, to generating their own questions based on their discipline, literature or stage in the learning process (Gao, 2015).

In the table, open-inquiry dominates close-inquiry. There seems a tendency to move towards open-inquiry; this might be linked to stages in students' mastery of the subject contents (Makarevitch & Kralich, 2011) to involve them more effectively in research (Wheeler & Bell, 2012). This is in line with authors suggesting that open-inquiry should be encouraged when conditions have been fulfilled, as it boosts students' inquisitiveness and interest in science (Zion & Mendelovici, 2012) as well as it helps connecting the teaching content to research activities (Spronken-Smith & Walker, 2010).

Decision about the audience, output, assessment and knowledge acquired in a course, seem mostly being made by teachers. This can be explained by the involvement of novice students who still need to develop related competences (Feldman, Divoll, & Rogan-Klyve, 2013) and are to be guided in dealing successfully with research (Levy & Petrulis, 2012).

The fact that decisions about knowledge are also divided between teachers, students or negotiated might suggest that teacher might link research activities to knowledge being acquired and developed by students as contributions to the research field (Willison & O'Regan, 2012).

4.3. What are the reported benefits of adopting RBL in the Engineering and Science programs/courses listed in this review?

Positive outcomes from implementing RBL are reported in 38 out of 47 studies. Top benefits are discussed below.

Firstly, 24 out of 47 studies emphasize the development of research skills at various stages of the research cycle (Robson & Morgan, 2012; Blume et al., 2015; Lefurgy & Mundorff, 2017; Christe et al., 2016). Assumptions from Knutson, Smith, Nichols, et al., (2010) and Follmer et al. (2016) seem well-grounded when they state that research-based work is beneficial to involve students with different backgrounds and motivational levels and develop research competences.

Higher learning performance is emphasized in 25 out of 47 studies (Knutson, Smith, Wallert, et al., 2010; Makarevitch & Kralich, 2011; Peraza et al., 2012). This is consistent with literature underlining the impact of RBL on students' development of knowledge and skills (Myers & Burgess, 2003; better acquisition of subject-related concepts (Tomasik, Lecaptain, et al., 2014); Howard & Miskowski, 2005; Treacy et al., 2011; Ifenthaler & Gosper, 2014; Wannapiroon, 2014; Blume et al., 2015; Kortz & Kraft, 2016), compared to a traditional teaching approach (Russell & Weaver, 2011). Research activities seem to foster a deeper processing of knowledge content that is immediately linked to a broader set of concepts and procedures in memory. This explains why Pu, Huang, & Wenjia (2014) state that a research-based curriculum allows students to experience their actual knowledge construction process.

A larger appreciation of the course as an outcome of RBL is reported in 18 out 47 studies (Knutson, Smith, Wallert, & Provost, 2010; Iyer, Smith, Kudrle, & Leon, 2015; Al-Maktoumi et al., 2016; Tomasik, Cottone, Heethuis, & Mueller, 2013). Related literature helps explaining this finding. Studies report an increase in students' positive perceptions of research classes (Keltie, 2015), a growing interest in the subject (Giacaman & Sinnen, 2014; Tungkasamit & Junpeng, 2012), and opportunities to apply knowledge to real-world problems (Makarevitch & Kralich, 2011).

Interest in research is underlined in 8 out of 47 studies (Buckner et al., 2007; Parra, Osgood, & Pappas, 2010; Peraza et al., 2012). Research experiences appear to

increase students' excitement about science (Kerr & Yan, 2016) as they realize the significance of research. They tend to continue being research practitioners and seek staying immersed in a scientific community (Shaw & Kennepohl, 2013; McCarthy, 2015). Students who advance their research competences seem developing a research spirit (C Terkowsky, May, Haertel, & Pleul, 2012) and are more likely to pursue postgraduate studies (Eagan et al., 2013) in highly-ranked academic institutions (Buckner et al., 2007).

Also, enhanced research self-efficacy was reported in 10 out of 47 studies (Jones, 2011; Chase et al., 2013; Gray et al., 2015**;** Winkelmann et al., 2015; Streu et al., 2016)**.** It seems being boosted by modelling of real-life scientific processes (Gao, 2015). The actual involvement seems to grow students' research confidence (Daniels et al., 2016). This is consistent with Carpi, Ronan, Falconer, & Lents (2017) who explain that self-efficacy in research is achieved through repetitive, consecutive and progressive practice at different research stages.

In a less outspoken way, other benefits have been reported: intrinsic motivation in science (5), positive attitudes towards research (4) and critical thinking (3).

4.4. What are the reported challenges of adopting RBL in the Engineering and Science programs/courses listed in this review?

Few studies reported mixed (13) and neutral (2) results. The main reported challenges are reported below.

Low RBL impact on learning performance was reported in 4 out of 47 studies (Tomasik et al., 2013; Chase, Pakhira, & Stains, 2013; Tomasik et al., 2014). In these studies, no significant differences between experimental and control groups could be observed. However, in most cases, additional qualitative survey results suggest higher achievement in experimental students (Chase et al., 2013), stronger positive views and appreciation of opportunities to learn as researchers (Tomasik, Lecaptain, et al., 2014).

Decreased interest in research and low course appreciation were found in 3 out of 47 studies (Baiduc et al., 2017; Streu et al., 2016; Wemhoff, 2014; Winkelmann et al., 2015).

Related students reported that research-based projects were too demanding in relation to the course content (Carnahan et al., 2000). As stated by Sweller (2011) and Paas, Renkl, & Sweller (2004) learning can be hindered by extraneous cognitive load resulting from instructional activities combining a focus on too many elements at the

same time. The apparently challenging course set-up seems to be unsuccessful with less research-oriented students (Shekar, 2012) who hardly show further interest in research (Wemhoff, 2014).

Besides, insufficient research training and time constraints were stated in 3 out of 47 studies, pointing at a lack of student preparation that causes insecurity (Streu et al., 2016) and feeling rushed to complete research tasks within allocated time (Tomasik et al., 2013). Learners seem being overwhelmed by the amount of data and information that impedes knowledge construction (Sweller, 2011) in a short period of time. Furthermore, insufficient prior knowledge might lead to experiencing a decreased usefulness of instruction (Boula, Morgan, Morrissey, & Shore, 2017).

A single study reported about limited staff availability to implement RBL conceptions (J. M. Buckley et al., 2013).

4.5. Considering the review results, what actions are being suggested to enhance future RBL implementations?

Based on the reported challenges, authors suggest adopting the following remedial actions.

The creation of research courses and implementing more regular assessment were suggested in 5 out of 47 studies to develop students' research competences (Tomasik, LeCaptain, et al., 2014; Chase et al., 2013). Authors stress this should take place early in their studies (Willison, 2012). Follmer et al. (2016) advise that research courses must be coherently organized. Others stress these courses should stress self-learning through research, direct practical experience (Shekar, 2012) and peer-interaction (Cockcroft et al., 2016). For instance, a short summer course might be a channel to introduce undergraduates to research (Bahr, 2009). Also, lab practice projects are seen as ways to initiate students in empirical research while incorporating underlying content knowledge (Dopico et al., 2014). The link between specific research activities and the process of acquiring subject domain knowledge is stressed by different authors (Buckner et al. 2007; Healey, Jordan, Pell, & Short, 2010).

Considering that implementing RBL is demanding (Shaw & Kennepohl, 2013) and could increase workload for teachers, Buckley & Higginson (2013) suggest academics set up RBL in close cooperation with actual research teams.

To measure RBL impact, continuous assessment is stressed to monitor students' research competences improvement, their scientific production and research interest (Wemhoff, 2014).

Also, more time and a gradual phasing were advised in 3 out of 47 studies (Streu et al., 2016; Symons et al., 2017; Tomasik et al., 2013). Students should first receive dedicated training that builds on a solid scientific foundation (Gamarra et al., 2010). This will help accomplishing lab work in a timely manner (Streu et al., 2016).

Besides, students should get enough time to iterate experimental practices to emulate actual scientific work (Vernon et al.,2016); otherwise they may not attain a relevant mastery level (Feldman et al., 2013). This explains why students involved in short research experiences hardly reflect significant changes (Bahr, 2009). In fact, benefits and abilities are only attained when students devote longer periods of time to research (Zydney et al., 2002; Tomasik et al., 2014).

Avoiding complexity, but fostering authentic research were proposed in 2 out of 47 studies (Vernon et al., 2016). This might prove difficult to achieve when work is linked to real life labs exclusively (Gray et al., 2015). But it is also risky to engage in activities that are too far from legitimate research endeavors. This presents a major challenge to simulate a realistic research environment in the classroom (Fraser, 2008). Teachers should address genuine researchable problems (Dopico et al., 2014) as students' best capabilities seem to emerge when involved in authentic research (Howitt et al., 2010).

Regarding complex research designs, Dadach (2016) advocates that also less complicated lab experimentation can help novice undergraduates to connect theories and research applications. Activities should be manageable and not too complicated; otherwise, students' interest in pursuing research might be waning (Wemhoff, 2014).

V. Limitations

There are some limitations in the present work. Firstly, many research reports lack clarity in their description of information needed to answer the above research questions. In some cases, key information was only explained briefly or not present; thus affecting the development of a comprehensive picture of the RBL experience reported about. Secondly, some research articles could not be consulted to restricted access. The limited information provided in accessible abstracts, was insufficient to include related studies in the analysis. Finally, this scoping review focused on particular research question that were derived from a specific RB: framework. Other analysis

frameworks could help identifying other information and perspectives about the nature of RBL and its actual implementation.

VI. Conclusions

This literature review helped mapping the nature of research about RBL in Engineering and Science education programs from 2000 to 2017. The majority of studies report positive outcomes of RBL. Implementations reflect a rich variety of research activities when linked to a research cycle. Next to benefits, also challenges were reported when implementing RBL. This helped to define concrete actions to improve future RBL implementations.

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Chapter 3

Impact of a Research Based Learning redesign of an engineering course on students' intention to do research

This chapter is based on:

Camacho, M. H., Valcke, M., & Chiluiza Garcia, K. (2017). The effect of Research based learning activities' on students' intention to do research in graduate courses. In *9th International Conference on Education and New Learning Technologies, EDULEARN17* (pp. 6571-6579). International Academy of Technology, Education and Development (IATED).

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Chapter 3

Impact of a "Research Based Learning" redesign of an engineering course on students' intention to do research

Abstract

Nowadays, universities have a pronounced interest in linking teaching and research. To foster this linkage, Research-Based Learning (RBL) helps redesigning curricula as such that students are actively involved in the research process. This is in contrast to thetraditional product focus towards teaching and research. We hypothesize that students involved in RBL, will develop a higher intention to do research. Next, we consider changes in autonomous motivation, perceived behavioral control (self-efficacy), behavioral beliefs and subjective norm. Age, gender and the specific course context were considered as covariables.

A quasi-experimental pretest-posttest design was set up involving 52 engineering students in a public Ecuadorian university course. Research instruments built on Bandura's guidelines to determine self-efficacy, Ajzen's Theory of Planned Behavior to explain the intention to do research along with behavioral beliefs and subjective norm; and Deci and Ryan's Intrinsic Motivation Inventory to determine autonomous motivation. A six-week RBL intervention was designed, involving students in research whereas students in the control condition simply read the research articles.

Results show RBL students attain higher levels of intention to do research. However, these differences are yet not significant. Though also positive trends are observed, changes in the other variables did not interact in a significant way.

The results look promising, but research limitations have to be consider. Moreover, RBL invoked an innovative way of thinking about the teaching-research nexus. From a single course focus , a focus at program level is being adopted as an avenue for future research.

I. Introduction

At university level, teaching and learning are often linked to research. This relationship is often regarded as the core of university education (Boyd et al., 2011). Research about the teaching-research nexus (TRN) has increased during recent decades with a focus on the quality and outcomes of TRN in both students and academics (Malcolm, 2013). Recent studies centre on a stronger process level involvement of students in research. This redesign is often labelled as Research Based Learning (Galeano & Morales-Menendez, 2012).

As to the expected outcomes of RBL, authors point at student's willingness or intentions to do research in which the role of students shifts from that of a passive learner towards an active one who can produce research ideas or results (R. Griffiths & Griffiths, 2004), a deeper understanding of the nature of science, higher self-efficacy as well as developed inquiry skills and content awareness (Winkelmann et al., 2015), a stronger orientation to become a researcher by participating in research and inquiry so that students are producers not only consumers of knowledge (Healey & Jenkins, 2009) and a research grounded involvement in the teaching content (Jenkins & Healey, 2010). Research also points at critical student variables mediating the impact of RBL. In this context, we can build on the Theory of Planned Behaviour (Ajzen, 1985a), stressing three types of precursors of intentions to carry out research: (a) Perceived Behavioural Control (PBC) often labelled or measured through Self-Efficacy (SE) or other internal control factors, (b) Behavioural Beliefs (BB) and (c) Subjective Norm (SN). Other authors add to these precursors the following mediating variables; motivation (Deci & Ryan, 2000) and engagement (Quaye & Harper, 2015).

Research stresses – in addition – the role of individual background variables, such as gender (Lin & Chen, 2013), demographics (Moss-Racusin et al., 2012), age (Jung & Ejermo, 2014) and educational program influencing the nature of the research experience (Brew, 2013).

There is a lack of evaluative research in RBL. The present study tries to fill this gap. After presenting the conceptual and theoretical base for the study, we outline its design. A discussion of the results leads to defining implications, addressing limitations and developing directions for future research.

II. Conceptual and theoretical base

Linking teaching and research is central to the Humboldt definition of a research-oriented university (Sam & van der Sijde, 2014). This implies academic level teaching and learning provides concrete opportunities for research (Söderlind & Magnell, 2015). Different frameworks help to model teaching-research nexus. An influential model was developed by Healey (2005) (see figure 1).

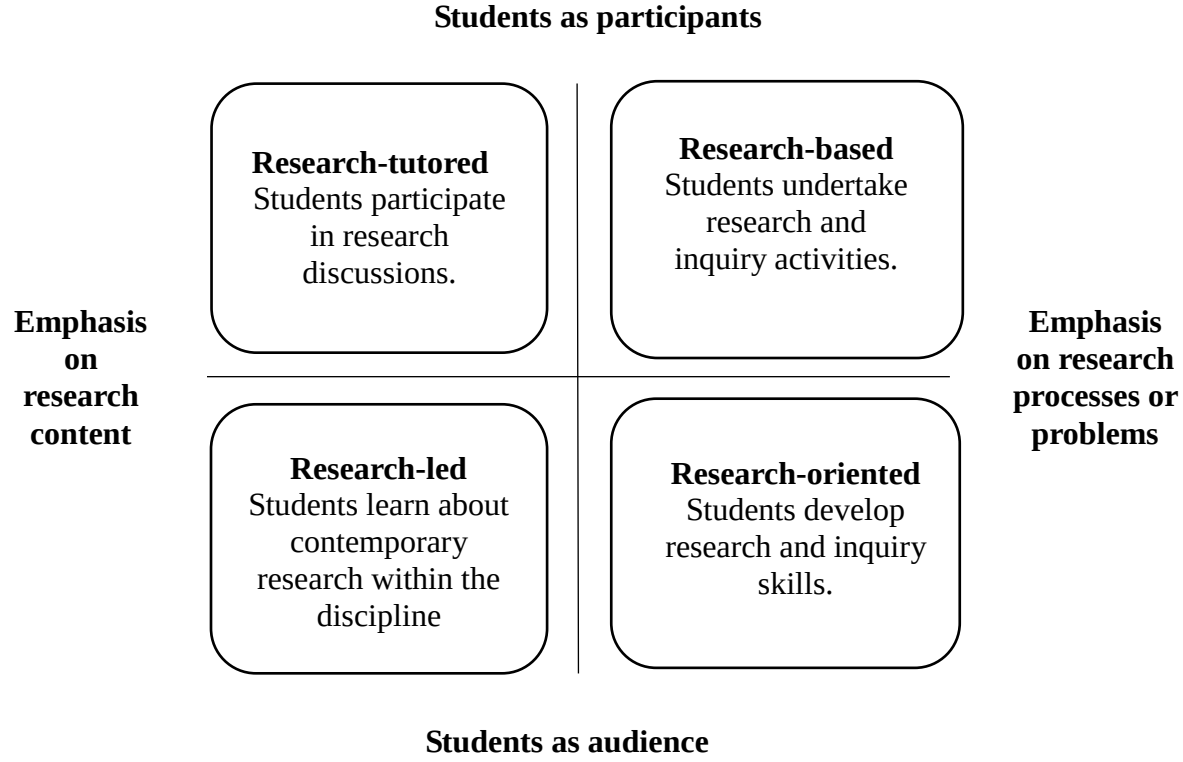

Figure 1. TRN framework opposing two dimensions (based on Healey, 2005a, p.70)

In this framework, either the teacher or the student is at the centre of the process; or there is a focus on the outcomes of research or a focus on the research process. Combining both axes results in four quadrants, presenting distinctive approaches towards the TRN. The traditional approach is found in the lower left; labelled as teaching "about" research. More engaging is the upper left when students are involved with research outcomes by reading articles, reviewing them, developing reviews, etc. The two approaches at the right hand side emphasize an involvement in doing research, working with research tools, developing or using instruments, designing and following research protocols, etc. (Healey, 2005a). In the current study, we focus on the approach in the upper right corner: students are engaged in different steps/phases of the research cycle. Brew (2013) labels this as Research Based Learning (RBL). RBL builds on inquiry and implies observation processes, making questions, examining

sources of information, checking existing information and trying to find gaps, collecting and analysing data and interpreting and communicating results (Maaß & Artigue, 2013). These activities build on the research cycle as reflected in e.g., the Research Skill Development Framework (J. Willison, Sabir, & Thomas, 2016) and Kolb's Learning Cycle as synchronized with Jungmann's Research Cycle (Ossenberg & Jungmann, 2013).

Potential outcomes of RBL-based courses or programs can be different. Most authors stress increases in research related knowledge, skills and attitudes (Pu et al., 2014). Others stress the acquisition of research planning skills (Brew, 2013), develop of research questions and design of experiments (Claudius Terkowsky, May, Haertel, & Pleul, 2012), or students willingness to pursue future involvement in research (Zhu & Singh, 2012). However, there is a lack of empirical evidence about the impact of RBLto ground the above assumptions. The current study responds to this lack of empirical research.

We centre on the variable "Intention to do research" as the expected RBL outcome. It is defined as developing an interest in research, usually perceived in terms of career choices (Guerin & Ranasinghe, 2010a). We build on the Theory of Planned Behaviour (TPB) that helps defining precursors of "intentions to do research" (Ajzen, 1991). The theoretical linkage between TPB and RBL is hardly present in the scarce empirical RBL-research. The TPB puts forward three precursors:

- Behavioural beliefs (BB) push people's intentions and actions. They refer to "beliefs about the likely consequences of the behaviour, some positive and others negative" (Ajzen, 2011, p. 1117). It refers to what students think they will get as benefit from the involvement in research activities.
- Subjective Norm (SN) refers to the "the perceived social pressure to perform or not to perform the behavior" in question (Ajzen, 1991, p. 188). These norms point at what students consider about what others think about being involved in research.
- Perceived Behavioural Control (PBC) refers to people's perceptions about the extent to which they are able to perform a specific behaviour or its controllability. Based on Ajzen (2002), we can distinguish between self-efficacy (SE) as to the perception of being able to carry out research and the extent to which carrying out research is up to the student.

Authors point at the importance of mediating variables during RBL; such as motivation

(Healey & Jenkins, 2009b; Klauser & Schlicht, 2012; Schlicht & Klauser, 2014) and student engagement (Henrie, Halverson, & Graham, 2015).

In the context of the current study, we build on the Self Determination Theory of Deci & Ryan (2000) to operationalize the concept of autonomous motivation. RBL will have an impact when it supports the three Basic Psychological Needs (BPN) of Autonomy, Belonging/Relatedness and Competence (Wood, 2016).

As stated by Jang, Kim, & Reeve (2016), perceived autonomy processes, support and need satisfaction reiterate the importance of motivation already discussed above. Educators should therefore push student autonomy by providing individual responsibilities, academic tasks, setting up a stimulating class environment and other external factors (S. Saeed & Zyngier, 2012).

Next, we consider student variables: gender, age and study context though the literature is rather scarce as to empirical evidence pointing at potential interactions of these variables with the outcomes of RBL.

The above conceptual and theoretical base helps developing the following theoretical model (see Fig. 2). The figure emphasizes how the differential impact of RBL might interact with changes in critical variables and how student background variables might interact with expected changes.

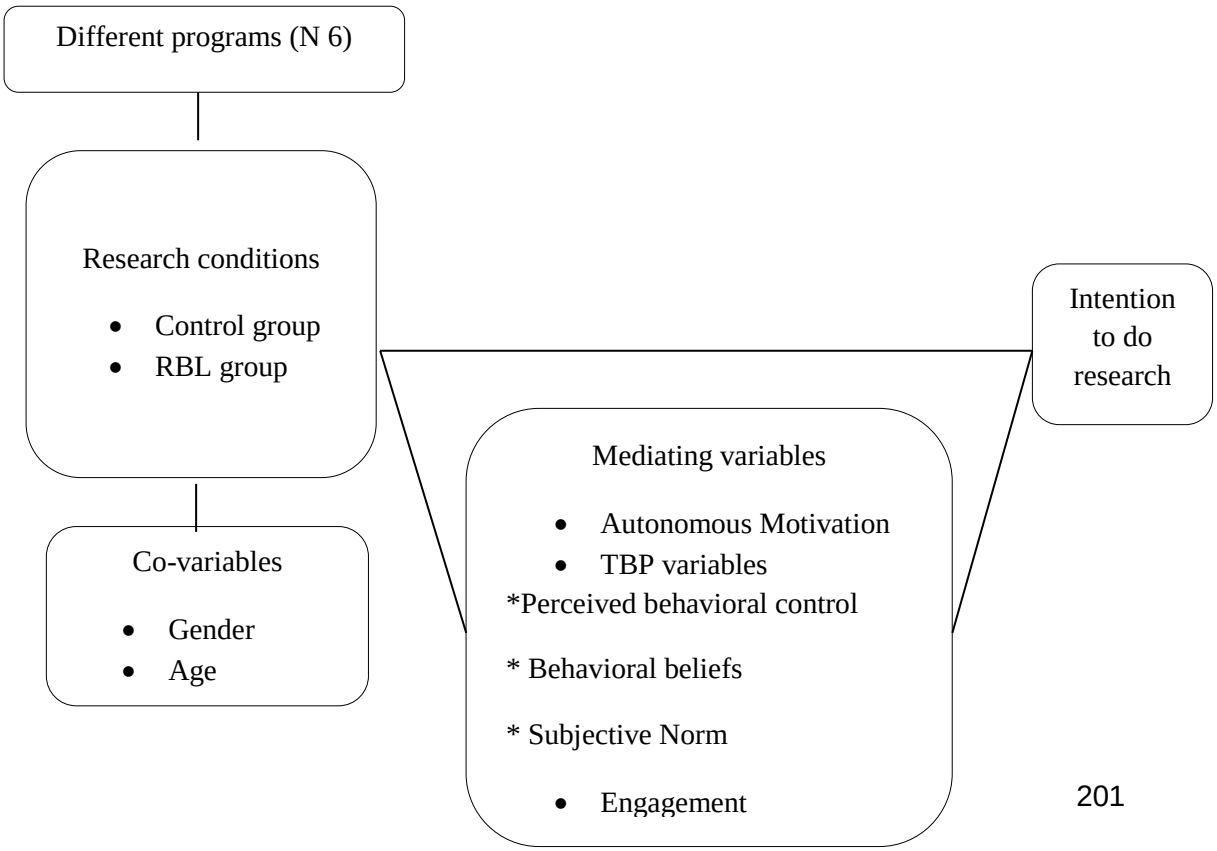

Figure 2. RBL intervention design considering mediating variables and co-variables.

III. Research Design

A quasi-experimental pre-test – post-test design was set up studying the differential impact of an RBL and non-RBL version of the same course.

3.1. Hypotheses

H1: *Students involved in the RBL version of a course will reflect a higher intention to do research as compared to students involved in the control condition version of the same course.*

H2: *Students involved in the RBL version of a course will reflect a higher intention to do research as compared to students involved in the control condition version of the same course, considering the different course contexts, the changes in autonomous motivation, perceived behavioural control, behavioural beliefs and subjective norms and the interaction with co-variables (age and gender).*

3.2. Sample

Graduate engineering students (N 59), of a level A Ecuadorian University, were involved. Student numbers in graduate programmes are small. Students of 6 programmes, taking the same course were selected. A sub-sample of students was randomly assigned to the control or the experimental RBL condition. Potential differences due to differences in programmes were controlled.

Informed consent was obtained from all students. The study was approved by the educational authorities of the university. Table 1 summarizes key background characteristics of the students in the research conditions in terms of program, age and gender. Due to individual circumstances, 7 students dropped out of the study, resulting in full data set from 52 students.

Table 1.

Student characteristics (N 52, M and SD)

	Control Group			RBL Group		
Program	Age	Male	Female	Age	Male	Female
1	28.44(3.047)	5	2	29.91(3.780)	7	4
2	28.67(0.577)	0	3	34.00(3.559)	2	2
4	31.75(9.605)	2	2	35.00(5.020)	4	2
5	30.75(4.992)	3	1	31.25(2.630)	2	2
6	35.50(0.707)	2	0	33.00(2.828)	1	1
7	28.00(2.828)	2	0	33.67(1.528)	3	0

M (SD) = Mean (Standard deviation)

3.3 Research Instruments

Research instruments were piloted in a study prior to the RBL intervention, involving students not included in the present study. English language versions of the research instruments have been added in appendix A of the article.

Prior to the intervention, students were presented with a background questionnaire.

The Theory of Planned Behaviour (TPB) helped the development of most other scales.

The *Intentions to do Research* scale was designed on the base of TPB guidelines (Ajzen, 1985a). Each of the 10 items reflects a phase in the research cycle for engineers; example item: *"Being involved in research would enable me to discover requirements and gaps in knowledge".* The scale (INT) reflects a high reliability (pretest α= 0.820).

To determine Perceived Behavioural Control (PBC), we developed a Self-Efficacy scale on the base of Bandura's guidelines (2006). The 27-items in this SE-scale asked students to indicate their degree of confidence – on a scale from 0 to 100 - to carry out specific research activities. Example item: "*Rate your degree of confidence to generate preliminary research questions or problems*". The SE scale reflects high reliability (α= 0.933).

To measure Subjective Norm (SN), the TPB guidelines were applied of Ajzen (1985, 1991)This resulted in a 10-item scale (5-point Likert scale); example item: *"Experienced researchers think I must select appropriate research methods and justify them".* The SN scale reflects high reliability (α= 0.846). The change between post and pre-test in SN is considered in the analyses.

To determine Behavioural Beliefs (BB), again (Ajzen, 1991) was adopted to develop a 10-item scale (5-point Likert scale); example item: *"Having research skills such as analyzing data and interpreting research findings would be important"*. It reflects high reliability (α= 0.831).

To determine *Autonomous Motivation* (AM), we adopted seven items from the Intrinsic Motivation Inventory of Deci & Ryan (1982) and three items from the Motivation at Work scale (Gagne et al., 2010). The 10 item AM-scale asked students to indicate on a 7-point Likert scale their agreement with statements; such as *"I enjoy doing research related activities very much"*. The scale reflects high reliability (α= 0.884).

In view of the statistical analyses, the difference between pre- and post-test scores for INT, SN, PBC, BB and AM are used to test the hypotheses.

3.4 Nature of the RBL intervention

Appendix B gives an example of an RBL activity and the alternative for the control group students. An equal amount of time was put forward to tackle each activity version. This implies students in the control condition; though to a much lower extent. They were mainly expected to read the related materials. The fact all students were involved in a kind of research activity is linked to deontological concerns about equal opportunities for all students.

Each week, students were involved in research activities as illustrated in table 2.

Table 2

Steps in the research cycle and related activities for experimental and research groups

Steps	RBL	Control
Problem identification	Identify the research problem and summarize it	Identify information in an article and complete the table
Immersion in theory:	Write citations and	Search information in the

references/citations	references in APA style	literature base of an article
Select and justify research methods	Evaluate and justify the author's research methods	Derive information from the abstract of an article
Select and justify research methods	Select and evaluate own research methods	Extract information from an article
Analyse and interpret research data	Write the discussion of results section	Infer and predict information from an article
Interpret research findings	Write the conclusion of an article	Relate the text to personal and professional experience

Note: The research cycle was adapted from Ossenberg & Jungmann (2013)

IV. Procedure

The study was set up during the first semester of the academic year 2016-2017, starting with a pre-test phase. Next to the background questionnaire, the different scales were administered as described above, following a predefined protocol. Students were present in their regular classroom. Scales were filled out online (Google forms). Administration took between 40-45 minutes.

Next, students in the experimental condition followed the RBL version of the course during the subsequent six weeks. Students in the control condition followed the traditional TRN version of the course. Students turned in tasks through the online learning management system.

After the intervention, all students filled out – during regular class - the online post-test version of the instruments.

4.1 Analysis approach

All analyses were carried out with SPSS® version 20. A significance level of $p < .05$ was put forward. Descriptives, and analysis of covariance (ANCOVA) were applied (research conditions and programs as factors), and with the mediating variables and student variables as covariables. Statistical assumptions were tested (homogeneity of variance, normal distribution) and Bonferroni correction was applied. Effect sizes were calculated to interpret significant results (Cohen's *d*), considering the guidelines of Baguley (2009).

V. Results

The results in table 3 reflect small differences between research conditions. RBL students seem to reflect a higher average INT score. Students in the control group seem to be slightly more engaged.

Table 3

Summary of descriptive results in relation to all research variables (N)

Variables	RBL(n=30)	Control (n=22)
Intention to do Research [a]	0.08 (0.43)	-0.6 (0.51)
Change in AM [b]	0.01 (0.73)	-0.28 (0.75)
Change in PBC [a]	4.79 (8.34)	2.78 (9.14)
Change in BB [a]	-0.02 (0.40)	-0.01 (0.38)
Change in SN [a]	0.11 (0.56)	0.14 (0.65)

M (SD) = Mean (Standard deviation)
[a] maximum score is 5; [b] maximum score is 7

Figure 4 plots the differences in Intention to do Research between the RBL and the control group, but considering the different programs.

Estimated marginal means of differences in Intention to do research

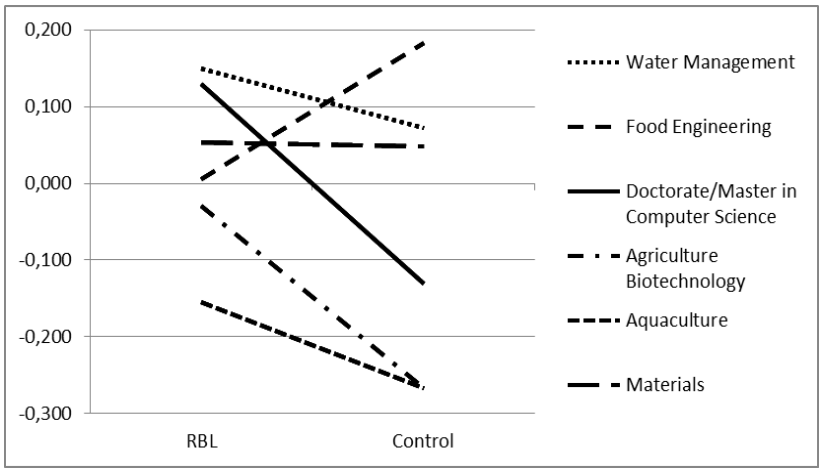

Figure 4. Differences in Intention to do Research considering the nature of the programs.

Hypothesis 1

Though, the descriptives suggest a positive trend in the RBL condition, the analysis of variance analysis results reveal no significant differences in INT ($F_{(1, 50)} = 1.32$, $p = .257$).

Hypothesis 2

Table 4 summarizes the analysis of co-variance results. We again observe a non-significant differential impact of RBL on changes in Intention to do Research ($F_{(5, 33)} = 0.411$, $p = .664$). Also, there seems to be no interaction impact due to changes in study variables.

Table 4

Analysis of covariance results when considering interaction and co-variables next to the potential impact of program differences

	F	***df***	***p***
Condition	0.58	1	0.45
Program	0.98	5	0.44
Condition*program	0.42	5	0.83
Change in PBC [a]	1.05	1	0.31
Change in BB [a]	14.07	1	0.001
Change in SN [a]	3.15	1	0.085
Change in AM [b]	1.64	1	0.209
Gender	0.21	1	0.650
Age	0.11	1	0.74

F= ratio of 2 measures of variance; df=degrees of freedom; p≤0 =statistical significance

[a] maximum score is 5; [b] maximum score is 7

VI. Discussion

The present study tried to fill a gap in the available literature by setting up an empirical study of an RBL intervention. The results reflect a clear trend, and show how students in a research-based learning version of the course attain slightly higher levels of intention to do research. However, these differences are yet not significant. This is not

in line with the findings of Healey (2005) who suggests that students attain most benefits from research when they are actively involved in inquiry-based activities, such as the ones assigned to the experimental participants in the present study.

There are a number of explanations for the non-significant findings. First, students in the control condition were similarly involved in – though basic – research. This might have also boosted in these students a level of intention in doing research. Also the short duration might have limited the possibility for intention to emerge.

An additional explanation might be related to the fact students from 6 different programs were involved. The RBL design had to comply with the broad content focus of all 6 programs and as such students were asked to tackle rather general papers or carry out general activities. This lack of specialisation focus might have invoked lower interest in students. We reiterate in this context Bocchino et al., (2012) that research interest is invoked when research activities are related to students' career. Similarly Hernández (2020) emphasizes that research must be associated to the course contents in order to develop students' intention to participate in research.

Next, we looked at variables that were expected to interact with the positive impact of the RBL experience. This could not be confirmed. First of all, the lack of overall impact on Intention to do Research, makes it less feasible to identify significant differences.

In table 4 we see that Behavioural Beliefs is the only significant result when interacted as a co-variable in the analysis. Looking at table 3, we nevertheless see trends in changes in autonomous motivation, engagement and TPB constructs (BB, PBC, and SN). As to Autonomous Motivation, students in the control condition could also have felt supported in their basic psychological needs by the "new" nature of the research activities presented in the control condition. Though not significant, we repeat – together with other researchers – that these variables should still be considered in future research as they are strong predictors of the intention to perform behaviour (Vincent et al., 2015).

VII. Implications

We consider that the present study is an initial contribution on how to operationalize Research-Based leaning in future practices. It also highlights aspects that researchers must carefully analyse such as involving students from different courses or programs and embedding research tasks within the regular course.

From a practical perspective, the above-mentioned leads us to reflect on the fundamental role of task structure when implementing RBL. Although deontological concerns must be taken care of, it seems to be key that the nature of the control condition is clearly differentiated from the experimental condition. Involving students in a basic or traditional research approach may somewhat awaken their interest for research and thus, develop their intention. As already mentioned, this could in a way, explains the non-significant results.

Additionally, our results underline the need to adapt RBL to specific contexts where class size and study fields are take into account, given that they can lead us to non-significant results.

VIII. Limitations

The above introduced a number of limitations: small sample size; short duration, too small differences between the design of the experimental and control condition. Also, differences between programs - not controlled by the research design – could have played a role; such as research experience of the teachers, teacher beliefs, time frame of a course, and extra course demands beyond control of the research. Also, our study built on quantitative data. This prevents developing a deeper insight into the actual research experience of students.

These limitations present a clear agenda for future RBL related research. Especially the design of the RBL as compared to the control condition needs special attention. This might first imply setting up qualitative studies to compare the actual experiences of students in both conditions and whether they both report differences. In addition, to circumvent the differences emerging from different course settings, a new study could be set up in a single course setting, while involving a larger number of enrolled students. This is not an easy undertaking given the limited student numbers in advanced engineering courses in the target Ecuadorian University. Building on the limitations as to the quantitative nature of the study, a mixed method design could help developing a richer picture (interviews, focus groups, video analysis). Lastly, involving teachers as key actors in the TRN, could help establishing an additional perspective on RBL.

IX. Conclusion

The results of the present study push a research programme aiming at more in-depth research. Though the results are not significant, the RBL approach has invoked in the

local university setting an innovative way of thinking about the teaching-research nexus. From a focus on a single-course innovation, a focus at a programme level approach of RBL has emerged. This opens avenues for new and promising research endeavours.

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Chapter 4
Research Based Learning in a Transversal Entrepreneurship and Innovation undergraduate course

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Chapter 4

Research-Based Learning in a Transversal Entrepreneurship & Innovation Undergraduate Course

Abstract

The present article reports about an empirical quantitative study involving 107 undergraduate students from Entrepreneurship and Innovation courses in a public university. Students were randomly assigned to 3 conditions: structured Research-Based Learning (RBL), semi structured RBL and control.

We hypothesized that studying in a structured RBL condition would result in a higher intention to do research (INT) and research competences, operationalized as course achievement (CA) along with positive changes in autonomous motivation (AM), perceived behavioral control (PBC), behavioral beliefs (BB) and subjective norm (SN); as compared to studying in a semi-structured RBL and control condition. The intervention lasted 7 weeks as part of a regular course and was based on Brew's RBL framework. A significant differential impact was observed in overall course achievement and in specific research skills clusters. No significant differences were observed in INT, AM, PBC, BB and SN. The results lead to clear implications and directions for future research.

I. Introduction

The idea of integrating teaching and research – labelled as Teaching-Research Nexus (TRN) - has become central to university curricula around the world (Tight, 2016). Research acknowledges the benefits of involving students in research to promote learning (Corwin, Graham, & Dolan, 2015; Corwin et al., 2015; Soltano, Meyer, & Larrivee, 2016). However, research also reports a lack of practical approaches to TRN (Brew, 2010b).

Research-Based Learning (RBL) has been put forward as a potential TRN methodology (Schlicht & Klauser, 2014) which involves students in actual research (C. D. Jones, 2011).

Available empirical evidence, mostly from engineering and science courses, shows how RBL promotes student research skills (Wilson, Howitt, Roberts, Åkerlind, & Wilson, 2013; Tomasik, Cottone, Heethuis, & Mueller, 2013; Chase, Pakhira, & Stains, 2013), intentions to do research (Shaw & Kennepohl, 2013; Baiduc, Drane, Beitel, & Flores, 2017; Firdaus & Darmadi, 2017), research motivation (Bahr, 2009) and research self-efficacy (Anthony Chase et al., 2013). However, few authors have reported RBL implementations in undergraduate academic disciplines such as Entrepreneurship (Guerin & Ranasinghe, 2010; Pittaway, 2009). The present study addresses this gap in the literature, by focusing on RBL in an "Entrepreneurship and Innovation" course.

II. Theoretical background

2.1 The Nature of Research-Based Learning

TRN is central to the Humboldt definition of a research-oriented university (Sam & van der Sijde, 2014) and implies opportunities for doing research (Söderlind & Magnell, 2015). Different TRN frameworks can be found in the literature. For instance, Griffiths (2004) describes three ways of engaging students in research by either focusing on the subject content (research-led), research processes (research-oriented), or inquiry activities (research-based learning). Healey & Jenkins (2009) define a fourth way, emphasizing the discussion of scientific material (research-tutored). Similarly, Levy & Petrulis (2012) stress an additional focus on students developing existing ideas or discovering new ones. These variations suggest different ways and levels of engagement in the research cycle (Jenkins & Healey, 2010).

Brew (2013) presents a more operational approach and develops a comprehensive RBL "curriculum wheel", explaining decision-making about (1) the study context, characteristics of students, learning outcomes, abilities to be focused upon, type of

instructional tasks and evaluation processes and (2) whether these decisions are made by teachers, decided by students or negotiated between them. The latter shows how RBL varies in the level of student autonomy in carrying out research. Brew's curriculum wheel is adopted in our study to operationalize the RBL-approach. Of importance in the context of this study is that RBL can as such be highly structured or less structured when presented to students.

2.2 RBL benefits

Previous studies suggest RBL improves students' research competences (McNamara, 2016), and interest in pursuing future research degrees (Brownell, Kloser, & Fukami, 2012; Guerin & Ranasinghe, 2010), a stronger study commitment, conception of science and stronger communication skills (Willis, Krueger, & Kendrick, 2013), gives a boost to their learning process, knowledge acquisition, and development of cognitive thinking skills (Sota & Peltzer, 2017).

Healey (2005) claims that undergraduate students could get benefits in their subject learning when engaged in inquiry activities. Similar studies demonstrate that inserting research competences develops students' knowledge production (Walkington et al., 2011) and improve subject-related competences (Lambert, 2009). Alvarado & Spring (2018) state that RBL might increase retention and develop a scientific character. Furthermore, RBL helps students to contribute to faculty research productivity when integrated in academic activities (Horta, Dautel, & Veloso, 2012), generates subject motivation, and develop understanding of research methods (I. C. Fuller et al., 2014).

III. Defining an RBL research model

To explain the impact of RBL on the variables listed above, we build on a number of theoretical frameworks that link RBL-implementations to dependent and interaction variables.

Firstly, we build on Brew (2013) to define the nature of RBL (see Table 2) and to distinguish a structured and semi-structured version of RBL. This mirrors the different levels of control in her Curriculum Wheel. Students involved in RBL settings are reported to attain higher grades (Tomasik, Cottone, Heethuis, & Mueller, 2013) and learning performance (Follmer, Zappe, Gomez, & Kumar, 2015); hence repositioning learning content in a significantly different way (Schneider & Preckel, 2017).

Next, we build on the Theory of Planned Behavior (Ajzen, 1985a), to look at precursors of the dependent variables: Intentions to do research (INT) and Research

competences, operationalized as Course Achievement (CA), given the quantitative nature of this study. TPB defines three precursors to INT and future behavior:

(a) Perceived Behavioral Control (PBC) – often operationalized as self-efficacy - refers to people's awareness of how simple or complex it may be to perform a specific behavior (Ajzen, 1991). Bandura (1997) defines self-efficacy as a belief about one's own ability, in this case research activities. RBL is expected to boost student confidence to conduct research (Jones, 2011; John & Creighton, 2011; Joubert, Hebel, & McNeill, 2017).

(b) Behavioral Beliefs (BB) refer to someone's opinions about a specific behavior (Ajzen, 1991); such as being involved in research. RBL studies report an increase in students' attitudes towards research (Chang & Ramnanan, 2015; Wiley & Stover, 2014; Ryan, 2016; Colbert-White & Simpson, 2017).

(c) Subjective Norm (SN) refers to normative assumptions of others in a student context which invoke a feeling of being connected to them (M. Hill et al., 1996). RBL research reports how students feel stimulated to present their research to others (Cole, Inada, Smith, & Haaf, 2013), get feedback from faculty (Follmer et al., 2015) and even perceive gains in shared competences (Tomasik, LeCaptain, et al., 2014).

Thirdly, we build on Self-Determination Theory (SDT) to identify the impact and role of student motivation in RBL settings (Ryan & Deci, 2000). SDT stresses how Autonomous Motivation (AM) is enhanced and promotes willingness to be involved in behaviors when key psychological needs have been satisfied. RBL is as such expected to increase students' need for "Autonomy" because they get opportunities to carry out actual research. Next, they are boosted in their "Competence" because they are able to achieve complex tasks. Lastly they are improved in their "Belonging" due to the collaborative setting in which they set up research (McCarthy, 2015; Wood, 2016).

The above theoretical and empirical base helps developing the following research model. Figure 1 emphasizes how the impact of RBL affect variables in a direct and indirect way.

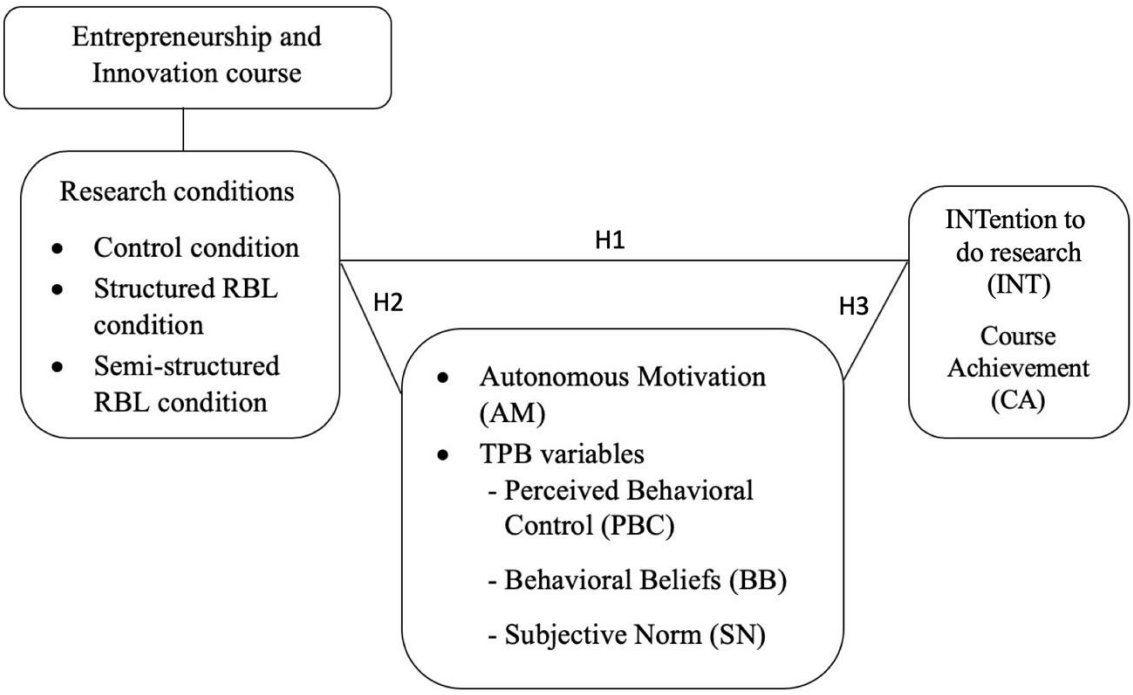

Figure 1. Theoretical model linking RBL to specific student variables.

3.1 Materials and Methods

A quasi-experimental pretest–posttest design was set up studying the differential impact of three alternative implementations of the "Entrepreneurship and Innovation" course.

3.2 Hypotheses

H1: Studying in a structured RBL condition will result in higher Intentions to do research and Course Achievement (CA) as compared to studying in a semi-structured RBL or control condition.

H2: Studying in a structured RBL condition will result in higher positive changes in AM, PBC, BB and SN as compared to studying in a semi-structured RBL or control condition.

H3: Changes in AM, PBC, BB and SN will interact with the impact of studying in a structured RBL, semi-structured RBL or control condition on Intentions to do research and CA.

3.3 Context of the Study & Sample

Entrepreneurship & Innovation is a transversal undergraduate course offered at the top public university where our research study took place. It is mandatory for all students to enrol in this course once they have completed about half of their total degree credits. The aim of this course is to help students develop general business competemces which they may later apply in their specific study fields. It combines practical approaches where students follow the entrepreneurial cycle towards the creation of their own services or products.

Undergraduate students enrolled in this course (N=118) were the participants in our study. For research purposes 4 parallel classes taught by 2 different teachers were selected. Two classes were randomly assigned to the control condition, and the other two classes to the experimental or Research-Based Learning condition: one to the structured RBL and one to the semi-structured RBL. Each teacher was in charge of an RBL and a control condition class. This helped controlling potential differences due to teaching styles.

Table 1 summarizes student characteristics. Due to individual circumstances, 11 students dropped out of the study, resulting in a full data set of 107 students.

Table 1.

Student characteristics (N 107, M and SD)

Control Group			Structured RBL			Semi-structured RBL		
Age	Male	Female	Age	Male	Female	Age	Male	Female
21.98	21	31	22.11	12	24	23.26	12	7
(2.27)			(2.28)			(3.51)		

All participant students signed an informed consent form. The study was approved by the educational authorities of the course coordinator and teachers.

3.4 Research Instruments

Instruments were piloted in a study prior to the RBL intervention, involving students not included in this study (appendix A). In addition, students were presented with a background questionnaire.

The Theory of Planned Behavior guidelines (Ajzen, 1985, 1991) helped the development of the INT, SN and BB scales (5-point Likert). Below we report pretest reliability values and an example item.

The INT scale consisted of 10 items (pre-test α= 0.845): *"As a student of the Entrepreneurship and Innovation course, I will be able to empathize with people by knowing their needs regarding a particular problem."*

The SN scale reflected 10-items (α= 0.742): *"My classmates in the Entrepreneurship and Innovation course suggest that I brainstorm possible solutions to the problem and explain how to solve it."*

The BB scale contained 10 items (α= 0.810): *"My ability to select and justify techniques that help me generate ideas or solutions to the problem will strengthen me as an Entrepreneurship and Innovation student."*

The PBC scale was built following Bandura's guidelines (2006) and contained 27-items (α= 0.968): "*Rate your degree of confidence to define a problem based on the perceptions of people.*"

To determine Autonomous Motivation (AM), we adopted seven items from the Intrinsic Motivation Inventory (Deci & Ryan, 1982) and three from the Motivation at Work scale (Gagne et al., 2010), resulting in a 10 item AM-scale (α= 0.931). Students were asked to indicate on a 7-point Likert scale their agreement with statements such as *"I enjoy doing research related activities very much in my Entrepreneurship and Innovation course."*

To determine the development of Research Competences (RC), we calculated scores for the 10 course assignments within the intervention.

3.5 *Nature of the RBL intervention*

We set up RBL within an "Entrepreneurship and Innovation" course. This implied linking the research cycle (Brush et al., 2003) to the entrepreneurial cycle (adapted from Jungmann & Ossenberg, 2014); as depicted in Figure 2 (see also Roach, 2017).

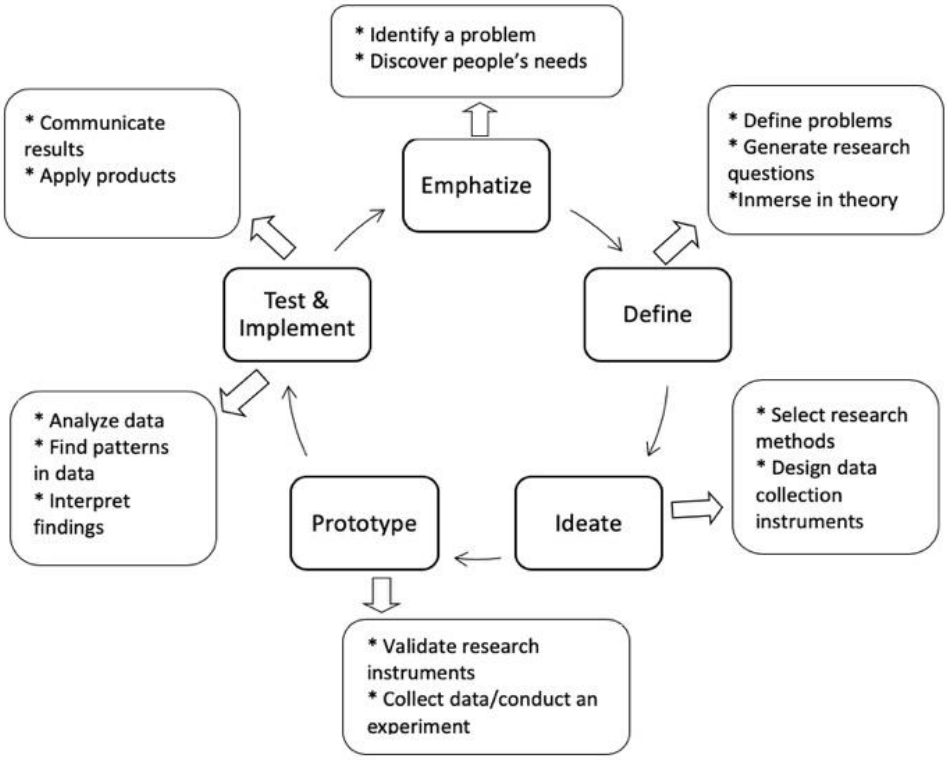

Figure 2. Research cycle (Jungmann & Ossenberg, 2014) linked to the entrepreneurial cycle (Brush et al., 2003).

To measure Research Competences, students were requested to work on 10 course assignments (1 or 2 per week) to be submitted via an online learning management system. These assignments were graded on the base of a specific rubric over 10 points. All students participated in some kind of research activity; meeting deontological concerns about equal opportunities.

The main difference between both RBL conditions depended on the proportion of research instruction, structure and guidance. This is described in detail in Table 2.

The differences in the RBL implementation followed the RBL model of Brew (2013). For example, in cluster 1 (identify a research problem), RBL moves from a fixed design, where students do the task based only on material provided by the teacher to making their own decisions about existing researchable problems in the community. In cluster 2 (define a research problem), students make their own choices regarding existing problems inside and outside university. In cluster 3 (immerse in theory), the RBL design is shared as tasks are initially structured by the teacher and then students select what information to search and how to justify its relevance. The same applies to the assignments in relation to the other clusters. Table 2 exemplifies how research

conditions reflect different levels in autonomy and specifications of instructional variables.

Table 2.

Differences between research conditions when tackling the 10 course assignments

Entrepreneurial cycle steps	Research assignment and cluster	Course assignments Structured RBL	Course assignments Semi-structured RBL	Course assignments Control condition
Empathize	Identify a problem	Identify a problem in an article. Write a synthesis including main ideas with arguments and conclusions. Follow the guide to write a synthesis appropriately.	Identify a problem in an article. Write a synthesis including the main ideas.	Identify the requested information in an article.
		Identify 5 existing problems that people need to solve. Then choose one and write down a description. Consult at least three sources that help you answer questions regarding the problem. Follow APA format guidelines. See examples.	Identify 5 existing problems that people need to solve. Then choose one and write down a description. Consult at least three sources to find information regarding the problem. Follow APA format guidelines.	Identify 5 existing problems that people need to solve. Then choose one and describe it.
Define	Define a problem	Read the author's definition of problem	Identify a problem in your university and write a	Define and describe a problem that exists in your

	identification. Identify a problem in your university and write a description about it. Provide answers to the list of questions below.	description about it. Explain what the problem is about and why it is important to solve it.	university.
	Read the author's definition of problem identification. Define and describe a problem outside your university that needs to be researched and justify why. Find information in two different sources. Follow APA format guidelines for citations and references. See examples.	Define and describe a problem outside your university that needs to be researched. Find information in two different sources. Follow APA format guidelines for citations and references.	Define and describe a problem outside your university that needs to be researched.
Immerse in theory	Investigate characteristics of an innovative product. Justify what problems and needs it solves. Cite at least two bibliographical sources.	Investigate characteristics of an innovative product. Find information in two sources.	Investigate the characteristics of a product and what problems it solves.
	Investigate about a problem that exists in your	Investigate about a problem that exists in your university.	Investigate about a problem that exists in your

		university. Consult at least 3 different sources. Follow APA format guidelines for citations and references. See examples.	Consult at least 3 different sources. Follow APA format guidelines for citations and references.	university.
Ideate & Prototype	Design research instruments Collect data	Design a questionnaire to validate your hypothesis. Then interview three people, record their answers and complete the tables. To carry out your interviews successfully, follow the guide. Check suggested links to further tips for an appropriate interview.	Design a questionnaire to validate your hypothesis. Interview three people, record their answers and complete the tables.	Prepare a set of questions and interview three people, record their answers and complete the tables.
Test	Interpret findings	Interpret interview findings. Write down the objective, how you presented the product to the interviewee and the steps you followed in each stage of the interview. Complete tables.	Interpret findings from the interviews. Write down key information provided by the interviewee and complete the tables.	Interpret findings from the interviews. Complete the tables.

		Read about the importance of sharing findings with fellows and the community as a way to promote new ideas and build future collaborations. Compare your experience in the mini-business with a classmate. Write about the positive and negatives aspects, difficulties, perceptions, results and your own learning.	Compare your experience in the mini-business with a classmate. Describe positive aspects, negative aspects and results.	Compare and reflect on results from the mini-business.
Implement	Communicate results	Present the results of the mini-business in terms of objectives achieved, methods and instruments used, data collected, implementation of the product and sales percentages. Review the guide for successful oral presentations. Focus on eye-contact, voice tone,	Present the results of the mini-business in terms of objectives achieved, methods and instruments used, data collected, implementation of the product and sales percentages. Review the guide for a successful oral presentation.	Present the results of the mini-business in terms of objectives achieved, methods and instruments used, data collected, implementation of the product and sales percentages.

	enthusiastic attitude, adequate visual aids and the organization of the content. Watch a related video.

3.6 *Procedure*

The study was set up during the first semester of the academic year 2017-2018. Data was gathered during 9 weeks which included 2 weeks for pre and post-tests and 7 weeks for course assignments. The background questionnaire and all scales were administered during regular class time, following a protocol. Administration took between 40-45 minutes.

Next, students followed their version of the course, considering the research condition during the subsequent 7 weeks. Teachers followed a detailed syllabus containing all materials and assignments. The overall setting involved students in a "mini-business" to create a new product during an entrepreneurial cycle. By the end of the semester, students presented their business results and explained how every phase of the entrepreneurial cycle had been implemented.

Every week students turned in assignments that were graded individually by the researcher on the base of rubrics. The final assignment - the presentation of their business results – was evaluated by four external examiners on the base of a specific rubric that focused mainly on their communication competences (final stage of the entrepreneurial cycle).

After the intervention, all students filled out – during regular class time – the post-test version of the instruments.

IV. Results

All analyses were carried out with SPSS® version 24. Next to the calculation of descriptives, hypotheses were tested on the base of analysis of (co)variance with research conditions as factors. Focusing on the dependent variable Research Competences, both an overall score was used in the analysis, next to cluster scores focusing on specific research competences.

Focusing on INTentions to do research (INT), a difference score was calculated between the pre- and posttest value. The same applies for the testing of H2 and H3 where difference scores were calculated for SN, BB, PBC and AM.

A significance level of $p < .05$ was put forward. Statistical assumptions were tested (homogeneity of variance, normal distribution) and Bonferroni correction was applied. In case of violation of assumptions, Tamhane's T2 was calculated. Effect sizes were calculated to interpret significant results (Cohen's *d*), considering guidelines of Baguley (2009).

Table 3 summarizes the descriptive results that reflect small differences between research conditions. Firstly, we observe a decrease over time in INTentions to do research and Autonomous Motivation in all conditions; though this is the least in the structured RBL condition. These students reflect a higher average in their perceived behavioral control (PBC) and behavioral beliefs (BB) while students in the semi-structured RBL condition reflect higher subjective norm scores. For each cluster in course achievement, we observe that structured RBL students outperform the students in other research conditions.

Table 3

Summary of descriptive results in relation to all research variables (N)

Variables	**Structured RBL (N=35)**	**Semi-structured RBL (N=19)**	**Control (N=52)**
Change in Intention [a]	-0.07 (0.86)	-0.18 (0.37)	-0.20 (0.58)
Change in AM [b]	-0.24 (0.96)	-0.34 (1.02)	-0.56 (1.02)
Change in PBC [a]	1.21 (9.75)	-1.18 (15.26)	1.08 (14.61)
Change in BB [a]	0.06 (0.66)	-0.07 (0.39)	-0.15 (0.56)
Change in SN [a]	0.06 (0.53)	0.16 (0.47)	-0.01 (0.59)
Course Achievement (overall)[c]	8.80 (1.31)	6.70 (2.43)	7.94 (1.89)
Course Achievement (clusters) [c]			
Cluster 1	8.89 (1.43)	5.97 (3.43)	6.84 (2.44)
Cluster 2	8.63 (2.35)	7.17 (3.33)	8.24 (1.97)
Cluster 3	8.77 (1.25)	6.30 (2.56)	7.53 (1.86)
Cluster 4	8.67 (2.71)	7.66 (3.56)	8.34 (2.86)
Cluster 5	8.84 (2.01)	5.98 (3.90)	8.79 (6.25)
Cluster 6	9.08 (1.09)	8.48 (0.97)	8.22 (1.48)

[a] maximum score is 5; [b] maximum score is 7; [c] maximum score is 10

Hypothesis 1

The analysis of variance results reveals no significant differences in INTention to do research ($F_{(2, 104)} = .448$, $p = .915$). However, the analysis results reflect significant differences between conditions in overall Research Competences (RC) ($F_{(2, 104)} = 8.24$, $p = .001$, partial eta squared=.13). Post-hoc comparison results show that the mean score of students in the structured RBL condition (M=8.80, SD=1.31) significantly differs from the semi-structured RBL condition (M=6.70, SD=2.44). Cohen's d= 0.89 reflects a large effect size. Additionally, the structured RBL condition (M=8.80, SD=1.31) differs significantly from the control condition (M=7.94, SD=1.89). Cohen's d= 0.40 reflects a medium size effect.

The analysis of variance per research competence cluster reveals significant differences between conditions in the following clusters: 1 (identify a research problem), 3 (immerse in theory) and 6 (communicate results). No significant differences between conditions were found in cluster 2 (define a research problem), 4 (design research instruments and collet data) and 5 (interpret findings).

Post-hoc comparison results indicate that the mean score for the structured RBL condition was significantly different in the following clusters 1 (M=8.89, SD= 1.44), 3 (M=8.78, SD=1.25) compared to both semi-structured RBL (M=6.70, SD=2.43) and control condition (M=7.94, SD=1.89). However, in cluster 6, the structured RBL condition significantly only differs significantly (M=9.0833, SD=1.0987) from the control condition.

No statistically significant differences were observed in research competence clusters 2 (M=8.63, SD=2.36), 4 (M=8.67, SD=2.71) and 5 (M=8.84, SD=2.01).

Hypothesis 2

The analysis of variance reveals no significant differences in Autonomous Motivation ($F_{(2, 104)} = 1.122$, $p = .330$), Perceived Behavioral Control ($F_{(2, 104)} = .240$, $p = .787$), Behavioral Beliefs ($F_{(2, 104)} = .266$, $p = .767$) and Subjective Norm ($F_{(2, 104)} = .755$, $p = .473$).

Hypothesis 3

Table 4 summarizes the analysis of covariance results. We again observe a non-significant differential impact of RBL on changes in Intention to do Research ($F_{(2, 97)} = .461$, $p = .632$). As could be expected, also no interaction effect is observed due to changes in the co-variables AM, PBC, SN except for BB.

Table 4

Analysis of covariance results with INTentions to do research as the dependent variable (N 108)

	F	***Df***
Condition	0.46	2
Change in AM	1.84	1
Change in PBC	1.84	1
Change in BB	62.06*	1
Change in SN	0.11	1

F= ratio of 2 measures of variance; *df*=degrees of freedom; * *p*<.05

Table 5 summarizes the analysis of covariance results when looking at overall and clustered Research Competences. Only the main effect of the research condition seems to be significant in overall Research Competences ($F_{(2, 97)} = 7.355$, $p = .001$). As discussed above, structured RBL students outperform those in the semi-structured RBL and control condition. No significant interaction effects related to changes in co-variables can be found.

Also, the main effect of research conditions seems to be significant in these clusters: identify a research problem ($F_{(2, 97)} = 10.62$, $p = .000$), immerse in theory ($F_{(2, 97)} = 10.03$, $p = .000$) and communicate results ($F_{(2, 97)} = 3.948$, $p = .022$). Only the latter shows a significant interaction effect related to changes in Autonomous Motivation.

Table 5

Analysis of covariance results with overall RC and Clustered RC as the dependent variable (N 108)

	F	***Df***
Condition	7.35**	2
Change in AM	3.30	1
Change in PBC	1.28	1
Change in BB	0.96	1

Change in SN	0.24	1
Identify a research problem		
Condition	10.62**	2
Change in AM	0.77	1
Change in PBC	3.53	1
Change in BB	1.43	1
Change in SN	0.10	1
Immerse in theory		
Condition	10.03**	2
Change in AM	0.05	1
Change in PBC	2.70	1
Change in BB	1.35	1
Change in SN	0.66	1
Communicate results		
Condition	3.94*	2
Change in AM	4.50*	1
Change in PBC	0.24	1
Change in BB	0.42	1
Change in SN	1.36	1

F= ratio of 2 measures of variance; df=degrees of freedom; *p≤0.05; ** p≤0.01

V. Discussion

Based on Brew's Curriculum Wheel (2013) two RBL implementations were developed within an "Entrepreneurship and Innovation" course and compared to a control condition.

Contrary to expectations, studying in the different research conditions did not result in differences in students' intentions to do research. These non-significant findings may result from shared design characteristics in all three conditions. All Entrepreneurship and Innovation students had to develop a range of research competences (Brush et al., 2003); thus pushing them to conduct research in a smaller or larger extent. Research

intentions were as such fostered in all conditions, given the course goals (Willison, 2012).

Concerning Research Competences (RC), we distinguish between overall research competences and research clusters. Overall RC seems to differ between conditions. A better development of research competences is observed in structured RBL compared to semi-structured RBL and control condition. As stated by Myatt (2012) undergraduate research experiences appear to be associated to students' higher gains and may contribute to academic performance (Howard & Miskowski, 2005).

Similarly, significant differences between conditions are observed in 3 research clusters: identify research problems, immerse in theory and communicate research results. In the first two, students in the structured RBL condition outperform the other conditions whereas in the third, they excel only compared to students in the control condition.

We can explain our results by looking at the "structure" in the research tasks. The fact that structured RBL significantly outperform semi-structured RBL and control students could be associated to the idea that learning through inquiry should be supported with sufficient guidance (Lehtinen & Viiri, 2017). This is in consonance with Brew's (2013) curriculum "wheel" approach with gradual changes in levels of autonomy and structure. Also, Kirschner, Sweller, & Clark (2006) along with Colbert-White & Simpson (2017) point out that unguided instruction is less effective compared to methodologies that emphasize clear structure and guidance.

Research activities are complex in nature and entail substantial efforts (De Jong, 2010) leading to high cognitive loads (Sweller, 2015). Little or no structure seems to invoke extraneous cognitive load that affects available cognitive resources to process information (Sweller, Van Merrienboer, & Paas, 1998). This extraneous cognitive load was reduced in the structured RBL setting due to clearer direction (Sweller, 2016), examples (Paas et al., 2004), less cognitive disruption (Annett Schmeck, Opfermann, van Gog, Paas, & Leutner, 2015) and a stronger focus on instructional design (B. Morrison, Dorn, & Guzdial, 2014).

The non-significance differences found in 3 research skill clusters can be explained by their positioning in the course. Two of them appear towards the end. They include tasks that integrate earlier research competences, thus conducing to larger levels of complexity and cognitive demands to tackle them. This could have invoked in all

students – irrespective of the research condition - a too high level of extraneous cognitive load. The tasks could have pushed their cognitive resources to their limits (Sweller, 2011) preventing the transfer of earlier learning to novel contexts (Paas, Tuovinen, Tabbers, & Van Gerven, 2003; Boula, Morgan, Morrissey, & Shore, 2017).

Also, the fact that most students lack prior knowledge linked to the course contents could have hindered the deployment of strategies in research tasks. As described by Bloom, Engelhart, Furst, & Krathwohl (1956), individuals can successfully deal with new content when they can rely on prior knowledge. Early exposure to research might be less favorable in novice students due to deficiencies in their theoretical background (Ameen, Batool, & Naveed, 2018). Therefore, novice students handling unfamiliar content need more guidance (P. Kirschner et al., 2006).

Regarding our second hypothesis, we could not confirm that higher positive changes in Autonomous Motivation, Perceived Behavioral Control, Behavioral Beliefs and Subjective Norm would result from studying in a structured RBL condition compared to a semi-structured RBL or control condition. These findings contradict the assumption that conducting research increases students' self-confidence (Russell, Hancock, & McCullough, 2017) and research practice appreciation (Myers, Sawyer, Dredger, Barnes, & Wilson, 2018).

As earlier displayed in table 3, students in the 3 conditions reflect a progressive decrease in both intentions to do research and autonomous motivation. The latter shows students' low determination and involvement in research. This could be explained by the fact that students were demanded to submit assignments within short time periods and received evaluation rubrics primarily focused on scores rather than on explicit feedback. As explained by Deci & Ryan (2012) there are specific factors such as the burden of deadlines and the lack of encouraging feedback that may have put more pressure on students; thus depleting their autonomous motivation. Similarly, being confronted with obligatory research assignments plus most students' limited research knowledge may have affected their self-confidence to do research appropriately (Rosenkranz, Wang, & Hu, 2015).

As can be expected from the results in relation to H2, the third hypothesis could not be confirmed. We could not demonstrate that changes in autonomous motivation, perceived behavioral control, behavioral beliefs and subjective norm interact with the impact of studying in a structured RBL, semi-structured RBL or control condition on students' intentions to do research and research competences. The fact that students

were not given opportunities to choose topics of their interest in relation to the assignments and mostly had to deal with imposed research activities, probably made them feel less autonomously motivated to dedicate time and effort to them. Also, the absence of detailed individual feedback could have undermined students' confidence in their own research skills (Niemiec & Richard, 2009; Cortright, Lujan, Blumberg, Cox, & DiCarlo, 2013) as they could not acknowledge to what extent they were progressing (Cheong, Reeve, & Moon, 2012). This may explain the no significant effect of RBL on students' intention to do research and the no interaction with covariables.

In relation to overall research competences, despite the significant impact of RBL on it; again, we could not observe any interaction with covariables. We may assume that some students developed research competences throughout the course due to continuous exposition to research tasks (Myatt, 2012) and not because of pressures or expectations from others such as teachers or parents (Hagger, Sultan, Hardcastle, & Chatzisarantis, 2015; Popa & Voicu, 2015) or a highlighted particular interest to learn (Cortright et al., 2015).

In clustered research cim, we could only confirm changes in autonomous motivation interacting with the impact of RBL in relation to the cluster "communicate results". Since this cluster was positioned at the end of the course, students could have already assimilated research knowledge that enabled them to integrate what was required in the task. Also, the fact that this cluster involved the presentation of results from a mini-business project of students' own choice, could have given them sense of volition and willingness to achieve well; thus reflecting higher levels of autonomous motivation (Rosenkranz, Wang, & Hu, 2015). As stated by Deci & Ryan (2000), when students are involved in class activities that provide them choice and autonomy, they perform better and their motivation boosts simply by the learning experience as such and no other factors.

VII. Practical Implications & Further Research

The findings of our research study have some implications. From a practical perspective, this study offers guidelines about how to link the entrepreneurial cycle to the research cycle when designing students' course assignments.

Also, we develop an RBL implementation based on the wheel model proposed by Brew (2013) that can be replicated by other researchers in alternative academic disciplines. Our results suggest that research is definitely implied in all stages of the

entrepreneurial cycle and this is why, students in all conditions somehow developed intentions to do research. Therefore, a mixed methods approach could be recommended in order to go beyond statistical measures and explore students' changing views and opinions.

VI. Conclusions

Research Based Learning was researched in this study as an operational implementation of TRN. The present study is a starting point for future RBL implementations. It presents a benchmark in terms of the design of RBL and the impact on variables in undergraduate students. Although we could not confirm all hypotheses, we found a significant differential impact of RBL on overall achievement; and in some of research skill clusters, which demonstrate a positive impact on research competences. This is encouraging and opens avenues for future research that adopts mixed method designs and involve other undergraduate student populations. In this way TRN contributes to the innovation of teaching and learning in undergraduate higher education.

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Chapter 5
Research Based Learning in a Rural Development graduate course

This chapter is based on:

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Chapter 5

Research-Based Learning in a Rural Development Graduate Course

Abstract

The present article reports about a qualitative study involving a total population of 6 students from a Sociology and Rural Development graduate course in a public university. We aimed to study the impact of RBL on students' research competences. Also we explored such impact considering changes in autonomous motivation and research self-efficacy. Students worked on weekly assignments following an RBL approach and received feedback. Three rounds of interviews were conducted in order to explore students' insights and perceptions of their own learning using RBL.

Qualitative data seem to confirm our assumptions about the nature of the relationship between the research variables.

I. Introduction

At present, higher education is undergoing worldwide innovations where different ways of teaching and learning are needed to deal with existing society demands (Tang et al., 2018). In this regard, promoting a teaching-research nexus is key not only to achieve academic institutional aims (Arias, 2015) but mainly to develop fundamental competences in contemporary professionals (Smith, Densmore, & Lener, 2016). This partly explains why instructional models to promote research and inquiry (Brew & Jewell, 2012), such as Research-Based Learning (RBL), have gained importance among students and academics (Eid, 2014) as they seem to enhance quality in higher education (Klauser & Schlicht, 2014; Amelia, 2018), and consequently standards of professional distinction (B Quinn, 2016).

Earlier RBL studies in graduate courses (Feldman, Divoll & Rogan-Klyve, 2013; Wannapiroon, 2014) report benefits, such as development of students' research competences (Shaw & Kennepohl, 2013), improved critical thinking (Chase et al. 2017), increased self-efficacy and intentions to embark in scientific careers (Bangera & Brownel, 2014; Daniels et al., 2016; Winkelmann et al., 2015). Other studies suggest that RBL can improve students' autonomous motivation (Camacho, Chiluiza, & Valcke, 2017), or personal willingness to be involved in gratifying behaviors (Mouratidis & Michou, 2011).

However, evidence also points at less successful RBL practices. Some authors claim that the lack of knowledge or experience to implement an RBL setting is a critical factor (Howitt et al., 2010). Others point at negative students' perceptions about the length of RBL courses (Streu et al.,2016) or the time spent in research (Tomasik et al., 2013). Also, students seem to have difficulties to engage in authentic research due to a poor connection between classwork and research (Winkelmann et al., 2015). Furthermore, it appears that students' exposure to RBL does not ineludibly increase their interest in research careers (Eagan et al., 2013) as there are other specific factors which may affect it, such as personal choice and tutor quality (Baiduc et al., 2017).

These inconclusive findings explain the need to go beyond quantitative ways to study the impact of RBL and look for a deeper exploration of student's insights about RBL.

In the following section, we describe our conceptual and theoretical framework to explain the impact of RBL on students' research competences and its interplay with other variables such as autonomous motivation and self-efficacy. We start by

explaining the inconclusive effect of some earlier RBL practices relying on quantitative approaches, which leads us to the choice for a qualitative method in the present research study.

II. Conceptual and Theoretical Framework

2.1 Inconclusive impact of Research Based Learning (RBL)

As clearly stated in earlier literature, RBL is a type of experimental learning that encourages students to learn and conduct research that suits their particular knowledge field (Brew, 2013), allowing them to understand the nature of science (Quave, 2014).

RBL is linked to inquiry, formulation of research questions and cultivation of critical thinking and problem-solving skills (Zhao Weidong, Wu Haifeng & Wang Anhua, 2009; Al-Maktoumi, Al-Ismaily & Kacimov, 2016). Also, RBL seems to foster student confidence to create novel knowledge (Gilardi & Lozza, 2009), understanding of subject contents (Zhu & Singh, 2012); and subsequently, better academic achievement (Sota & Peltzer, 2017).

RBL has proved to develop students' research competences (Wannapiroon, 2014) from devising a research question (Wagner, 2014), searching literature, writing academically to disseminating research results (Yeoman & Zamorski, 2008) as they experience the actual research process (Pu, Huang, & Wenjia, 2014).

However, past quantitative studies also show that RBL has not always produced positive learning outcomes (Hollowell, Osler, & Hester, 2015; Keltie, 2015; Walter, 2012). For instance, Grover (2004) reports how students involved in RBL seem to have developed research competences, but there is no evidence of assessable improved achievement. Similarly, Chase, Pakhira & Stains (2013) report a partial to no RBL impact on student performance. These inconclusive findings are difficult to explain on the base of the available quantitative data. This justifies the alternative qualitative approach adopted in the present study.

In this study we integrate an RBL approach in a graduate course following the research cycle proposed by Klauser & Schlicht (2012). We adopted this cycle given that its stages appropriately match the course aims, activities and learning outcomes.

Figure 1 depicts this 8-steps research cycle that should be seen as iterative. The cycle starts with the exploration of problems and definition of objectives, followed by research design, data collection and interpretation of findings. The identification of new gaps in

knowledge emerge at the end of the cycle and is a starting point for the next iteration of the research cycle.

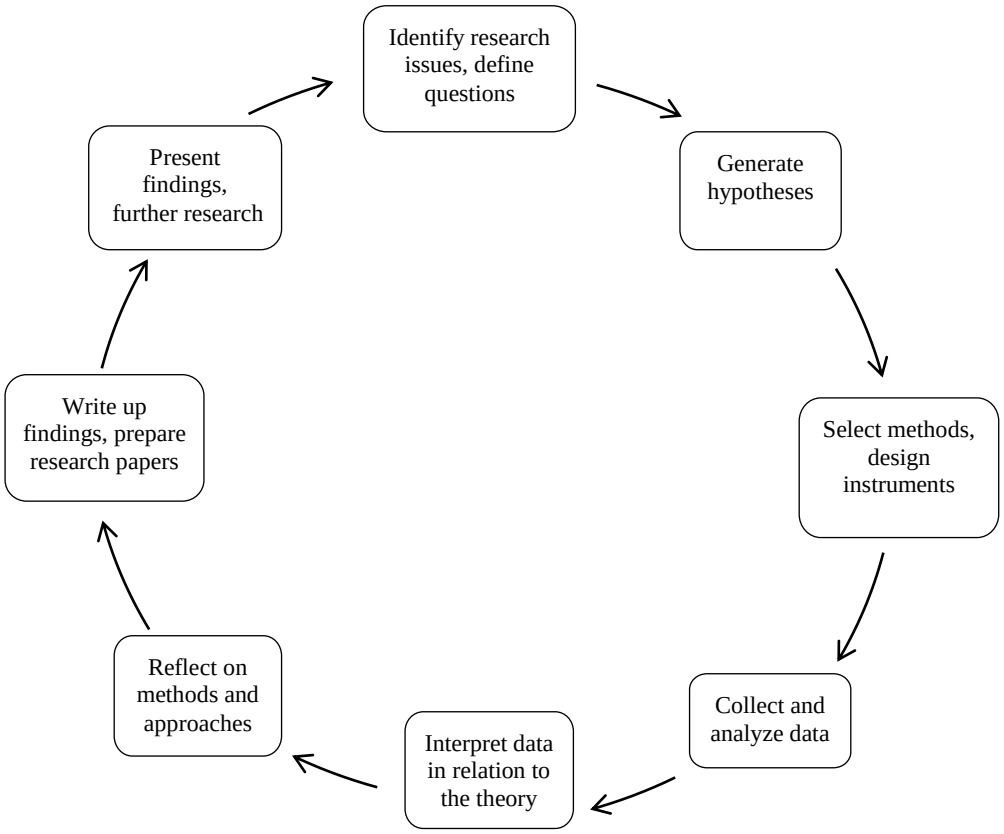

Figure. 1 Research cycle for graduate courses adapted from Klauser & Schlicht (2012).

2.2 The Interplay of Autonomous Motivation (AM) with RBL

An increasing number of studies have found that autonomous motivation plays a consistent role in RBL settings (Sumbawati & Anistyasari, 2018; Granjeiro, 2019; Ommering, van Blankenstein, Wijnen-Meijer, van Diepen, & Dekker, 2019). Therefore, we build on the Self-Determination Theory (SDT) from Deci and Ryan (1982) to explain the interplay of autonomous motivation in our RBL intervention.

In the context of our research study, we aim to find out whether there is an impact of RBL on students' research competences along with changes in their autonomous motivation to do research.

In the next lines, we firstly define AM and the three basic psychological needs: autonomy, competence and relatedness. Correspondingly, we emphasize the role of these needs to achieve AM in our RBL intervention.

Figure 2 depicts the three basic psychological needs in connection with autonomous motivation and the behaviour to be performed.

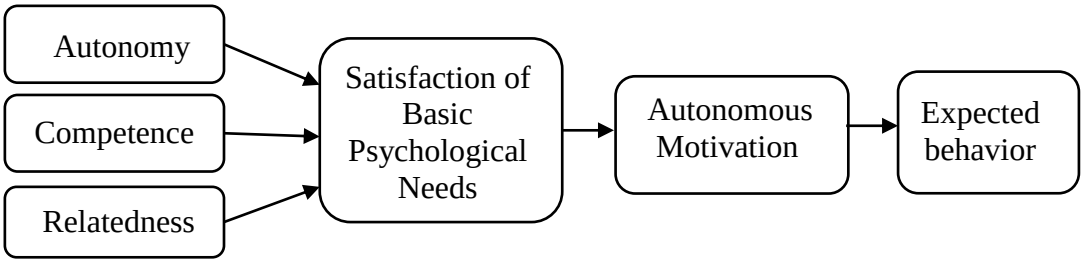

Figure 2. Basic Psychological Needs in relation to Autonomous Motivation and Behaviour. Adapted from Edward L. Deci & Ryan (2002)

AM emerges from internal sources comprising motivation that arises due to external influences when individuals feel identified with beliefs or emotional situations associated to them (Deci & Ryan, 2008). In this regard, AM is defined as willingness to participate in activities merely for the significance and personal gratification resulting from the learning task per se, or its related effects; and not influenced by external factors (Hagger and Chatzisarantis 2016; Vansteenkiste, Maarten Aelterman et al., 2018).

AM appears to be driven by satisfaction of the basic psychological needs for autonomy, competence and relatedness; resulting in better performance (Niemiec and Richard, 2009; Deci and Ryan, 2016).

According to Deci & Ryan (2002), the need for autonomy is met when students perceive that they can adopt own initiatives or act according to their beliefs. For instance, giving students a voice in RBL experiences regarding research topics, questions, methods, products, etc. might have a positive effect on their research competences. It seems that individuals' increased autonomy tends to enhance the performance of desired tasks (R. M. Ryan & Deci, 2008) as they feel motivated to do them (Ryan, Williams, Patrick, & Deci, 2009; Reeve, 2012).

Competence refers to feeling capable to interact with others successfully (Deci & Ryan, 2002) This need is fulfilled when individuals are allowed to manage their own capacities in order to achieve expected results (Chiniara and Bentein, 2016).

Therefore, students seem to feel more competent when they can develop positive ownership of their learning (Fielding and Bragg, 2003); for instance, conducting research on their own. Furthermore, it is possible that students successfully engaged in a RBL setting perceive themselves as competent to carry out research-related activities. As stated by Deci & Moller (2005) when situations are favorable in terms of stimulating tasks, individuals are more willing to develop their competences.

As for relatedness, it is defined as a stronger sense of belonging when individuals work towards shared aims (Deci & Ryan, 2000). Liu and Breit (2013) stress how students tackling together genuine community problems via research activities, feel more connected, report increased relatedness (Liu and Breit, 2013) and reflect a stronger development in their research competences (Rosenkranz, Wang, and Hu 2015). Apparently, learning environments such as RBL settings link individuals' optimal relatedness to an enhanced performance (Ryan & Powelson, 1991; Gonzalez & Chiviacowsky, 2018).

Available quantitative research supports the above assumptions (Overall, Deane and Peterson, 2011; Page, Ralebitso-Senior, and Orr, 2017). However, little is known about students' insights in regards to their own autonomous motivation when involved in RBL settings. Once again, this justifies the need for qualitative data which help us to fill in this existing gap.

2.3 The Role of Self-efficacy to explain RBL

In the present research study, we build in the Self-Efficacy Theory (Bandura, 1994) to explain the role of self-efficacy in our RBL intervention.

Preliminary work in this field supports the assumption that self-efficacy interplays with the impact of RBL on students' research competences (Quinney & Parker, 2010; Adedokun, Bessenbacher, Parker, Kirkham, & Burgess, 2013; Chumwichan & Siriparp, 2016) in graduate courses (Phillips & Russell, 1994; Tiyuri et al., 2018). In view of the preceding findings and the strong connection of self-efficacy with students' learning (Schunk, 1989), we rely on it to explain the expected effect of RBL in this study.

In the next paragraphs, we define self-efficacy, the four sources associated to it and their interplay with RBL in our intervention.

Bandura (1997) defines self-efficacy as beliefs individuals hold in regards to their own ability to carry out specific tasks. In this regard, high levels of self-efficacy might lead to cognitive growth and greater academic performance (Bandura, 1993).

The above is linked to the aims of this research study as we expect to find positive changes in students' research self-efficacy in connection with their research competences. This is in line with authors stating that research self-efficacy is certainly related to RBL and the development of research competences (Ketelhut, 2007; Swan, Inkelas, Jones, Pretlow, & Keller, 2018; Liesman, Powell, & Antonou, 2019; Sebastian et al., 2019).

As displayed in figure 3, research self-efficacy can be acquired from four main sources: mastery of experiences, vicarious experiences, verbal persuasion and emotional and physiological states (Bandura, 1977b).

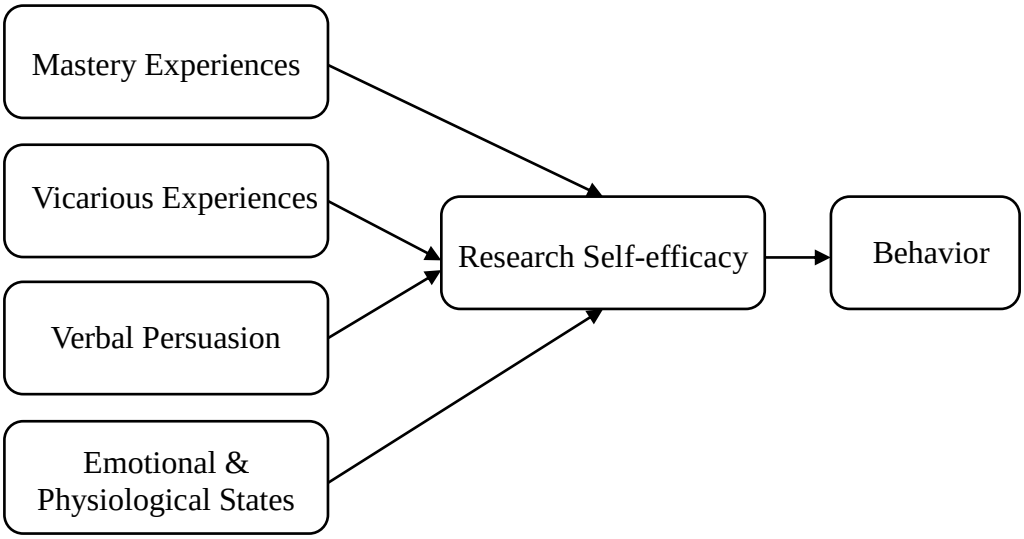

Figure 3. Sources of Research Self-efficacy. Adapted from Bandura (1977)

According to Bandura (1994), self-efficacy results from four sources: mastery experiences, vicarious experiences from role models, social persuasion and emotional and physiological states. This is confirmed by several authors in later studies (Phan & Ngu, 2016; Capa-Aydin, Uzuntiryaki-Kondakci, & Ceylandag, 2018; Gebauer, McElvany, Bos, Köller, & Schöber, 2019). Furthermore, it was found that these four sources seem to be related to RBL (Adedokun et al., 2013; Bierer, Prayson & Dannefer, 2015; Zhang et al. 2016; Hemmings & Kay, 2016). Next, we explain the role of each of these sources in our RBL setting.

Mastery experiences have proved to be the most influential source of self-efficacy (Bautista, 2011; Huang & Gao, 2013; Loo & Choy, 2013; Malmberg, Hagger, & Webster, 2014). They refer to people's attainments through continuous efforts and after overcoming difficulties (Bandura, 1994). In this regard, we anticipate that students involved in RBL who have effective accomplishments, may reflect positive changes in their self-efficacy to conduct research. It seems that individuals have a tendency to consider their own performance to assess their competences (Usher & Weidner, 2018). This is also supported by Carpi et al. (2017) when they explain that students' continual immersion in research can provide them with mastery experiences; thus increasing their self-efficacy, as they become successful in their research attempts (Seraji, Tavakkoli, & Hoseini, 2017).

Similarly, there is evidence supporting vicarious experiences as a strong source of self-efficacy and behavior (Ahn, Bong, & Kim, 2017; Capa-Aydin, Uzuntiryaki-Kondakci, & Ceylandag, 2018). A vicarious experience might take place when individuals consider others' performance as a reference to evaluate their own competences (Usher & Weidner, 2018). It results from observing the consequences that other individuals labelled as role models experience (Lunenburg, 2011) when performing a specific behavior. Perceiving others' positive consequences may result in one's positive expectations towards behaviors and vice versa (Bandura, 1977b).

In the context of this study, our aim is to find out whether students with strong research competences or who intend to pursue research careers can influence others to do the same. This is supported by Bandura (1977) and Pajares (2005) when they state that individuals can increase their levels of research efficacy by observing the way others behave and overcome learning difficulties.

The third source of self-efficacy is social persuasion which has also proved to be reliable within learning contexts (Hoi, Zhou, Teo, & Nie, 2017; Lau, Kitsantas, Miller, & Drogin, 2018). It refers to the impact people have on others when convincing them regarding their capabilities to accomplish tasks (Bandura, 1994). These constructive persuasions encourage individuals' own perceptions of their competences and vice-versa (Bandura, 1977b).

The above matches one of the aims of this study regarding expected changes in students' self-efficacy to conduct research when they are persuaded by others such as tutors, peers or experts in the field. This is in line with Bandura's emphasis on tutors' support in the development of students' competences (1977) given than effective

persuasion may lead people to work harder and achieve better results (Bandura, 1981).

The last source of self-efficacy is related to emotional and physiological states. People can judge their own confidence by the emotional states they go through when performing an action. Individuals' physiological states such as nervousness, tension, excitement, tiredness and humor states can also affect their levels of self-efficacy (Pajares, 1997) On the contrary, a great sense of efficacy is developed when individuals perceive themselves optimistic about their emotional reactions (Bandura, 1997).

This source of SE is linked to our intervention by helping to explain potential changes in students' emotional and physiological states when involved in RBL activities. This is consistent with authors who claim that individuals depend on on their emotional and physiological states to evaluate their competences, performance and make career decisions in any field (Bandura, 1981; Bruning & Kauffman, 2006; Lent, Ireland, Penn, Morris, & Sappington, 2017) such as research.

But, earlier quantitative results also show that changes in self-efficacy are not always observed in learning contexts such as RBL (Chase, Pakhira & Stains, 2013; Taheri et al., 2015; Foulstone, 2019), or seem not always significantly linked to changes in research competences (Heidari-gorji et al., 2016; van Blankenstein et al., 2019). These results reiterate the need for deeper exploration through qualitative data that help us to explain the nature of changes in self-efficacy.

III. Materials and Methods

3.1 Research Design

An empirical qualitative study was set up to look into the differential impact of RBL on students' research competences, considering changes in their autonomous motivation and self-efficacy in a Sociology and Rural Development graduate course. The research questions of the study are grounded on the theoretical model that integrates the above conceptual and empirical base.

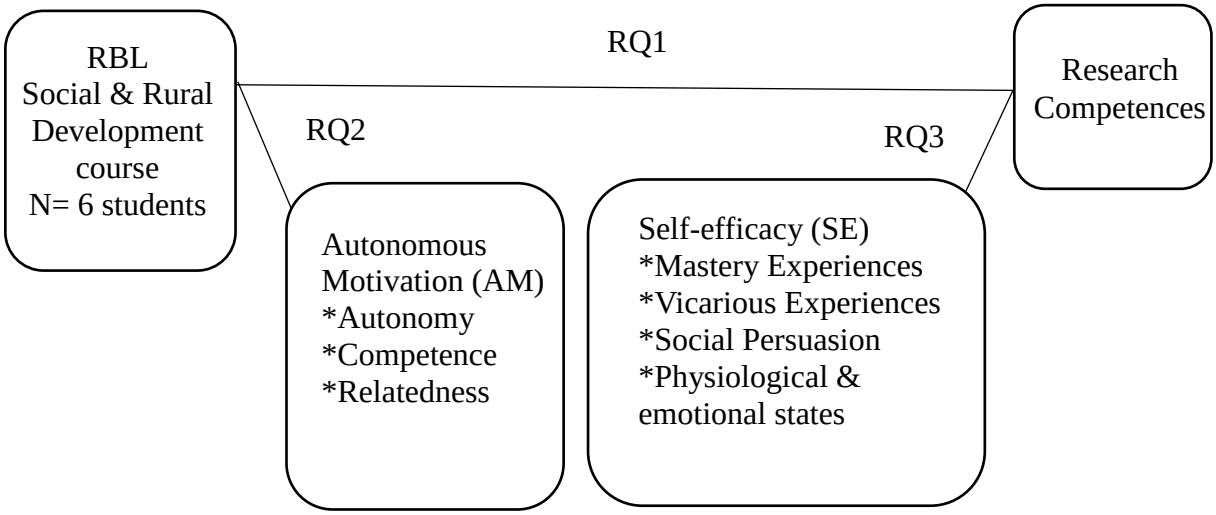

Figure 4. Research model connecting RBL to student variables involved in this research study.

To accomplish our research aims, we put forward the following research questions:

RQ1: What is the specific effect of engaging students in an RBL graduate course on their research competences?

RQ2: What is the effect of engaging students in an RBL graduate course on their research competences considering changes in autonomous motivation?

RQ3: What is the effect of engaging students in an RBL graduate course on their research competences considering changes in self-efficacy?

3.2 Sample

The complete population of students enrolled in the Sociology and Rural Development course (N=6) from a research-oriented master's program at an Ecuadorian public university was involved in the present study. Student age ranged from 25 to 34 years (M=27.66, SD=2.98) with only 1 female participant. All students and teacher gave their informed consent to participate in the study. Research instrument scores were not linked to students' final grades.

Given the research-oriented nature of the course, the intervention was embedded within a redesign of the regular class assignments. To guarantee treatment confidence, the teacher agreed beforehand on the way students' tasks would be related to research activities.

3.3 Research Instruments

To determine students' research competences (RC), a diagnostic research competency test involving activities aligned to specific stages of the research cycle described above, was designed. This test was administered at the beginning and end of the course. Pretest administration helped to determine students' prior knowledge and develop a baseline to look at potential changes during the intervention. Posttest administration helped to map changes over time. Test items in both versions were the same; though different Sociology and Rural Development articles for the class assignments developed by the students, were used to make items authentic and somewhat different at content level.

Building on Bloom et al. (1956) Taxonomy, the test item activities varied from basic to complex. For instance, introductory activities asked students to differentiate a journal article from a conference paper, identify citation styles, name scientific databases and write references. More complex activities required students to state a research problem, identify research questions and methodology, write references and propose further research based on current findings.

Following the course syllabus, six class assignments, clearly linked to stages of the research cycle, were designed by the teacher in collaboration with the researchers.

Table 1 depicts the course assignments, matching the research cycle proposed by Klauser & Schlicht (2012). From assignments 4 and 5 on, more extensive tasks, requiring deployment of several research competences were put forward.

Table 1

Description of course assignments linked to the research cycle

# assignment	Task	Research Cycle Stage
1	Present an existing article identifying problems, questions and objectives.	Identify community problems, explore questions and objectives
2	Identify and state the research problem in an article.	
3	Synthesize information, identify objectives, generate	Select approaches, propose research

	research questions in an article.	hypotheses and/or questions.
4	Plan a scientific search for a literature review on an agro-food item of your choice. Find appropriate literature for the review comprising at least 20 literature references from different countries. Analyze data from the included empirical cases. Fill in an analytical table.	Collect and analyze data.
	Write the literature review findings based on the selected agro-food item.	Interpret, write up findings and prepare research papers.
	Present the literature review findings as a report.	Present findings and identify further research questions.
5	Based on a research problem and questions identified in the literature review, select suitable research methods for a new research proposal.	Choose research methods and design instruments.
	Describe data collection methods and analysis for the research proposal.	Collect and analyze data.
	Write up the expected findings in the results section from the research proposal.	Interpret, write up findings and prepare research papers.
6	Write an abstract for an existing article suggested by the teacher.	Interpret, write up findings and prepare research papers.

Maximum score of each assignment was 10.

To measure changes in students' self-efficacy (SE) and autonomous motivation (AM) and how they are related to the impact of RBL on their research competences, we designed a structured interview consisting of 35 open-ended questions. As to SE, the 19 questions addressed the 4 sources of self-efficacy: mastery experiences (ME),

vicarious experiences provided by social models (VE), social persuasion (SP) and emotional and physiological states (EPS). Example items: ME*: "What efforts did you make in order to succeed in the assignments?"*, VE: *"Did you compare your assignment with peers?"*, SP: *"Do you feel that your teacher or classmates persuade you to improve your research competences?"*, EPS: *"When you send your assignments, do you feel positive about them?".*

In relation to AM, we built on the Intrinsic Motivation Inventory proposed by Deci and Ryan (1982). The 16 questions tapped into the 3 basic psychological needs: autonomy (A), competence (C) and relatedness (R). Example items: A: *"Did you investigate other sources to get more information about the tasks?"*, C: *"Did you feel confident about your research competences when tackling these assignments?"*, R: *"Do you feel supported by your classmates?".*

The research competency test and interview questions were validated by other researchers and piloted by students not included in the sample.

3.4 Nature of the intervention and Procedure

Given the small student population (N=6), all of them participated in the intervention, which was set up during the complete second semester of the academic year 2017-2018 (14 weeks). The research competency tests were administered at the beginning and end of the semester.

During the intervention, three rounds of oral interviews were carried out in weeks 2, 6 and 12. All interviews were recorded and transcribed. In every round, students were asked about the assignment, feedback, research achievements, difficulties experienced, and feelings associated to them.

All students tackled the same course version. Following the course syllabus, six assignments were designed by the teacher. Depending on the length and complexity of assignments, students were given one or two weeks to submit them through an on-line learning platform. They were encouraged to review supplementary material and to ask for guidance from the teacher and researchers, who were available in the on-line platform as course assistants.

For our research purposes, assignments were graded by the researchers on the base of a rubric. Students received qualitative feedback on their submissions, which were discussed during the interviews. Improvement chances were given to all the students, but few of them submitted new assignment versions. Rubrics, including their grades were sent to students by the middle and end of the semester.

IV. Analysis

NVivo (version 12) was used to analyze the interview data. The coding scheme focused on finding indicators referring to research competences (RC), autonomous motivation (AM) including autonomy, competence and relatedness; and self-efficacy (SE) involving mastery of experiences, vicarious experiences from social models, social persuasion and emotional and physiological states.

During coding, positive and negative comments for AM, SE and RC were coded separately. Next, we considered students' AM statements in terms of autonomy, competence and relatedness. Similarly, for SE coding continued with a focus on the four underlying SE-sources.

Intra-rater reliability was calculated by repeating the coding by the same researcher, but 10 days later. Cohen's kappa values reflect a high degree of intra-rater reliability:

$K_{AM_positive}$=.89, $K_{AM_negative}$=.85, $K_{SE_positive}$=.90, $K_{SE_negative}$=.0.93, $K_{RC_positive}$=.93,

$K_{RC_negative}$=.91.

$K_{AM_Autonomy}$=.80, $K_{AM_Competence}$=.91, $K_{AM_Relatedness}$=.91, $K_{SE_Mastery_Experiences}$=.90, $K_{SE_Vicarious_Experiences}$=.93, $K_{SE_Social_Persuasion}$=.91, $K_{SE_Emotional_Physiological_States}$=.86.

V. Results and Discussion

1.What is the specific effect of engaging students in an RBL graduate course on their research competences?

Based on data from the pre/post-research competency tests, course assignments and interviews, the results reflect a clear development of specific research skills.

Table 2 summarizes average test scores and assignment grades in connection to competences organized following the research cycle. The table also gives a first indication of findings based on the analysis of the interviews by showing the number of positive and negative indicators identified in the interviews.

Table 2: *Average test scores, assignment grades and number of positive and negative indicators based on the analysis of interviews*

Research competences	Grades (average)			Interviews	
	Pre-test scores	**Post-test scores**	**Assignments grades**	**Positive**	**Negative**
Identify community problems, explore questions and objectives	0.7/2	1.75/2	7.4/10	31/44	13/44
Select approaches, propose research hypotheses and/or questions.	0.3/1	0.7/1	6.6/10	14/33	19/33
Choose research methods and design instruments.	1.3/2	1.7/2	5.4/10	6/15	9/15
Collect and analyze data.	-	-	6.3/10	7/17	10/17
Interpret data, write up findings and prepare research papers.	-	-	5.3/10	16/30	14/30
Present findings and identify further research questions.	0.7/1	0.8/1	7.2/10	6/8	2/8

In general, students' post-test scores are higher compared to pre-test scores. In relation to the identification of community problems, exploration of questions and objectives, assignment grades demonstrate that students had a quite acceptable performance, suggesting a potential improvement in these competences by the end of the semester. This is also reflected in the large number of positive indicators such as "I feel capable to identify a problem", "I have made progress in the identification of research problems" in comparison with negative "identifying the problem is my weakness" or "I had many doubts to identify the research problem".

The fact that two assignments fully focused on problem identification and the subsequent feedback students got from tutors, could have enhanced this competence as reflected in: "Identifying the problem the first time took me longer than the second", "Identifying the problem was much easier in the following assignment because of the feedback I received". Also, problem identification was again included in other assignments such as the literature review and research proposal, which may have provided students with sufficient practice opportunities. This reinforces the importance of iteration in research practice (King & Edlin, 2016; Corwin et al., 2018) given that repetition might help students to emphasize and reflect on their research competences

(Pantoya, Hughes, & Hughes, 2013). As stated by Hurst et al., (2019) the more research students carry out, the more they become experts.

Concerning the selection of approaches and putting forward research hypotheses/ questions, students showed improvement in terms of test scores. However, when asked about the assignments, most reported having encountered difficulties; such as (1) lack of clarity of supplementary material: “I still have doubts about the research questions, the supporting material is confusing”, “Some supporting material for the research questions was provided, but not explained”, “I need additional supporting material on how to write research questions”; (2) poor skills: “Writing a research question is complex, I had to re-do it many times”, “I was unsure about how to write research questions”, “I couldn’t write a research question according to the literature” and (3) low performance: “I didn’t expect such a poor grade in research questions assignment”, “My performance in this assignment definitely went down”. These drawbacks limited the development of the aforementioned research competences given that students were not able to complete tasks fruitfully (Mullan et al., 2014), which is also evidenced in their lower grades. This advocates the need for research guidance (Cunningham et al., 2016; Lehtinen & Viiri, 2017; Sun, Tian, Huynh, & Nakamori, 2018) and tutors’ assistance when students conduct research (Levy & Petrulis, 2012) provided that sometimes they are not able to develop research competences independently (Hardat, Greven, & Schroeder, 2018). Therefore, it is crucial that students are regularly monitored by tutors in order to get the most from research activities (Obwegeser & Papadopoulos, 2016).

Regarding the selection of research methods, instruments design, data collection and analysis, interpretation of findings and identification of further research questions, they were all integrated in 2 main assignments: literature review and research proposal. In this regard, students stated that earlier assignments helped them to be prepared for these assignments as reflected in “Experience in past assignments, helped me to gain more research knowledge”, “I found the connection between the assignments, so it was easier”. However, they struggled to succeed in all the aforementioned competences, as shown in table 2. Reported difficulties were (1) task length: “I couldn’t include all the articles for my literature review”, “The research proposal was complicated because it was too long” and (2) poor writing competences: “My weakness is writing articles”, “I need to develop writing abilities and organize my ideas”. The latter was also reflected in students’ competency to write an abstract: “Structuring an abstract is my weakness”, “I expected a higher grade in my abstract assignment”.

A possible justification for the above findings might be explained as follows: Firstly, time seems to be a recurrent issue in RBL practices in view that research tasks usually demand quite a lot of time (Woolf, 2017). Secondly, research writing appears to be challenging for most students as it involves autonomous competence development and accountability for their own improvement (Smirnova, 2016). Students' indicators concerning their writing competences, reflect a poor perception of them; probably due to limited knowledge about academic writing of proposals and articles (I. Saeed, Khan, Bari, & Khan, 2018). This reiterates the need to increase research experiences within graduate courses (Stanley & Lewandowski, 2016) considering the importance of scientific writing as a way to share research results beyond the classroom context (Walkington, Hill, & Kneale, 2017).

RQ2: What is the effect of engaging students in an RBL graduate course on their research competences considering changes in autonomous motivation (AM)?

Interview data suggest a relationship between students' research competences and increased autonomous motivation (AM); especially when looking at indicators reflecting student autonomy and competence. These findings are in line with authors stating that higher student motivation as well as improved learning results can be achieved through research-based learning (Blume et al., 2015).

Table 3 summarizes the total of AM related indicators; split up along the axis positive-negative. The axis addressing the three basic psychological needs and a third axis focusing on the week 2, 6 and 12. The number of indicators increases when looking at the latter axis. This increase is nearly consistent in both the positive and negative indicators and in each psychological need.

Table 3: *number of indicators related to autonomous motivation constructs*

	Autonomy		Competence		Relatedness	
	Positive	Negative	Positive	Negative	Positive	Negative
Week 2	11/14	3/14	17/25	8/25	11/18	7/18
Week 6	16/23	7/23	17/31	14/31	11/20	9/20
Week 12	20/30	10/30	19/34	15/34	9/28	19/28
Total	47/67	20/67	54/90	36/90	31/66	35/66

Number of indicators in relation to total

When it comes to Autonomy, the number of positive indicators exceeds the number of negative indicators in each interview round: "I evaluate research papers and see if they

are of my interest", "I like to investigate using my own resources" and "I like to choose my research topic" versus: "The article selected by the teacher, did not get my attention" and "I felt forced to do the assignment, another topic would have been more enjoyable". Students tend to develop research skills when involved in activities allowing them to choose what to investigate based on preferences. As stated by Hagger et al. (2015) and Dwyer et al. (2017), giving students choice is critical. Although course activities are usually mandatory, offering choice in e.g. research topics and/or group set-up gives them a voice; and boosts their autonomy (Deci & Ryan, 2013; Rosenkranz, Wang, & Hu, 2015).

Looking at Competence, students' positive indicators in the second interview round, greatly outnumbered negative ones: "I can now read and interpret articles faster than I did before", "I felt competent to formulate research questions", "I am more capable to identify research problems". This initially denoted strong confidence in their research capabilities. However, we observe an increase in negative indicators in the next interview rounds: "I could not develop the research proposal correctly", "I didn't know how to write an abstract for a research paper", "I had trouble to write up research findings". This seems to be reflected in students' weaker performance in assignments involving these competences, as displayed in table 2. Though the number of students' positive and negative indicators is nearly the same, their achievement is less satisfactory. This suggests an over-estimation of their actual mastery, in which effort and time spent in earlier assignments do not always lead to improved performance (Hirshfield & Chachra, 2019). It also contradicts the idea that individuals with high positive perceptions are more likely to succeed in academic endeavors (Chiniara & Bentein, 2016). This inconsistent result can be explained as follows. On the one hand, getting regular feedback and the possibility to enquire about the quality of their work and make improvements could have increased students' competence (Niemiec & Richard, 2009; Odena & Burgess, 2017); see indicators such as: "I can write a better abstract because I know where I failed", "I feel more competent after learning from past assignments". On the other hand, as stated by Woolf (2017), dealing with tasks involving multiple research competences during short periods of time might be detrimental: "I was not able to write my findings correctly because of the short time I had", "I couldn't select research methods properly because I was busy with other assignments" could have affected their competence. This is because growing difficulty levels, alongside heavy work load and time pressure could have cause increased cognitive load in students, interfering with their performance (Sweller, 2011). Again,

this suggests that students should be guided and supported in their competences (Israel, Shehab, & Quentin M., 2018) particularly if they are expected to succeed in conducting research within limited periods of time (Risku, 2016).

Regarding Relatedness, the number of positive indicators in the first two interview rounds is barely larger than the negative ones: “I feel supported and this helps me to continue in the course”, “I could manage difficulties with my classmate’s assistance” versus “Nobody helped me but I found the way to do it”, “I don’t compare my assignment with classmates because it is not useful”, “They cannot support me the way I need, I prefer to do research alone”. Moreover, it seems that communication among students was rather poor towards the end of the course with increasing negative indicators in the last round. These did not only grow in number but became quite unpleasant: “I don’t feel any emotion to talk my classmates”, “I don’t even say hello to them”, “I don’t interact with them, they are narrow-minded”. “There is no time for interactions with my classmates” As stated by Reis, Sheldon, Gable, Roscoe, & Ryan (2018), the need for relatedness is not satisfied when there is absence of relevant talks, empathy and appreciation by others. Being weakly related certainly affected students’ research competences for choosing research methods, collecting data and preparing research papers, as shown in the course assignment grades in table 2. This confirms that students who feel well-integrated in a group can achieve more (Van den Broeck et al., 2008) and that being warmly backed and recognized by others seem to be of great importance for learning benefits (Amato et al. 2016; Bürgermeister, Ringeisen & Raufelder, 2016). Students might have been less autonomously motivated in their research competences due to the scarce chances to build encouraging relationships (Ruzek et al., 2016).

RQ3: What is the effect of engaging students in an RBL graduate course on their research competences considering changes in self-efficacy (SE)?

Table 4 reflects varying numbers of indicators as to the impact of the intervention on the 4 sources of SE.

Table 4: *number of indicators related to self-efficacy sources*

	Mastery Experiences (ME)		Vicarious Experiences (VE)		Social Persuasion (SP)		Emotional & Physiological States (EPS)	
	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Week 2	14/19	5/19	13/15	2/15	13/13	0/13	19/23	4/23
Week 6	18/29	12/29	11/17	6/17	10/12	2/12	14/24	10/24
Week 12	21/25	4/25	14/16	2/16	18/19	1/19	21/31	10/31
Total	53/73	21/73	38/48	10/48	41/44	3/4	64/78	24/78

Number of indicators in relation to total

Increasing numbers of positive indicators are observed in ME: “Before I was not able to state a research problem but now I could easily do it”, “Based on previous practice, I am confident to write an abstract and research questions”, “The feedback has helped me to understand how to write abstracts”. These vastly outnumbered negative indicators: “I did the literature review twice and I still have doubts”, “I read the article four times but identifying the research problem was difficult”.

Again, feedback seems to be important and the active use and discussion of the rubrics. As acknowledged by Bruning & Kauffman (2015), the information students get regarding their competences and the quality of their performance helps increasing their self-efficacy. This is in congruence with other authors’ findings concerning the positive influence of mastery experiences on students’ study-related research competences. (Kaya & Bozdag, 2016; Vishnumolakala et al., 2017; Webb-Williams, 2018).

Another interesting result is the positive influence of vicarious experiences from role models throughout the course. This is evidenced in indicators such as “When I see that my classmate achieves something, I try to do the same”, “It motivates me to try to develop competences like my classmates”, “When somebody is doing something well, I try to follow the same method”. As studied earlier by Lau et al. (2018), a vicarious experience is key to boost individuals’ self-efficacy especially when there is a clear connection between the person acting as a role model and the bystander (Ahn et al., 2016). In this study, such connection appears to be determined by students’ emotional and academic affinities: “Some classmates help me to get other perspectives

in research", "I like that a classmate who knows about the field, reads my assignment". It seems that having assignments reviewed by peers made students feel more confident about their work. This is in line with Lyman's ideas regarding the positive effect of peers' support on students' research self-efficacy (2019).

Given that most students labeled themselves as "novices" in research, - see indicators such as "It is the first time I'm actually doing research activities", "I have no experience in research" - they often intended to work closely with those who were perceived contributing to their learning: "I like to talk with people who know about research", "I only discuss the assignment with this classmate, not with the rest of the class". As mentioned by Schunk & Pajares (2009), people naturally aim to work with others who possess competences they wish to develop and that may influence their actions. Novice students are as such influenced by more experienced peers who they consider to be more competent (Ahn, Bong & Kim, 2017). It seems that witnessing how others succeed in a particular task provide the observer clear guidance on how to conduct the same task with a similar outcome (Schunk, 1995).

From the reported indicators regarding social persuasion, it is clear that most students were persuaded to develop research competences by their course teacher and other academics. Feedback on the assignments and discussions with the teacher and researchers might have contributed to this: "Feedback provided me confidence in my research competences", "The teacher gave me some hints so I could write the research questions", "I have improved my competence to write a research proposal due to the feedback I got". Therefore, feedback that includes recommendations, words of support and performance validations, promote students' efficacy (Bruning & Kauffman, 2015). This may have incited in learners a feeling that their tutors trust their present capabilities and see their potential for improvement. Moreover, the high level of satisfaction about the quality of teacher instructions may have persuaded them to comply with research activities: "I like my teacher's methodology, she tries to improve our research competences", "The teacher has a lot of research experience and that helps me to understand", "She has motivated me to develop research competences and now I want to apply for a doctorate degree". This is in line with Butz and Usher (2015) who stress that the way instructors shape their teaching and structure their feedback positively influences students' research self-efficacy.

More positive indicators were found about students' emotional and physiological states: "I felt happy when I could send my research proposal", "I'm motivated as I am learning about research" versus "When I received the rubric, I felt disappointed", "I was a bit frustrated about the abstract". As reflected in the indicators, students felt excited, determined and motivated to develop or improve their research competences in spite of difficulties. It seems that these emotional circumstances play a crucial role when self-assessing their research competences. Therefore, students' positive attitudes apparently lead to higher perceived efficacy (Bandura, 1994) whereas anxious emotional reactions towards tutors' feedback or their own performance might cause the opposite effect (Carter & Kumar, 2017).

VI. Implications

The theoretical model generated for the present study, which relies on the Theory of Self-efficacy (Bandura, 1994) and the Self-Determination Theory (Deci & Ryan, 1982) can serve as a contribution for implementing future studies aiming to explore interaction variables.

From a practical perspective, this intervention highlights the crucial role of feedback in a RBL setting. Results from this study along with earlier findings (Vásquez & Harvey, 2010) relate constructive feedback to the development of self-confidence and as a source of motivation in research (Jonassen, 2004). Future researchers should aknowledge the direct influence of feedback and incorporate it appropriately when designing a RBL intervention.

Furthermore, we are providing a validated research instrument model such as a semi-structured interview involving elements from our interaction variables. Instructors and researchers might use this instrument, which was initially tested and adapted to the context of their classes.

As part of our implications for policy and practice, we would inform program leaders about the need to not only on a single course, but to focus on a program. This way it would be possible to see students' competence development from one course to the next. In the case of this research study, we could not explore students' research production given the limitations of time.

VII. Limitations and Directions for further research

The present study has several limitations. First, the reduced number of students included in the sample might limit the scope of our research. This is why, it is suggested to join courses of the same nature or with similar characteristics.

Second, the weak research background from some students from the sample may have also affected our intervention. Although we implemented RBL in a research-oriented master course, no specific level of research knowledge was requested. This is why some of students in the sample had never participated in research before. It was evidenced in their class performance and in the outcomes of their research tasks. This could have brought together feelings of satisfaction and frustration at the same time, causing imbalance between positive and negative comments; and thus, affecting their levels of self-efficacy and autonomous motivation to conduct research. It is advised that all the students have some kind of initial training aiming to prepare them for the upcoming research tasks throughout the course.

Even though the intervention took a complete semester, it was not possible to focus on all the research cycle stages, especially those related to research production. It would be desirable to conduct follow up studies to explore how the same sample put their research competences into practice in subsequent courses. In these further studies, we could emphasize the production of research material for conferences or journals.

VI. Conclusion

The present study adds to the literature by emphasizing reasons why the implementation of RBL in graduate courses has an impact on students' research competences along with positive changes in their autonomous motivation and self-efficacy. Qualitative data seem to explain the nature of the relationship between the research variables: research competence, autonomous motivation and self-efficacy. This is promising and can inspire future RBL research involving mixed-methods designs and larger and differing student populations. In this way, the incorporation of RBL at graduate level could make an exceptional impact on the quality of teaching and learning in higher education.

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Chapter 6
General Discussion and Conclusions

Chapter 6
General Discussion

Abstract

The general aim of the present dissertation was to gain insights into Teaching-Research nexus (TRN) implementations that move towards Research-Based Learning (RBL) in order to redesign the existing curricula in a public Ecuadorian university. We assumed that adopting RBL would have an impact on university students' intention to do research and research competences; considering its interplay with autonomous motivation and self-efficacy.

To pursue this aim, we conducted three different empirical studies. This final chapter summarizes and integrates the main findings of these studies with a focus on the research objectives, hypotheses and research questions. Next, we present a general discussion of the most relevant findings. Finally, we describe the limitations of the studies in view of the proposed research objectives, leading to concrete directions for future research along with recommendations concerning RBL settings at university level. Similarly, we discuss the theoretical, methodological and practical implications for RBL implementation.

I. Introduction

In the last years, the role of higher education has gained importance due to its impact on professional competences currently required in the labor market (McGuinness, Whelan, & Bergin, 2014). Therefore, universities are expected to train graduates in a way they can develop broader capabilities which match the society demands (J. Hill, Walkington, & France, 2016). To achieve this objective, universities are shifting their focus from transfer to production of knowledge by promoting research (Mägi & Beerkens, 2016a). This is why, the relationship between teaching and research, known as teaching-research nexus, in higher education institutions, seems to be crucial (Ahammed, Hassanli, Iqbal, & Corcoran, 2017; Clark & Hordosy, 2019; Bajjaly, Tang, Julien, & Wolfram, 2018).

Different expressions of the TRN have been reported in the last years, aimed at promoting students' research spirit (Y. Li, Li, Yang, & Li, 2019) spreading current knowledge and improving subject learning (Pai & Chiplunkar, 2019).

Available literature also highlights that TRN may serve to enhance students' research competences, willingness to be involved in research tasks (Brennan, Cusack, Delahunt, Kuznesof, & Donnelly, 2019a) and intentions to pursue further research in

their professional life (Griffioen, 2019). However, findings concerning the effectiveness of TRN are still questionable (Hancock, Marriott, & Duff, 2019). As stated in the introductory chapter, despite the attempts universities make to incorporate TRN, there is an ongoing debate whether teaching and research should be integrated or remain disassociated (Edelheim, 2017; Shin & Kim, 2017; Duff & Marriott, 2017).

On the one hand, TRN appears to improve teaching as it relies on up-to-date research in the study field to stimulate students' research competences (Limniou & Mansfield, 2019). It is also suggested that students may perceive TRN as an advantage to their learning (Jusoh & Zainal Abidin, 2017) even if academics highlight research involvement over their own teaching (Griffiths, 2018).

On the other hand, recent literature reports that giving more attention to research than to teaching may be perceived as negative due to academics' limited availability to monitor students' learning (Lineweaver & Bergeson, 2019). Furthermore, it seems that TRN has mostly been adapted in a nonspecific way which does not consider specific subject-contexts (Griffiths, 2004) creating tensions in academics (Martin Daumiller & Dresel, 2018).

As explained in earlier chapters, an appropriate TRN implementation at university level is vastly needed. Therefore, in the present dissertation, Research-Based Learning (RBL) has been proposed as an effective approach, which seems to engage students in different stages of the research cycle where they can conduct authentic research (Griffiths, 2004). Previous studies report that RBL can successfully be applied in several knowledge fields involving science (Prahmana, Kusumah, & Darhim, 2017; Tohir, Abidin, Dafik, & Hobri, 2018) among others (Charitas, Prahmana, & Yaya, 2016; Gredig & Bartelsen-Raemy, 2018).

RBL benefits have been previously reiterated. These are associated to students' learnings gains, which are reflected in higher course grades compared to students in non-RBL settings (Usmeldi, 2018). Besides students' improved performance, their engagement in research tasks can also enhance their research competences from generating a research question, planning and conducting research tasks to presenting findings along with the ability to think rationally (Susiani, Salimi, & Hidayah, 2018).

This dissertation has focused on RBL practices involving both undergraduate and graduate students. This is clearly justified by Sumbawati & Anistyasari (2018) who state that undergraduates' exposure to RBL can enhance motivation leading to

educational success as they get more familiar with scientific material and appreciate the worth of research (Whittle, 2019). Similarly, graduates' participation in RBL seems to contribute not only to the achievement of learning aims but also to the development of a scientific mindset and a great number of research competences (Amelia, 2018b).

In the Ecuadorian context, there is a current need to overhaul university programs and turn them into more research-oriented. Hence, the adoption of suitable TRN methodologies is required. This is why the present dissertation focused on the incorporation of RBL in a public Ecuadorian university, where program renovations are taking place, aiming to intensify research in students' scholarship.

The general aim of this dissertation is to gain insights about the nature of RBL and its impact on university students' intention to do research and research competences. To achieve this objective, we conducted three empirical studies, centered on two main variables: students' intention to do research and research competences.

Other significant variables – such as autonomous motivation, self-efficacy (perceived behavioral control) and precursors of intention (subjective norm, behavioral beliefs) – were also examined. On the basis of the results, we discuss the main findings in detail in every chapter.

To accomplish the general aim of this dissertation, the following research objectives were addressed:

Research Objective 1 (RO1): Build an RBL scoping review in engineering and science education.

Research objective 2 (RO2): Evaluate the impact of RBL on students' intention to do research.

RO2 was subsequently addressed by stating two objectives:

> **Research Objective 2a (RO2a):** Evaluate the impact of RBL on graduate students' intention to do research considering changes in autonomous motivation, perceived behavioural control, behavioural beliefs and subjective norms; and the interaction with age and gender.
>
> **Research Objective 2b (RO2b):** Evaluate the impact of RBL on undergraduate students' intention to do research considering changes in autonomous motivation, perceived behavioural control, behavioural beliefs and subjective norms.

Research Objective 3 (RO3): Evaluate the impact of RBL on students' research competences.

RO2 was subsequently addressed by stating two objectives:

> **Research Objective 3a (RO3a):** Evaluate the impact of RBL on undergraduate students' research competences, considering changes in autonomous motivation, perceived behavioural control, behavioural beliefs and subjective norms.
>
> **Research Objective 3b (RO3b):** Evaluate the impact of RBL on graduate students' research competences, considering changes in autonomous motivation and self-efficacy.

Figure 1 presents an overview of how the research objectives are tackled throughout the three empirical studies in this dissertation. Next, we present a summary of main results from each study in connection with the research objectives. The main findings of chapter 2 are provided to address research objective 1. The findings of chapter 3 and 4 concentrate on research objective 2 whereas the findings of chapter 4 and 5 tackle research objective 3.

The third section of this chapter presents a general discussion of the main findings. Additionally, the fourth section outlines the theoretical and practical implications of the whole research experience. The fifth section of this chapter deals with research limitations in this dissertation. These limitations along with some of the most relevant findings lead to directions for future research, which are described in the sixth section. A final conclusion is presented at the end of this dissertation.

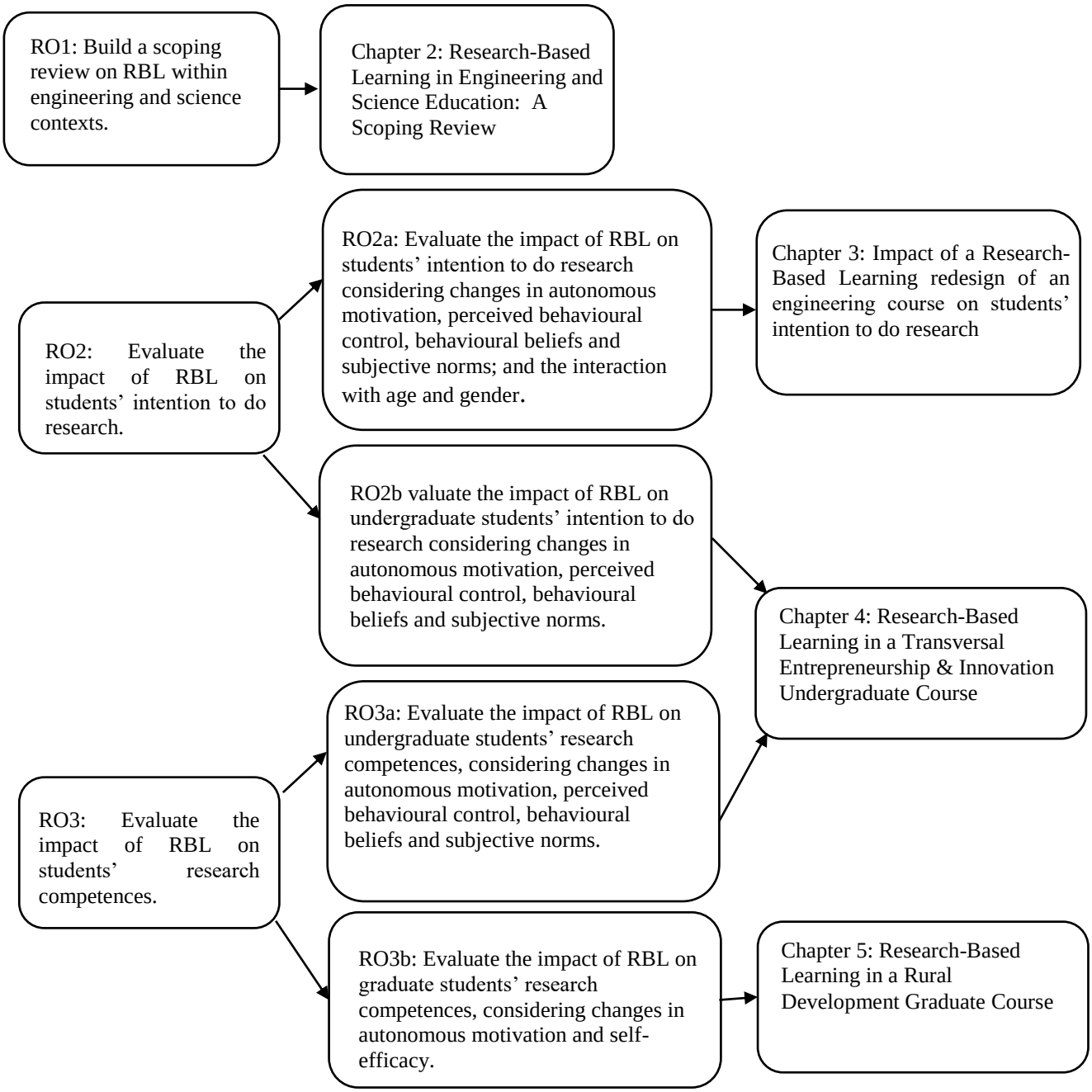

Fig 1. Overview of research objectives in relation to dissertation chapters.

II. Overview of the main results related to the research objectives

In this section, we summarize the main findings of each empirical study linked to the research objectives. Further information was provided in each of the preceding chapters.

Research Objective 1 (RO1): Build an RBL scoping review in engineering and science education.

To address research objective 1, a scoping review of empirical work on RBL was conducted. This review, which comprised a time frame from 2000 to 2017, reports earlier RBL studies focused on students' research competences, nature of RBL instruction according to Brew's framework (2013), benefits, challenges and suggested actions for improvement. It followed the five-stage framework of Arksey and O'Malley (2005). Four electronic databases were consulted to identify peer-reviewed literature written exclusively in the English language. Initially, the search identified 5,607 studies. However, after rigorous examination, only 47 studies met the inclusion/exclusion criteria and were subject of further analysis. The main findings concerning students' research competences put forward a robust emphasis on nearly all stages from the research cycle. However, "conducting research", "analyzing and interpreting results" and "communicating findings" were mostly emphasized in most studies. Regarding the nature of RBL instruction following Brew's framework (2013), it was found that most pedagogical issues are decided by teachers or negotiated with students, especially in studies conducted from 2012 onwards. The most stated RBL benefits were: research competences development, learning performance enhancement, course appreciation and research self-efficacy. About RBL challenges, low interest in research due to high levels of difficulty, lack of research training and time limitations were reported. The implementation of comprehensible research courses for beginners, which provide enough time for actual research along with regular assessment, were strongly suggested to improve the RBL experience.

Research objective 2 (RO2): Evaluate the impact of RBL on students' intention to do research.

To achieve research objective 2, two studies were conducted at a public Ecuadorian university. The first research study, reported in chapter 3, followed a pre/post-test experimental quantitative design and involved Engineering and Science graduate students. It explored students' intention to do research when involved in a redesigned RBL course compared to students in a regular version of the same course. At the same time, it was hypothesized that other variables such as autonomous motivation, and constructs from the Theory of Planned Behaviour (TPB): perceived behavioral control (self-efficacy), behavioral beliefs and subjective norm, considered as precursors of human intention, may interact with the effect of RBL. Additionally, the possible interaction effect of gender and age was assumed. Research instruments such as

scales, were developed following the framework of the Self-Determination Theory (Deci & Ryan, 1980), Self-efficacy Theory (Bandura, 2010) and TPB (Ajzen, 1991) and then adjusted to the context of the research.
The findings of this study reflected RBL students' slightly higher intentions to do research compared to control students. However, it was not possible to confirm our hypotheses, from a statistical point of view in any of the measured variables.

Research study 2, which also addresses RO2, is reported in chapter 4 of the present dissertation. It followed a similar research design but involved Entrepreneurship and Innovation undergraduate students. Again, our aim was also to explore the differential effect of RBL on students' intention to do research when involved in redesigned RBL courses compared to students in a regular version of the same course.

Building on Brew's research framework (2013) to define the nature of RBL in regards to amount of research instruction, students were randomly assigned to 3 conditions: structured RBL, semi-structured RBL and control. Research instruments designed for study 1 were adjusted to the new setting of the research.

Once again, increased students' intention to do research and its interactions with other variables could not be statistically confirmed.

Research Objective 3 (RO3): Evaluate the impact of RBL on students' research competences.
Research studies 2 and 3, reported in chapters 4 and 5 respectively, address RO3. Firstly, study 2 involving Entrepreneurship & Innovation students, intended to explore the impact of RBL on students' research competences. Additionally, we intended to confirm such impact along with changes in autonomous motivation, self-efficacy and constructs from Theory of Plan Behaviour (Ajzen, 1991). Research instruments designed for study 1 were adapted to the new research context in study 2. To measure students' research competences, 10 weekly assignments involving stages of the research cycle proposed by Jungmann & Ossenberg (2014) and the entrepreneurial cycle advocated by Brush et al., (2003), were designed. Results indicate that there was a significant RBL effect on students' overall research competences and in specific research comepentence clusters.

Secondly, qualitative data were collected in study 3 to also achieve R03. It was conducted in a public Ecuadorian university and involved a total population of 6 students from a Sociology and Rural Development graduate course. This study

explored the impact of RBL on the development of students' research competences and its interaction with other variables such as autonomous motivation and self-efficacy. Our assumptions were based on two theoretical frameworks: Self-Determination Theory (Ryan & Deci, 2017) and Self-efficacy (Bandura, 1977).

A research competency test was designed and administered at the beginning and end of the 14-week semester. During the intervention, three rounds of interviews were conducted in weeks 2, 6 and 12. The aim of this interview was to examine students' views regarding their research competences, levels of confidence and autonomous motivation to conduct research. Questions from this interview focused on the four sources of self-efficacy from Bandura's Self-efficacy Theory, (1977) and the three basic psychological needs from Deci & Ryan (1982). In every round of interviews, students were asked about their performance in the course, assignments' feedback, difficulties found and feelings connected to them.

All students followed the same version of the course. Six assignments, involving research-based tasks, were designed by the course teacher in accordance with the syllabus.

Overall, the main findings in this study reflect an impact of the RBL intervention on specific students' research competences along with positive changes in their self-efficacy. Although the results for students' autonomous motivation showed some negative trends regarding their relatedness, we concluded that these did not heavily affect learning.

III. General Discussion

In this section, we discuss the major research findings from the three empirical studies presented in chapters 3, 4 and 5 from a more generic perspective. Particular emphasis is given to the nature and design of RBL instructional activities that were set up as part of our interventions. Next, we look at the strengths and challenges resulting from the study design when aiming to analyse students' intention to do research and the development of research competences.

The inconclusive impact of RBL on intention to do research

Based on our theoretical assumptions, we expected that students involved in an RBL version of a course would reflect higher intention to do research as compared to students in the control condition version of the same course.

Although our main findings reflected a positive trend concerning RBL students' slightly higher intentions to do research in comparison with control students, differences were not statistically significant in either study 1 or 2. This is not consistent with previous research pointing at students' participation in research as one of the main factors that determines their intention to pursue further research opportunities (Willison & O'Regan, 2007; Hernandez, Woodcock, Estrada, & Schultz, 2018; Shuster et al., 2019).

This inconclusive impact of RBL on students' intention to do research seems to be associated to shared design characteristics in both interventions. Considering the nature of the courses involved (engineering, science and entrepreneurship), which seem to require the research competences development in compliance with their goals (Brush et al., 2003; Missingham, Shah, & Sabir, 2018; Ponce, Ibarra, Mata, & Molina, 2019), all students may have been pushed to conduct research at a basic or more advanced level. Therefore, research was fostered in all students, irrespective of their research condition, boosting their research spirit and consequently, their intention to do research (Corwin et al., 2018).

As for study 1, two other factors may have influenced the non-significant results. Firstly, the limited duration of the RBL intervention might have hindered students' intention to pursue research. Apparently, long-duration research experiences have a stronger impact on students' intention to participate in research compared to one-semester experiences (Hernandez et al., 2018).

The second factor that might have influenced the results is a lack of specialization focus of the RBL design that had to comply with the broad content focus of different courses involved in the study. This led us to use standard material, not related to the career field. As stated by Willison (2012), research tasks should be explicitly connected to students' branch of knowledge rather than designed in a general context. This lack of connection between RBL tasks and students' knowledge domain, may have decreased their intention to pursue research given that the RBL experience was not significant or appealing to them (Reich et al., 2017).

RBL as a bridge to develop students' research competences

Following available theoretical and empirical research, we assumed that students' involvement in an RBL version of a course would have an impact on their research

competences. We explored this assumption in two studies, set up in two different knowledge domains and using quantitative and qualitative approaches.

In study 2, we explored the impact of RBL on students' research competences, from a quantitative perspective. We assumed that students would develop research competences when involved in a structured RBL version of a course compared to semi-structured RBL and control versions of the same course. This was confirmed and seems to fit other authors' findings such as (Emelyanova, Teplyakova, & Boltunova, 2017; Uaciquete & Valcke, 2018; Glazunova, Kuzminska, & Voloshyna, 2018; Gyuris, 2018; Tungkasamit, 2019) who provided evidence that students' research competences are strongly associated to research participation through RBL.

The variable "research competences" was explored in two ways: overall research competences and research competence clusters . The results for seem to differ among conditions. A higher development of research competences was observed in structured RBL students in comparison with semi-structured and control conditions. In the case of research competence clusters, our assumptions were partly confirmed, given that, structured RBL students outperformed the other conditions only in three out of the six clusters: identify research problems, immerse in theory and communicate in research results.

In study 3, we explored the impact of RBL on students' research competences, from a qualitative point of view. Our results showed a clear development of specific research competences: identify research problems, explore questions and objectives. However, in the case of other research competences such as select research methods, design instruments, collect data, analysis, interpretation and presentation of findings, students' struggled to succeed.

We can explain the above results in a number of ways. Firstly, analyzing the structure of the research tasks included in one of the interventions. Although the research tasks were the same for all the conditions, structured RBL students were certainly exposed to explicit RBL instruction and direction. Apparently, the fact that structured RBL students achieved better results than semi-structured RBL and control students is associated with guidance in the research process (Lazonder & Harmsen, 2016).

Students who are guided to carry out research seem to be more likely to succeed in their endeavours (Ganguly, Herald, & Philip, 2016). This is in line with ideas from Lehtinen & Viiri (2017) and Spronken-Smith & Walker (2010) about the importance of structure and guidance when learning through inquiry. Similarly, Kirschner, Sweller, & Clark (2006) highlight that unguided or minimal instruction is not effective, especially when students lack prior knowledge in the field. In this regard, we must take into account that our participant students in study 2 were undergraduates with little or no research experience. This explains their need to be supported and properly directed in conducting research (Levy & Petrulis, 2012). As suggested by Agricola, Prins, van der Schaaf, & van Tartwij (2018), undergraduate students should be supported in the development of their research competences given that they are not acquired intuitively but taught, supervised and assessed critically (Wagner, 2014). This is in line with Brew's proposed undergraduate research framework (2013), concerning steady variations in levels of research autonomy and task structure.

We are aware of the fact that conducting research activities might be demanding for most students and require considerable efforts; which as stated by Sweller (2011) may lead to high cognitive loads. Therefore, the use of instructional procedures which do not provide sufficient guidance or structure to students may result in extraneous cognitive load, affecting students' cognitive resources to process information (Sweller, 2010). This extraneous cognitive load was probably reduced in the structured RBL condition due to a more adequate instruction design (B. B. Morrison, Dorn, & Guzdial, 2014) and less cognitive disturbance (A Schmeck, Opfermann, Gog, Paas, & Leutner, 2015).

Secondly, the non-significance differences found in the three aforementioned research clusters might be connected to their positioning in the course. This is emphasized by Garg & Passey (2018) when they refer to the importance of placing research competences appropriately within the curriculum. Focusing on complex tasks, which require lots of efforts and involve previous knowledge, towards the end of the intervention might have weakened students' cognitive resources, preventing them from performing as expected (Sweller, 2011). Furthermore, as mentioned earlier, the fact that most students lacked prior knowledge connected to the course contents and research, could also have contributed to the non-significant impact of RBL (Ameen, Batool, & Naveed, 2019).

In the case of study 3, participants were graduate students. However, their research background was also weak, especially in research writing. This was reflected in their poor performance when writing a research proposal. This limitation to produce research articles and proposals (I. Saeed et al., 2018) reiterates the need to increase research experiences in graduate courses (Stanley & Lewandowski, 2016) considering the importance of scientific writing as a way to share research results beyond the classroom context (Walkington et al., 2017).

The fact that students were able to succeed only in specific research competences, might be the result of providing students with sufficient practice opportunities in a particular competence. This reinforces the importance of iteration in research practice (King & Edlin, 2016; Corwin et al., 2018) given that repetition might help students to emphasize and reflect on their research competences (Pantoya et al., 2013).

The inconsistent impact of RBL on Autonomous Motivation

The assumption that students' involvement in RBL may have a significant impact on their autonomous motivation could not be fully proved. This contradicts findings from earlier studies which support that RBL can highly motivate students to join research course or take part in further research-related activities (Sumbawati & Anistyasari, 2018; Gredig & Bartelsen-Raemy, 2018; Amelia, 2018).

Our RBL interventions in quantitative studies 1 and 2 did not reflect either statistically significant changes in students' autonomous motivation or a direct impact on it.

In study 1, we could attribute this lack of significant impact to the fact that students in both experimental and control conditions could have felt supported in their basic psychological needs (Ryan & Deci, 2017) by the somewhat innovative nature of research. Although control students did not fully experience RBL, they were involved in TRN activities that seem to have awaken their research spirit in a way (Vereijken, van der Rijst, de Beaufort, van Driel, & Dekker, 2018).

In study 2 we can explain the non-direct impact of RBL on students' autonomous motivation by underlining the low satisfaction of their basic psychological needs. Dealing with a burden of deadlines, insufficient time for assignments, imposed research topics and the absence of encouraging feedback could have undermined students' autonomous motivation to do research (Deci & Ryan, 2013; Chen et al., 2015). As reiterated by Ryan & Deci (2017), the satisfaction of basic needs for competence,

autonomy and relatedness is crucial to keep students autonomously motivated in any task.

Contrary to the above findings, qualitative results from our RBL intervention in study 3 showed somewhat positive changes in autonomous motivation. This could be explained when analyzing to what extent the basic psychological needs where met.

As for autonomy, we could demonstrate that giving students choice in research, stimulate them to develop research competences (Hagger, Sultan, Hardcastle, & Chatzisarantis, 2015; Dwyer et al., 2017). However, the inconclusive impact on competence can be justified by an over-estimation of students' actual capabilities which at first denoted strong confidence in their research competences but in the end didn't reflect the expected performance. It seems that getting effective feedback could have initially increased students' perceived competence (Odena & Burgess, 2017) but again, dealing with complex research tasks plus time pressure might have increased the cognitive load in students, limiting their performance (Sweller, 2011). Similarly, the partial impact on relatedness might be explained by the lack of connection among the students which reiterates that autonomous motivation is low when individuals do not have opportunities to build positive relationships (Ruzek et al., 2016) and feel supported (Amato et al., 2016).

The shifting impact of RBL on Research Self-efficacy

Similar to autonomous motivation, a significant impact of RBL on research self-efficacy was not found in both quantitative studies 1 and 2. However, positive changes were reported in our qualitative study 3. The former contradicts earlier studies that support the positive interplay of RBL with self-efficacy (Böttcher & Thiel, 2018; Uaciquete & Valcke, 2018; Glazunova et al., 2018; Gyuris, 2018).

As for studies 1 and 2, we may attribute the lack of impact to students' limited research knowledge. This was particularly evident in study 2 where participants were undergraduate students who were scarcely familiar with research. As explained by Rosenkranz, Wang, & Hu (2015) and Hardat, Greven, & Schroeder (2018), novice students confronted with mandatory research tasks might experience uncertainty and decreased confidence to conduct research.

Another reason could be the short duration of the RBL intervention especially in studies 1 (6 weeks) and 2 (7 weeks) compared to study 3 (14 weeks). In this regard, Woolf (2017) acknowledges that time allotted for research activities must be adequate; otherwise it might lead to unnecessary negative emotional reactions that might deplete students' research self-efficacy (Carter & Kumar, 2017).

A third reason is probably the insufficient feedback provided to students in relation to their research competences, which did not allow them to monitor their own progress. This confirms that feedback that provides students' work validation, reassurance and advise to improve might boost self-efficacy (R Bruning & Kauffman, 2016).

Contrary to the above, study 3 results validate earlier assumptions regarding students' self-efficacy on the link between RBL and their aspirations to be involved in research activities (O. A. Adedokun, Bessenbacher, Parker, Kirkham, & Burgess, 2013b). It seems that students' research competences were certainly determined by positive changes in Bandura's four sources of self-efficacy (1977). The fact that students interacted more with tutors and received regular feedback on their performance could have contributed to achieving higher self-efficacy compared to studies 1 and 2. Apparently, when students feel persuaded to engage in research activities by their tutors or peers, they appear to develop self-confidence in their capabilities (Limniou, Mansfield, & Petichakis, 2019).

What about RBL impact on precursors of intention?

Comparable to the results for the variable "intention to do research", we could not observe positive changes in its precursors: behavioral beliefs, subjective norms and perceived behavioral control (already discussed as self-efficacy) in any of our two quantitative studies. This might be related to the lack of overall impact of RBL on intentions to do research, which made it less achievable to observe statistically significant differences. This is not congruent with previous findings concerning the effect of behavioral beliefs or attitudes and subjective norms to predict intentions and further behaviors (Ajzen & Fishbein, 1969; Utami, 2017; Mueller, Barrett, Wildermuth, Ferich, & Graefe, 2018; Kim, Kim, Choi, & Ham, 2018).

IV. Implications

In this section, theoretical, empirical and practical implications to the field of Research-Based Learning are presented.

4. 1. Theoretical Implications

At the theoretical level, the present dissertation built on the Theory of Planned Behavior (Ajzen, 1985b) to explain how students' intentions to do research can be predicted from their behavioral beliefs or attitudes, subjective norms and perceived behavioral control; resulting in the actual development of research competences, as expected behavior. Additionally, we relied on the Self-Determination Theory (Deci & Ryan, 2002) to address autonomous motivation and the Self-Efficacy Theory (Bandura, 1977) to explain research-self-efficacy, associated to perceived behavioral control in our dissertation.

Previous findings confirm that TPB serves as an appropriate framework to understand how intentions are formed and how they could eventually turn into behaviors within learning contexts (Steinmetz, Knappstein, Ajzen, Schmidt, & Kabst, 2016; Sutter & Paulson, 2017; Burns, Houser, & Farris, 2018). However, in none of our quantitative studies we could prove the expected impact of RBL on intentions to do research. This calls for further empirical research to validate these inconsistent results. Moreover, this suggests further approaches to explore the variable "intentions to do research", which do not only involve self-reported measures but include more verifiable approaches. It seems that relying on the use of self-reported measures might sometimes lead to subjective results. A possible bias in students' responses might not reflect their actual intentions but what they assume is academically expected from them (Fei, Lin, & Zhixin, 2018).

Concerning the other theories, similarly, our hypotheses related to the interplay of RBL with autonomous motivation and research self-efficacy could not be proved either. However, our qualitative findings were well supported in each of the elements comprised in the theories. It seems that in some cases, a qualitative approach could mirror students' RBL experience more effectively beyond quantifiable data (Buchanan, Harlan, Bruce, & Edwards, 2016). It might be suggested to address future studies involving the variable "intentions" by using mixed method approaches.

4. 2 Empirical implications

From an empirical point of view, this dissertation provides reliable information, and data based on innovative RBL implementations taking place in Ecuadorian Higher Education. Prior attempts to adopt a teaching research nexus were limited to exploring models and methodologies from a theoretical point of view (Vergara et al., 2016;

Maldonado, Bermeo, & Carvallo, 2016) promoting research in national universities, especially among academics (Van Hoof, Cueva, Fan, Cordero, & Farfán, 2014), but without clear guidance, expertise and authentic experiences where students learn by doing research (Müller-Christ, 2019).

In this connection, our first research study described in chapter 3 of the present dissertation, involved graduate students and teachers from three national universities, which initially implemented RBL under guidance of an international educational organization. The results provide a valuable evidence of several factors to be considered within the intervention, such as students and teachers' backgrounds, study variables, length, methodologies, research design and instruments, among others.

Similarly, our second research study, presented in chapter 4 is also an empirical contribution to the field as it describes a novel RBL implementation in a transversal undergraduate course where research was not the main aim and most students had little to no research experience. The results also provide insights regarding the key role of guidance, structure and feedback within an effective RBL setting (P. A. Kirschner et al., 2006).

In this way, our RBL findings may serve as a starting point for future academics who aim to provide their students with an authentic research experience.

4.3 Implications for practice and policy

From a practical point of view, the most relevant contribution of this dissertation to the field is the design and development of three interventions to evaluate the impact of RBL in Higher Education. These might be adapted in future practices, not only focusing on the present variables: intention to do research and research competences but in others of great relevance to students' learning. Our positive findings when evaluating the impact of RBL on research competences lead us to the need to further explore other variables such as knowledge acquisition, which also seems to interact with RBL (Parikh, 2002; Secret, Abell, Ward, Charles, & Perkins, 2017; Usmeldi, 2018). In this regard, students would not only benefit from RBL by developing competences to conduct research but also by gaining knowledge from a particular course.

Additionally, we provide reliable and validated research instruments which were especially designed for the present dissertation. In our first and second studies reported in chapters 3 and 4, scales were built to assess students' intention to do research, autonomous motivation and self-efficacy. We relied on existing frameworks and adapted the scales according to our research purposes and the study context.

Correspondingly, in our third research study reported in chapter 5, interviews were designed to assess research competences, autonomous motivation and self-efficacy. Also, they were supported by theoretical frameworks and adjusted to the research context. Future studies attempting to measure the impact of RBL on any of the variables involved in this dissertation, can benefit from the available instruments by adapting them or taking them as a reference for the construction of new ones.

Furthermore, this dissertation aims to inform policymakers and educational leaders about the urgent need to reformulate different elements of RBL in Higher Education in Ecuador. Therefore, we pose the following policy implications:

First, our findings lead us to the conclusion that effective RBL interventions resulting in an actual development of research competences, require time (Prahmana et al., 2017) that is often more than a single course. This probably suggests the need to shift our RBL focus from a course approach to a program approach in order to give students sufficient chances to experience different phases of research throughout the curriculum (Garg & Passey, 2018; (Jones & Lerner, 2019; Jungmann, 2019) and not only in one course. This is why we strongly advocate the idea of implementing RBL as a university approach given that it could be beneficial to develop students' role as researchers from the start of their studies to a latter adaptation to genuine research contexts (Hill & Walkington, 2016; Stanley & Lewandowski, 2016; Sternquist, Huddleston, & Fairhurst, 2018). This justifies the fact that we included undergraduate and graduate students in our interventions. We aimed to explore how RBL could impact students from a beginning stage to a more advanced research setting.

Second, our results regarding the need of structure and guidance in RBL, especially for students who are not familiar with research, highlight the importance of design expertise in an RBL setting. This should first emphasize the different needs of novice compared to more experienced students (Shergadwala, Kannan, & Panchal, 2016), the type of instructional activities, assessment and feedback that must be provided in order

to make the RBL experience effective (Al-Maktoumi, Al-Ismaily, & Kacimov, 2016b). Moreover, it is key that qualified academics who aim to be RBL developers are capable of adapting RBL to their specific context, paying special attention to class size, level of knowledge, study fields, etc. (Hayward, Kogan, & Laursen, 2016).

Finally, our third policy implication is linked to the above and refers to the need of research training for faculty involved in RBL. Although most academics teaching RBL courses are usually accredited with recognized research work in their field of expertise, sometimes they are not pedagogically trained as teachers (Postholm, 2019). The latter brings us to the question: do we need teachers or experts to implement RBL? We come to the conclusion that both teaching training and research experience are needed in RBL tutors (Basilio & Bueno, 2019). The opposite might result in ineffective practices where students do not gain from research and even lose confidence and motivation (van Blankenstein et al., 2019). Therefore, it is suggested that higher education institutions promoting RBL provide adequate training programs in order to enhance their teaching competences so they complement the research capabilities they have already achieved (Moon, 2016; Yusnita et al., 2018; Albareda-Tiana, Vidal-Raméntol, Pujol-Valls, & Fernández-Morilla, 2018).

V. Limitations and Directions for future research

Despite the careful planning of the research studies comprised in this dissertation, a number of limitations must be acknowledged. At the same time, we put forward directions for future research that intend to go beyond the present limitations. These directions focus on the scope and research variables, sample, methodology and relevance of RBL activities.

5.1. The scope and research variables

Initially, we identify key aspects related to RBL in Higher Education. However, the analysis of our findings reveals that there are other key aspects that were not included. Looking at our dependent variables, we evaluated the impact of RBL on intentions to do research and research competences in different interventions in a somewhat disconnected manner. This means that we did not prove that intentions to engage in a behavior actually turned into actions, as assumed by Ajzen in the Theory of Planned Behavior (1985). It would have been interesting but probably a bit too ambitious, to have a follow-up study involving the same participants to confirm whether research intentions became actual behaviors. In this regard, it is suggested that this type of

follow-up study is considered and analyzed in terms of feasibility and time frame within a PhD dissertation that is usually limited to 4 years.

A second limitation was the selection of variables. The results of our systematic literature review indicated that there are several key variables interacting with RBL. Even though our choice for dependent variables was justified in the literature (Woolf, 2017; Cirino et al., 2017; Sweat, Marshall, Foltz-Sweat, & Broatch, 2018), we missed to incorporate other variables such as knowledge acquisition, critical thinking, research perceptions, among others. It is convenient to take these variables into account for further RBL research as there is enough evidence of their connection to the field (Knutson, Smith, Nichols, Wallert, & Provost, 2010; Blume et al., 2015; Corwin et al., 2018). Analyzing other variables linked to RBL can help us to build a more complete picture of the importance and benefits of learning through research.

A third limitation was not to intentionally include teachers as participants of our studies. Although our research aim was from the beginning focused on students, the collaboration of teachers in our interventions has been crucial and even had impact on our results. It is recommended to consider the voice and role of teachers in future studies given that RBL by nature, associates teaching component with research (Spronken-Smith & Walker, 2010).

5.2 Sample

The limitations in research sample size were mostly evident in two of our studies. Study 1 initially involved a suitable number of graduate students from three public universities in Ecuador. This is why, sample size was not expected to be a problem. However, few students accepted the challenge to enroll in an innovative program with a strong research orientation and full-time commitment.

In view of the reduced number of students and high rate of dropout during the intervention, our results probably did not reach statistical significance and might not be replicable in the future, given the central importance of sample size in research findings (Saccenti & Timmerman, 2016). Due to this lack of students in graduate courses, we focused our study 2 on a transversal course with a high number of undergraduate students.

Study 3 involved a total population of 6 students enrolled in a master program and which was considered our sample. This was in a way a limitation, and among other reasons, led us to shift from a quantitative approach to a qualitative one.

Considering the above, it is suggested to design RBL interventions involving programs or course with higher number of students, or maybe joining courses with common learning objectives. In the case of quantitative studies, the idea is to attempt to generalize results in view of the impact that sample size can have on them (Bujang & Adnan, 2016).

5.3 Methodology

Our first limitation regarding methodology was the duration of RBL interventions. Although we increase the length of time of the intervention from 6 and 7 weeks in studies 1 and 2 to a complete semester (14 weeks) in study 3, we still consider that a single RBL course might be too short to achieve research competences development. We argue that the traditional RBL course setting is probably not the most appropriate in view that students should experience the whole research cycle through meaningful and authentic research activities (Emelyanova et al., 2017). Therefore, our research direction in this regard is to promote RBL projects instead of just a course. This setting might be convenient given its practical approach, broader scope and reduce time pressure compared to a course in which duration is usually a constraint (Li, Zhang, & He, 2015).

Our second limitation was the number of research instruments we had to administrate simultaneously. In our studies 1 and 2, we built scales for measuring our research variables: intention, behavioral beliefs, subjective norms, self-efficacy and autonomous motivation. One of the scales contained 27 items and the others, 10 items each. This might have created stress and anxiety in many students (Hardré, Crowson, Xie, & Ly, 2007) given that they fill out paper-based versions of the scales. Our future direction in this regard is to focus on fewer variables, prioritizing key ones, so the number of research instruments is reduced. Additionally, we could administrate the scales with small breaks or on two different days. Hence, students could respond in a more relaxed way and avoid unreliable data which may affect our results.

Our third limitation has to do with teachers' disruptive participation in our RBL intervention. This was reflected especially in study 2 where students belonged to four

different courses with two teachers in charge of them. Our need for collaboration from these teachers, in the sense that they would allow us to do the intervention, probably made them feel involved in the study as participants. This apparent "willingness to participate" pushed teachers to take an unexpected role in our intervention by imposing their teaching style. This could have motivated students in a positive or negative way (Bartholomew et al., 2018; Filippello, Buzzai, Costa, Orecchio, & Sorrenti, 2020), influencing our results. In this connection, our research direction is to be aware that teaching styles may have an impact on our intervention and try to control this variable as much as possible by having agreements with the teachers involved.

Our fourth limitation refers to data gathering methods. In our studies 1 and 2 we strictly used quantitative methods to evaluate the impact of RBL. However, this choice may have limited the possibility to explore some of our variables from a broader perspective (Queirós, Faria, & Alemida, 2017). For example, we could not get significant results for the variable "intention to do research" which was measured quantitatively in two of our studies. It is possible that by using a qualitative or mixed approach, we could have determined in a more specific way the reasons students had for not reflecting such intention. Therefore, it is advisable to integrate mixed methods for data gathering as they not only allow the possibility to generalize results but also offer a clear understanding of what is researched (Shekhar, Prince, Finelli, Demonbrun, & Waters, 2019).

5.4 Relevance of RBL activities

This last subset of limitations refers to the significance of students' research activities we designed for our interventions. It is worth mentioning that we were not completely autonomous to decide what type of research activities had to be included in the intervention as we were required to agree with course coordinators and teachers about it. In our first study, our intervention was not part of the regular course planning but additional. This did not work well as students at first felt forced to comply with research activities that were not included in their syllabus. However, we managed to persuade them about it, highlighting the benefit of doing research in a graduate course.

Taking into account the lesson learned in study 1, we change our approach in studies 2 and 3. We agreed beforehand with course teachers to integrate our intervention to the regular class activities. In the case of study 2 involving undergraduate students, they did not notice that they were doing research connected to the course aims. In the case

of study 3 involving graduate students from a research-oriented master course, they appreciated the input provided by our research activities which were also embedded in the regular class assignments.

As a research direction, it is suggested to plan RBL activities carefully so they match the course aims and contents (Lo Piccolo & Thomas, 2008). It is important to make agreements with course teachers and try to assist them in monitoring students' work so they feel willing to collaborate with us. Students should not feel that there is "extra work" by doing research activities but enjoy them. Maybe we could encourage them to present research products in institutional magazines and later on, in international journals. In this way, they feel their work is appreciated by others (Hawke et al., 2018).

VI. Conclusion

The present dissertation has provided insights into the nature of Research Based Learning and its impact on students' intentions to do research and research competences. Building on the different chapters, we present the following conclusions: a) RBL impact on intentions to do research showed positive trends but could not be proved; b) the implementation of a structured RBL version of course reflected a higher positive impact on research competences in comparison with control versions of the same course; c) the implementation of RBL contributed to develop specific research competences but not others due to weak research backgrounds; d) other variables such as autonomous motivation, self-efficacy and intention precursors did not interact with the impact of RBL.

Our findings also call for further actions d) analyze the feasibility of follow-up studies that serve to evaluate RBL impact on dependent variables that are associated to each other; e) use larger samples in view of the impact they may have on our research results; f) revise methodological decisions concerning duration of RBL interventions, data gathering method, disruptive teachers' participation in the intervention and excessive number of research instruments that may cause stress in students and finally; h) emphasize the design of relevant research activities that contribute to course learning.

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English Summary

Effects of using Research-Based Learning on the development of academic competences of graduate students

Currently, there is an increasing interest on the key role of higher education around the world (Stein et al., 2019). However, an appropriate interpretation of this role might be challenging in view of the many changes happening in the last years (Altbach et al., 2010).

To a great extent, the role of higher education is linked to the current demands of the society such as manpower and economic progress (Pegkas & Tsamadias, 2014). Nonetheless, it is also associated to the development of knowledge, pointing at resolving world problems (Lilles & Rõigas, 2017); for instance, overpopulation, lack of quality education, insufficient resources, etc. (Aleixo et al., 2018).

In this context, the challenge for higher education institutions is to train future professionals who are capable of dealing with the above mentioned global problems and offer solutions (Fukuda-Parr, 2016). Therefore, universities aim to move away from an emphasis on the transmission of knowledge to the construction of new knowledge (Böttcher & Thiel, 2018). This aim entails the development of students' academic competences, particularly research competences, which can empower them to face global problems more effectively (Zlatkin-Troitschanskaia et al., 2016). At the same time, there is a pronounced interest from students to participate actively in the production of knowledge within higher education (Dollinger et al., 2018).

In view of the aforementioned, the relationship between teaching and research, known as teaching-research nexus (TRN) in higher education appears to be crucial (Ahammed et al., 2017). In this regard, different expressions of TRN have been reported throughout the last years, aimed at boosting students' research spirit (Y. Li et al., 2019), developing research competences (Brennan et al., 2019a) and intentions to participate in further research practices (Griffioen, 2019).

In the Ecuadorian context, there is a current need to overhaul university programs and turn them into more research-oriented (Vergara et al., 2016). Hence, the adoption of suitable TRN methodologies is needed. This is why the present dissertation focuses on the incorporation of Research Based Learning (RBL) in a public Ecuadorian university, as an effective approach that seems to engage students in different stages of the research cycle where they can conduct authentic research (Griffiths, 2004). Previous studies report successful RBL practices in several knowledge fields involving

science (Prahmana, Kusumah, & Darhim, 2017; Tohir, Abidin, Dafik, & Hobri, 2018) among others (Charitas, Prahmana, & Yaya, 2016; Gredig & Bartelsen-Raemy, 2018).

The general aim of this dissertation is to gain insights about the nature of RBL and its impact on university students' intention to do research and research competences. To achieve this objective, we conducted three empirical studies, centered on two main variables: students' intention to do research and research competences.

Other significant variables – such as autonomous motivation, self-efficacy (perceived behavioral control) and precursors of intention (subjective norm, behavioral beliefs) – were also examined.

To accomplish the general aim of this dissertation, the following research objectives were addressed: First, build an RBL scoping review in engineering and science education. To address this objective, a scoping review of empirical work on RBL was conducted. This review, which comprised a time frame from 2000 to 2017, reported earlier RBL studies focused on students' research competences, nature of RBL instruction according to Brew's framework (2013), benefits, challenges and suggested actions for improvement. It followed the five-stage framework of Arksey and O'Malley (2005). Four electronic databases were consulted to identify peer-reviewed literature and after rigorous examination, only 47 studies met the inclusion/exclusion criteria. The main findings concerning students' research competences put forward a robust emphasis on nearly all stages from the research cycle. However, "conducting research", "analyzing and interpreting results" and "communicating findings" were the most emphasized. Regarding the nature of RBL instruction following Brew's framework (2013), it was found that most pedagogical issues are decided by teachers or negotiated with students, especially in studies conducted from 2012 onwards. The most stated RBL benefits were: research competences development, learning performance enhancement, course appreciation and research self-efficacy. About RBL challenges, low interest in research due to high levels of difficulty, lack of research training and time limitations were reported. The implementation of comprehensible research courses for beginners, which provide enough time for actual research along with regular assessment, were strongly suggested to improve the RBL experience.
Our second research objective was evaluate the impact of RBL on students' intention to do research. To achieve this objective, two studies were conducted at a public Ecuadorian university.

Study 1 (chapter 3) followed a pre/post-test experimental quantitative design and involved Engineering and Science graduate students. It explored students' intention to do research when involved in a redesigned RBL course compared to students in a regular version of the same course. At the same time, it was hypothesized that other variables such as autonomous motivation, and constructs from the Theory of Planned Behaviour (Ajzen, 1991) : perceived behavioral control (self-efficacy), behavioral beliefs and subjective norm, considered as precursors of human intention, may interact with the effect of RBL. Additionally, the possible interaction effect of gender and age was assumed. Research instruments such as scales, were developed following the framework of the Self-Determination Theory (Deci & Ryan, 1980), Self-efficacy Theory (Bandura, 2010) and Theory of Planned Behavior (Ajzen, 1991) and then adjusted to the context of the research.
The findings of this study reflected RBL students' slightly higher intentions to do research compared to control students. However, it was not possible to confirm our hypotheses, from a statistical point of view in any of the measured variables.

Study 2 (chapter 4) followed a similar research design but involved Entrepreneurship and Innovation undergraduate students. Again, our aim was also to explore the differential effect of RBL on students' intention to do research when involved in redesigned RBL courses compared to students in a regular version of the same course.

Building on Brew's research framework (2013) to define the nature of RBL in regards to amount of research instruction, students were randomly assigned to 3 conditions: structured RBL, semi-structured RBL and control. Research instruments designed for study 1 were adjusted to the new setting of the research.

Once again, increased students' intention to do research and its interactions with other variables could not be statistically confirmed.

Our third objective was to evaluate the impact of RBL on students' research competences. This objective was addressed in studies 2 and 3.
Study 2 (chapter 4) involved Entrepreneurship & Innovation students and intended to explore the impact of RBL on students' research competences. Given the quantitative nature of our study, we operationalized the variable "research competences" as "course achievement". Additionally, we intended to confirm such impact along with changes in autonomous motivation, self-efficacy and constructs from Theory of Plan Behaviour (Ajzen, 1991). Research instruments designed for study 1 were adapted to

the new research context in study 2. To measure students' research competences, 10 weekly assignments involving stages of the research cycle proposed by Jungmann & Ossenberg (2014) and the entrepreneurial cycle advocated by Brush et al., (2003), were designed. Results indicated that there was a significant RBL effect on students' research competences, reflected in their overall achievement and in specific research clusters.

Study 3 (chapter 5) was conducted in a public Ecuadorian university and involved a total population of 6 students from a Sociology and Rural Development graduate course. Using a qualitative approach, this study explored the impact of RBL on the development of students' research competences and its interaction with other variables such as autonomous motivation and self-efficacy. Our assumptions were based on two theoretical frameworks: Self-Determination Theory (Ryan & Deci, 2017) and Self-efficacy (Bandura, 1977).

A research competency test was designed and administered at the beginning and end of the 14-week semester. During the intervention, three rounds of interviews were conducted in weeks 2, 6 and 12. The aim of this interview was to examine students' views regarding their research competences, levels of confidence and autonomous motivation to conduct research. Questions from this interview focused on the four sources of self-efficacy from Bandura's Self-efficacy Theory, (1977) and the three basic psychological needs from Deci & Ryan (1982). All students followed the same version of the course. Six assignments, involving research-based tasks, were designed by the course teacher in accordance with the syllabus.
Overall, the main findings in this study reflected an impact of the RBL intervention on specific students' research competences along with positive changes in their self-efficacy. Although the results for students' autonomous motivation showed some negative trends regarding their relatedness, we concluded that these did not heavily affect learning.

Overall, our main findings report that a) RBL impact on intentions to do research showed positive trends but could not be proved; b) the implementation of a structured RBL version of course reflected a higher positive impact on research competences in comparison with control versions of the same course; c) the implementation of RBL contributed to develop specific research competences but not others due to weak research backgrounds; d) other variables such as autonomous motivation, self-efficacy and intention precursors did not interact with the impact of RBL.

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Dutch Summary

Nederlandstalige samenvatting

Effecten van onderzoeksgebaseerd leren of de ontwikkeling van de academische competentities van studenten

Momenteel is er steeds meer belangstelling voor de sleutelrol van het hoger onderwijs over de hele wereld (Stein, Andreotti, & Suša, 2019). Een juiste interpretatie van deze rol kan echter uitdagend zijn, gezien de vele veranderingen die de afgelopen jaren hebben plaatsgevonden (Altbach, Reisberg, & Rumbley, 2010).

De rol van het hoger onderwijs is voor een groot deel gekoppeld aan de huidige eisen van de samenleving zoals mankracht en economische vooruitgang (Pegkas & Tsamadias, 2014). Desalniettemin wordt het ook geassocieerd met de ontwikkeling van kennis, wijzend op het oplossen van wereldproblemen (Lilles & Rõigas, 2017); bijvoorbeeld overbevolking, gebrek aan kwalitatief onderwijs, onvoldoende middelen, etc. (Aleixo, Leal, & Azeiteiro, 2018).

In deze context is de uitdaging voor instellingen voor hoger onderwijs om toekomstige professionals op te leiden die in staat zijn om met de bovengenoemde mondiale problemen om te gaan en oplossingen aan te bieden (Fukuda-Parr, 2016). Daarom willen universiteiten af van de nadruk op kennisoverdracht naar de constructie van nieuwe kennis (Böttcher & Thiel, 2018). Dit doel behelst de ontwikkeling van academische competenties van studenten, met name onderzoekscompetenties, die hen in staat kunnen stellen om mondiale problemen effectiever aan te pakken (Zlatkin-Troitschanskaia, Pant, & Coates, 2016). Tegelijkertijd is er een uitgesproken interesse bij studenten om actief deel te nemen aan de kennisproductie binnen het hoger onderwijs (Dollinger, Lodge, & Coates, 2018).

Gezien het bovenstaande lijkt de relatie tussen onderwijs en onderzoek, bekend als onderwijs-onderzoek nexus (TRN) in het hoger onderwijs, cruciaal (Ahammed, Hassanli, Iqbal, & Corcoran, 2017). In dit opzicht zijn de afgelopen jaren verschillende uitingen van TRN gerapporteerd, gericht op het stimuleren van de onderzoeksgeest van studenten (Li, Li, Yang, & Li, 2019), het ontwikkelen van onderzoekscompetenties (Brennan, Cusack, Delahunt, Kuznesof en Donnelly, 2019) en intenties om deel te nemen aan verdere onderzoekspraktijken (Griffioen, 2019).

In de Ecuadoriaanse context is er momenteel een noodzaak om universitaire programma's te herzien en om te zetten in meer onderzoeksgericht (Vergara et al., 2016). Daarom is de goedkeuring van geschikte TRN-methodologieën nodig. Daarom richt dit proefschrift zich op de integratie van Research Based Learning (RBL) in een openbare Ecuadoriaanse universiteit, als een effectieve benadering die studenten lijkt te betrekken in verschillende stadia van de onderzoekscyclus waar ze authentiek

onderzoek kunnen doen (Griffiths, 2004). Eerdere studies rapporteren succesvolle RBL-praktijken op verschillende kennisgebieden met wetenschap (Prahmana, Kusumah, & Darhim, 2017; Tohir, Abidin, Dafik, & Hobri, 2018) onder andere (Charitas, Prahmana, & Yaya, 2016; Gredig & Bartelsen-Raemy, 2018).

Het algemene doel van dit proefschrift is om inzicht te krijgen in de aard van RBL en de impact ervan op de intentie van universiteitsstudenten om onderzoek en onderzoekscompetenties te doen. Om dit doel te bereiken, hebben we drie empirische onderzoeken uitgevoerd, gericht op twee hoofdvariabelen: de intentie van studenten om onderzoek te doen en onderzoekscompetenties.

Andere significante variabelen - zoals autonome motivatie, zelfeffectiviteit (waargenomen gedragscontrole) en voorlopers van intentie (subjectieve norm, gedragsovertuigingen) - werden ook onderzocht.

Om het algemene doel van dit proefschrift te bereiken, werden de volgende onderzoeksdoelstellingen behandeld: Bouw eerst een RBL scoping review in engineering en wetenschappelijk onderwijs. Om deze doelstelling te bereiken, werd een empirisch onderzoek van empirisch werk op RBL uitgevoerd. Deze beoordeling, die een tijdsbestek omvatte van 2000 tot 2017, rapporteerde eerdere RBL-onderzoeken gericht op de onderzoekscompetenties van studenten, de aard van RBL-instructie volgens Brew's framework (2013), voordelen, uitdagingen en voorgestelde verbeteracties. Het volgde het vijffasenraamwerk van Arksey en O'Malley (2005). Er werden vier elektronische databases geraadpleegd om door vakgenoten beoordeelde literatuur te identificeren en na grondig onderzoek voldeden slechts 47 onderzoeken aan de criteria voor opname / uitsluiting. De belangrijkste bevindingen met betrekking tot de onderzoekscompetenties van studenten leggen een sterke nadruk op bijna alle stadia van de onderzoekscyclus. “Onderzoek doen”, “analyseren en interpreteren van resultaten” en “communiceren van bevindingen” werden echter het meest benadrukt. Wat betreft de aard van RBL-instructie volgens Brew's framework (2013), werd vastgesteld dat de meeste pedagogische kwesties worden beslist door leraren of worden onderhandeld met studenten, vooral in studies die vanaf 2012 worden uitgevoerd. De meest genoemde voordelen van RBL waren: ontwikkeling van onderzoekscompetenties, verbetering van leerprestaties, cursuswaardering en zelfredzaamheid van onderzoek. Over RBL-uitdagingen, lage interesse in onderzoek vanwege hoge moeilijkheidsgraden, gebrek aan onderzoekstraining en tijdslimieten werden gemeld. De implementatie van begrijpelijke onderzoekscursussen voor beginners, die voldoende tijd bieden voor daadwerkelijk onderzoek samen met regelmatige beoordeling, werd sterk aangeraden om de RBL-ervaring te verbeteren.

Ons tweede onderzoeksdoel was het evalueren van de impact van RBL op de intentie van studenten om onderzoek te doen. Om dit doel te bereiken, zijn twee studies uitgevoerd aan een openbare Ecuadoraanse universiteit.

Studie 1 (hoofdstuk 3) volgde een pre- / posttest experimenteel kwantitatief ontwerp en omvatte afgestudeerde ingenieurs en ingenieurswetenschappen. Het onderzocht de intentie van studenten om onderzoek te doen wanneer ze betrokken waren bij een opnieuw ontworpen RBL-cursus in vergelijking met studenten in een reguliere versie van dezelfde cursus. Tegelijkertijd werd verondersteld dat andere variabelen zoals autonome motivatie en constructen uit de Theory of Planned Behavior (Ajzen, 1991): waargenomen gedragscontrole (zelfeffectiviteit), gedragsovertuigingen en subjectieve norm, beschouwd als voorlopers van de mens intentie, kan interageren met het effect van RBL. Daarnaast werd uitgegaan van het mogelijke interactie-effect van geslacht en leeftijd. Onderzoeksinstrumenten zoals schalen zijn ontwikkeld volgens het raamwerk van de Self-Determination Theory (Deci & Ryan, 1980), Self-efficacy Theory (Bandura, 2010) en Theory of Planned Behavior (Ajzen, 1991) en vervolgens aangepast aan de context van het onderzoek.

De bevindingen van deze studie weerspiegelden de iets hogere intenties van RBL-studenten om onderzoek te doen in vergelijking met controlestudenten. Het was echter niet mogelijk om onze hypothesen te bevestigen, vanuit een statistisch oogpunt in een van de gemeten variabelen.

Studie 2 (hoofdstuk 4) volgde een soortgelijk onderzoeksontwerp, maar betrof studenten in ondernemerschap en innovatie. Nogmaals, ons doel was ook om het differentiële effect van RBL op de intentie van studenten om onderzoek te doen wanneer ze betrokken zijn bij opnieuw ontworpen RBL-cursussen te onderzoeken in vergelijking met studenten in een reguliere versie van dezelfde cursus.

Voortbouwend op Brew's onderzoeksraamwerk (2013) om de aard van RBL te definiëren met betrekking tot de hoeveelheid onderzoeksinstructie, werden studenten willekeurig toegewezen aan 3 voorwaarden: gestructureerde RBL, semi-gestructureerde RBL en controle. Onderzoeksinstrumenten ontworpen voor onderzoek 1 zijn aangepast aan de nieuwe setting van het onderzoek.

Nogmaals, de toegenomen intentie van studenten om onderzoek te doen en de interacties met andere variabelen konden niet statistisch worden bevestigd.

Ons derde doel was om de impact van RBL op de onderzoekscompetenties van studenten te evalueren. Deze doelstelling werd behandeld in studies 2 en 3.

Studie 2 (hoofdstuk 4) betrof studenten ondernemerschap en innovatie en was bedoeld om de impact van RBL op de onderzoekscompetenties van studenten te onderzoeken.

Gezien het kwantitatieve karakter van ons onderzoek, hebben we de variabele "onderzoekscompetenties" geoperationaliseerd als "cursusprestaties". Bovendien waren we van plan een dergelijke impact te bevestigen, samen met veranderingen in autonome motivatie, zelfeffectiviteit en constructen uit Theory of Plan Behavior (Ajzen, 1991). Onderzoeksinstrumenten ontworpen voor onderzoek 1 werden aangepast aan de nieuwe onderzoekscontext in onderzoek 2. Om de onderzoekscompetenties van studenten te meten, 10 wekelijkse opdrachten die betrekking hebben op stadia van de onderzoekscyclus voorgesteld door Jungmann & Ossenberg (2014) en de ondernemerscyclus bepleit door Brush et al., (2003), zijn ontworpen. De resultaten gaven aan dat er een significant RBL-effect was op de onderzoekscompetenties van studenten, wat tot uiting kwam in hun algehele prestatie en in specifieke onderzoeksclusters.

Studie 3 (hoofdstuk 5) werd uitgevoerd aan een openbare Ecuadoraanse universiteit en omvatte een totale populatie van 6 studenten van een graduate cursus sociologie en plattelandsontwikkeling. Met behulp van een kwalitatieve benadering onderzocht deze studie de impact van RBL op de ontwikkeling van de onderzoekscompetenties van studenten en de interactie ervan met andere variabelen zoals autonome motivatie en zelfeffectiviteit. Onze aannames waren gebaseerd op twee theoretische kaders: zelfdeterminatietheorie (Ryan & Deci, 2017) en zelfeffectiviteit (Bandura, 1977).

Aan het begin en einde van het 14 weken durende semester werd een onderzoekscompetentietest ontworpen en afgenomen. Tijdens de interventie werden in de weken 2, 6 en 12 drie sollicitatierondes gehouden. Het doel van dit interview was om de mening van studenten te onderzoeken over hun onderzoekscompetenties, vertrouwen en autonome motivatie om onderzoek te doen. Vragen uit dit interview waren gericht op de vier bronnen van zelfeffectiviteit uit Bandura's Self-Efficacy Theorie (1977) en de drie psychologische basisbehoeften van Deci & Ryan (1982). Alle studenten hebben dezelfde versie van de cursus gevolgd. Zes opdrachten, die betrekking hebben op op onderzoek gebaseerde taken, zijn ontworpen door de cursusdocent in overeenstemming met de syllabus.

Over het algemeen weerspiegelden de belangrijkste bevindingen in dit onderzoek een impact van de RBL-interventie op de onderzoekscompetenties van specifieke studenten, samen met positieve veranderingen in hun zelfeffectiviteit. Hoewel de resultaten voor de autonome motivatie van studenten enkele negatieve trends vertoonden met betrekking tot hun verwantschap, concludeerden we dat deze geen grote invloed hadden op het leren.

Over het algemeen rapporteren onze belangrijkste bevindingen dat a) de impact van RBL op voornemens om onderzoek te doen positieve trends vertoonde maar niet kon worden bewezen; b) de implementatie van een gestructureerde RBL-versie weerspiegelde natuurlijk een hoger positief effect op onderzoekscompetenties in vergelijking met controleversies van dezelfde cursus; c) de implementatie van RBL heeft bijgedragen tot de ontwikkeling van specifieke onderzoekscompetenties, maar niet van anderen vanwege zwakke onderzoeksachtergronden; d) andere variabelen zoals autonome motivatie, zelfeffectiviteit en precursoren van intentie hadden geen interactie met de impact van RBL.

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Academic Output

Journals (A1)

Camacho, M. H., Chiluiza, K., & Valcke, M. (2019). Research based learning in a transversal Entrepreneurship and Innovation undergraduate course. *Studies in Higher Education*, 1-14.

Camacho, M. H., Chiluiza, K., & Valcke, M. (2020). Research based learning in a Rural Development graduate course. Manuscript submitted for publication.

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Appendices

Chapter 3

Research Instruments

General Background Questionnaire

The purpose of this questionnaire is to gather background and demographic information about you and your research experience. Please tick the appropriate box (☑) and write your answers in the space provided. There is no "right" or "wrong" answer. Some questions may have more than one answer so tick as many boxes as is appropriate for you. To ensure anonymity please do not write your name on the questionnaire.

Personal Information

1. Registration number: _____

2. Age: _____

Gender: □ Male □ Female

Current occupation: _____

Education

3. Where do you study?

_____

4. What is the program you are currently enrolled in?

□ Master □ Doctorate

5. How long have you been studying this program?

□ 1 semester □ 1 year □ more than 1 year

6. What is your area of study?

Food Engineering □ Material Science Engineering □ Mechanical Engineering □

Agriculture Biotechnology □ Water Management Engineering □

Computer Science Engineering □ Aquaculture □

7. How many courses have you completed so far?

_____

8. Why did you choose to study a research-oriented master program?

□ To pursue further studies later (for example a doctorate/post-doctorate)

□ To become a full-time university professor

□ To have better salary opportunities

□ Other: _____

8. How many hours a day do you dedicate to your studies (outside university hours)

□ 0-1 hours □ 2-3 hours □ more than 3 hours

Research Experience

9. Did you take any research courses in your bachelor's degree?

Yes □ No □

If so, how many courses? _____

10. At this point, have you published any scholarly works (e.g. refereed journal articles)?

Yes □ No □

If you answered "yes" please list number and type of scholarly works:

_____

_____

11. Have you presented at national/international conferences

Yes □ No □

If yes, please indicate which ones:

_____

Autonomous Motivation Scale

For each of the following statements, please indicate how true it is for you, using the following scale:

1 2 3 4 5 6 7

Not true at all somewhat true very true

Situation	Score
1. I enjoy doing research related activities very much.	
2. Research related activities are fun to do.	
3. I think research is a boring activity.	
4. Research related activities do not hold my attention at all.	
5. I would describe research as a very interesting activity.	
6. I think research is quite enjoyable.	
7. While I do research, I think about how much I enjoy it.	
8. Doing research related activities brings me moments of pleasure.	
9. Doing research fits my personal values.	
10. I choose research because it allows me to reach my life goals.	

Self-efficacy in Research Scale

This questionnaire is designed to help us get a better understanding of your beliefs regarding your skills to do research in the Engineering Science field.

Please rate how certain you are that you can do the things listed below by writing the appropriate number. Your answers will be kept strictly confidential and will not be identified by name.

Rate your degree of confidence to perform the activities listed in the table by recording a number from zero to 100 using the scale given below:

0 10 20 30 40 50 60 70 80 90 100

Cannot do at all moderately can do highly certain can do

Activities	**Confidence (0-100)**
1. Paraphrase and do citations	
2. Build up research methods related to research questions.	
3. Extract information from data	
4. Disseminate research findings in research groups.	
5. Check if the solution to the preliminary research questions/problems already exists.	
6. Define independent and dependent variables	
7. Apply models created from research findings.	
8. Present research results in conferences and/or publish them.	
9. Interpret research findings in the context of methods and theory	
10. Identify a need or a knowledge gap.	
11. Carry out an experiment/intervention	
12. Design methods/methodologies from research findings.	
13. Comment and compare results.	

14. Find patterns in data	
15. Validate research instruments before using them.	
16. Define preliminary research questions/problems	
17. Generate research questions/hypothesis	
18. Develop research products	
19. Implement findings in theory and/or practice	
20. Justify the selection of research methods.	
21. Clarify objectives and fine tune research questions based on literature	
22. Write scientific articles.	
23. Identify reliable sources	
24. Analyze the collected data	
25. Design experiment/data collection instruments	
26. Define research objectives	
27. Collect data (interviews, questionnaires, field trips, laboratory tests)	

Theory of Planned Behaviour Scales

The present survey is part of an investigation that tries to discover some of the reasons why graduate students have the intention to become researchers. Specifically, we are interested in your personal opinions regarding your intention to do research. Please read each question carefully and answer it to the best of your ability. There are no correct or incorrect answers. We are merely interested in your personal point of view. All responses to this survey are completely confidential.

Instructions

Questions in this survey make use of rating scales of 5 places. Tick the space ✓ that best describes your opinion.

Intention to do research Questionnaire

Intentions	1 Strongly Disagree	2 Disagree	3 Neither agree nor disagree	4 Agree	5 Strongly agree
1. I plan to discover research requirements and knowledge gaps.					
2. One of my aims is to define good preliminary questions/problems.					
3. My objective is to generate and fine-tune research questions.					
Intentions	1 Strongly Disagree	2 Disagree	3 Neither agree nor disagree	4 Agree	5 Strongly agree
4. Identifying reliable literature for my research work is one of my goals as a researcher.					
5. By becoming a researcher, I intend to select and justify appropriate research methods.					
6. My intention is to conduct my own research study/project.					
7. My ambition is analyze data and interpret research findings					

appropriately.					
8. I aim to implement my research findings in the future.					
9. It is my wish to present my research work in conferences and/or have it published.					
10. One of my future goals is to develop research products.					

Behavioral Beliefs Scale: Evaluation of Outcomes

Evaluation of Outcomes	1 Strongly Disagree	2 Disagree	3 Neither agree nor disagree	4 Agree	5 Strongly agree
1. Discovering requirements and gaps in knowledge would be positive for me.					
2. Being able to define preliminary research questions/problems is desirable.					
3. Being capable of generating and fine-tuning research questions is valuable.					
4. It is very likely that I can identify reliable literature.					
5. Having a career as a researcher would enhance my ability to select and justify appropriate research methods.					
6. Conducting my own research is good.					
7. Having research skills such as analyzing data and interpreting research findings would be important.					

8. Implementing my research findings would be valuable.					
9. It would be positive that I could present my research work in conferences and/or get it published.					
10. Developing research products would be valuable for my professional growth as a researcher.					

Subjective Norm Scale: Normative Beliefs

SUBJECTIVE NORM Normative Beliefs	1 Strongly Disagree	2 Disagree	3 Neither agree nor disagree	4 Agree	5 Strongly agree
1. My professors think that I should try to discover research requirements and gaps in knowledge.					
2. I feel pressure to develop good preliminary questions/problems from my professors.					
3. My colleagues suggest that I should generate and fine-tune research questions.					
4. Most of my colleagues suggest that I should identify reliable literature.					
5. Experienced researchers think I must select appropriate research methods and justify them.					
6. My friends recommend me to conduct my own research.					
7. My program coordinator suggests me to analyze data and interpret findings appropriately.					

8. My program coordinator recommends me to implement my research findings.					
9. Most people who are important to me would like that I present my research work in conferences and/or have it published.					
10. Most researchers from my university would suggest that I develop research products.					

Rubric

Excellent (2.5)	**Good (2)**	**Below Average (1)**	**Ineffective (0.5)**
Clearly identifies key Ideas that support the given facts	Identifies key ideas that support the given facts but they are not completely clear.	Key ideas that support the given facts are not clearly identified or stated in the writing.	Key ideas that support the given facts are not present in the writing.
Undoubtedly justifies his/her answer to the requested topic by referring to key ideas from the text.	Somewhat justifies his/her answer to the requested topic by referring to key ideas from the text.	Vaguely justifies his/her answer to the requested topic by referring to key ideas from the text.	Does not justify his/her answer to the requested topic and/or does not refer to key ideas from the text
Writes his/her answer in the requested paragraph length	Writes his/her answer a bit shorter or longer than the request paragraph length (7 lines/11 lines)	Writes his/her answer considerably shorter or longer than the requested length (around 6/12 lines)	His/her answer is completely below/or exceeds the requested paragraph length
Uses APA citation style appropriately	Uses APA citation style somewhat appropriately.	Rarely sees APA citation style appropriately.	Poorly uses APA citation style in all/ most references.
Total			

Chapter 5

Self-efficacy Interview Questions

1. Mastery Experiences

2. How do feel about your performance in the first 2 assignments?

3. Do you consider that you succeeded in them? Why?

4. What efforts did you make in order to succeed in your work? Do you feel that your abilities have improved if we compare the first assignment to the second?

5. Did you experience any difficulties? What were they? How did you manage them?

6. What would you do different next time to avoid these difficulties?

2. Vicarious Experiences from Social Models

1. Did you compare your assignment with peers or ask for help to your classmates? Was it helpful?

2. Do think that you classmates succeeded in their assignments? Why?

3. Do your think that your classmates experienced difficulties in the assignments? How did they probably manage?

4. Do you feel that some of your classmates had a better performance in these assignments? Why?

5. Do you perceive that any of your classmates is very good at research-related activities? Why? Does it inspire you to improve your performance and research skills?

3. Social Persuasion

1. Do you feel that your teacher or classmates persuade you to improve your class performance? Do they also persuade you to improve your research skills?

2. What kind of feedback did you receive in the first 2 assignments? How did you feel when you receive this feedback?

3. Was your assignment score according to what you expected? Do you feel like trying harder for next assignment? Did you feel discouraged about the assignment feedback? Why?

4. Psychological States

1. When you sent your first and second assignment, did you feel positive about them? Why?

2. How did you feel when you receive feedback on both assignments?

3. Considering that your feedback was quite positive, do you feel more capable of doing research-related activities?

4. Considering that you received suggestions for improvement in your assignments, how do you feel about your research capabilities?

5. In a 10-point scale, how would you rate your research capabilities in the first and second assignment? Why? How could you improve them?

Autonomous Motivation Interview Questions

1. Competence

1. Have you felt confident in your research abilities in these first two assignments?

2. Every time you received the assignments, did you feel capable of handling them?

3. Do you see yourself meeting the challenge of improving your research skills at the end of the semester?

4. Were you able to do most of the research activities included in the assignments? Why?

What activities from the first and second assignment you were not able to complete or had trouble with? Why?

5. In a 10-point scale, how confident in your research abilities did you feel in assignment 1 and 2?

2. Autonomy

1. Do you consider that you have developed research skills which allow you do the course assignments?

2. Did you investigate other sources in order to get more information on the tasks requested in the assignments?

3. After completing the first and second assignments, can you identify some of your strengths and weaknesses?

4. Beyond the assignment scores, do you think these research-related activities are meaningful to you? Would you need these skills in the future? Why?

5. Do you feel forced to do research-related activities in your assignments or you have some kind of choice? How?

6. Did you feel interested in the assignment topics as you were working on them? Why?

3. Relatedness

1. Did you have interactions with your classmates outside the classroom setting when working on assignment 1 and 2? Did you feel connected with them in the common goal of developing your research skills?

2. Did you feel supported by your classmates? Who supported you? How?

3. Do you think that counting on the support of your teacher and/or classmates may help you to succeed in this course? Why?

4. Do you feel free to ask for help regarding course assignments to your teacher and/or classmates in case you need it?

5. Do you feel as part of a group in this course? In what way?

Research Competency Test 1

As you know, the main purpose of research-oriented master's degrees is to develop research competences, in this case focused on rural development. In the same way, these programs aim to increase your intention to become a researcher and undertake postgraduate studies.

By researcher, we mean an academic who demonstrates specialized knowledge, research and academic skills to produce high-quality written work that could be presented to an audience.

The present evaluation attempts to measure and evaluate your research skills before the start of the master's degree.

Carefully read each of the following questions and answer them as appropriately as possible.

Review the article “Production Flexibility in Extensive Beef Farming Systems”. Work on the activities described below:

A. Answer the questions posed in the following table (2 points)

Is it a conference article or an indexed journal / magazine?	
What style of bibliographic citation has been used?	
What kind of annexes have been included?	
Name at least 3 databases where you can find information related to the topic of this article	

B. Read the summary (abstract) of this article. Then synthesize and state the research problem (2 points)

C. Read the "Research Proposal" and "Methods" section carefully (1 point)

1. Identify a research question that you try to answer in this article.

2. Describe the purpose of the methodology used. Would you change the methods proposed by the authors? Justify your answer (2 points)

D. The information detailed below corresponds to two of the references cited in this article (which have been removed for purposes of this evaluation). Using the same citation style used in this article, write the respective references (2 points)

1.Article title: The temporal dimension in farming systems research: the importance of maintaining flexibility under conditions of uncertainty
Authors: Larry Lev., David J. Campwell
Year: 1987
Journal title: Journal of Rural Studies
Volume: 3
Issue Number: 2
Pages: 123-132
Doi.org/10.1016/0743-0167(87)90028-3D.

Reference 1:

2. Article title: Resilience and stability of Ecological Systems

Authors: C.S. Holling

Year: 1973

Journal title: Annual Review of Ecology and Systematics

Volume: 4

Issue Number: Not Mentioned

Pages: 1-23

Doi / 10.1146 / annurev.es.04.110173.000245

Reference 2:

D. Read the "Conclusions" section of this article. Mention 2 relevant topics that should be considered for future research (1 point)

_____

_____

Research Competency Test 2

As you know, the main purpose of research-oriented master's degrees is to develop research competences, in this case focused on rural development. In the same way, these programs aim to increase your intention to become a researcher and undertake postgraduate studies.

By researcher, we mean an academic who demonstrates specialized knowledge, research and academic skills to produce high-quality written work that could be presented to an audience.

The present evaluation attempts to measure and evaluate your research skills before the start of the master's degree.

Carefully read each of the following questions and answer them as appropriately as possible.

Review the article “Agro ecology and healthy food systems in semi-humid tropical Africa: Participatory research with vulnerable farming households in Malawi”. Work on the activities described below:

A. Conteste las preguntas planteadas en la siguiente tabla (2 puntos)

Is it a conference article or an indexed journal / magazine?	
What style of bibliographic citation has been used?	
What kind of annexes have been included?	
Name at least 3 databases where you can find information related to the topic of this article	

B. Read the summary (abstract) of this article. Then synthesize and state the research problem (2 points)

_____

_____

C. Read the "Research Settings" and "Methods" section carefully (1 point)

1. Identify a research question that you try to answer in this article.

2. Describe the purpose of the methodology used. Would you change the methods proposed by the authors? Justify your answer (2 points)

D. The information detailed below corresponds to two of the references cited in this article (which have been removed for purposes of this evaluation). Using the same citation style used in this article, write the respective references (2 points)

1. Book title: Agroecology: The Ecology for Sustainable Food Systems
Authors: Stephen Gliessman
Year: 2015
Edition number: 3rd
Publisher Name: CRC Press
Place of publication: Boca Ratón, Florida, USAD.

Reference 1:

2. Article title: Estimation of causal effects using propensity score weighting: an application to data on right heart catheterization
Authors: Keisuke Hirano, Guido W. Imbens
Year: 2001
Journal Title: Health Services Outcomes Research Methodology
Volume: 2
Issue Number: 3

Pages: 259-2782.

Reference 2:

D. Read the "Conclusions" section of this article. Mention 2 relevant topics that should be considered for future research (1 point)

_____

_____

_____

Data Storage Fact Sheet

Data Storage Fact Sheet 1

Name/identifier study: Chapter 3 (Study 1)
Author: María Helen Camacho
Date: April 2020

1. Contact details

1a. Main researcher
- name: María Helen Camacho
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If a response is not received when using the above contact details, please send an email to
data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational
Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the data sets to which this sheet applies

* Reference of the publication in which the data sets are reported:

Camacho, M. H., Valcke, M., & Chiluiza Garcia, K. (2017). The effect of Research based learning activities' on students' intention to do research in graduate courses. In *9th International Conference on Education and New Learning Technologies, EDULEARN17* (pp. 6571-6579). International Academy of Technology, Education and Development (IATED). http://dx.doi.org/10.21125/edulearn.2017.2497

* Which data sets in that publication does this sheet apply to?
All data sets used in the study.

3. Information about the files that have been stored

3a. Raw data

* Have the raw data been stored by the main researcher? [X] Yes / [ ] No
If No, please justify:
* On which platform are the raw data stored?
[X] researcher PC
[X] research group file server
[ ] other (specify):

* Who has direct access to the raw data (i.e., without intervention of another person)?
[X] main researcher
[X] responsible ZAP
[ ] all members of the research group
[ ] all members of UGent
[ ] other (specify):

3b. Other files
* Which other files have been stored?
[x] File (s) describing the transition from raw data to reported results. Specify: The coding scheme used for the content analysis of scales
[x] File(s) containing analyses. Specify: SPSS-output file and reports about the results of the data analysis.
[x] Files(s) containing information about informed consent
[ ] A File specifying legal and ethical provisions
[ ] File(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...

* On which platform are these other files stored?
[x] individual PC
[x] research group file server
[ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?

[x] main researcher
[x] responsible ZAP
[ ] all members of the research group
[ ] all members of UGent
[ ] other (specify): ...

4. Reproduction
* Have the results been reproduced independently? [ ] Yes / [x] No
* If yes, by whom (add if multiple):
- name:
- address:
- affiliation:
- e-mail:

Data Storage Fact Sheet 2

Name/identifier study: Chapter 4 (Study 2)
Author: María Helen Camacho
Date: April 2020

1. Contact details

1a. Main researcher
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1b. Responsible Staff Member (ZAP)
- name: Martin Valcke (supervisor PhD research)
- address: Henri Dunantlaan 2, 9000 Ghent, Belgium
- e-mail: Martin.Valcke@UGent.be

If a response is not received when using the above contact details, please send an email to
data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational
Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the data sets to which this sheet applies

* Reference of the publication in which the data sets are reported:

Camacho, M. H., Chiluiza, K., & Valcke, M. (2019). Research based learning in a transversal Entrepreneurship and Innovation undergraduate course. *Studies in Higher Education*, 1-14.

* Which data sets in that publication does this sheet apply to?
All data sets used in the study.

3. Information about the files that have been stored

3a. Raw data

* Have the raw data been stored by the main researcher? [X] Yes / [ ] No
If No, please justify:
* On which platform are the raw data stored?
[X] researcher PC
[X] research group file server
[ ] other (specify):

* Who has direct access to the raw data (i.e., without intervention of another person)?
[X] main researcher
[X] responsible ZAP
[ ] all members of the research group
[ ] all members of UGent
[ ] other (specify):

3b. Other files
* Which other files have been stored?
[x] File (s) describing the transition from raw data to reported results. Specify: The coding scheme used for the content analysis of the scales
[x] File(s) containing analyses. Specify: SPSS-output file and reports about the results of the data analysis.

[x] Files(s) containing information about informed consent
[ ] A File specifying legal and ethical provisions
[ ] File(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...

* On which platform are these other files stored?
[x] individual PC
[x] research group file server
[ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?
[x] main researcher
[x] responsible ZAP
[ ] all members of the research group
[ ] all members of UGent
[ ] other (specify): ...

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* Have the results been reproduced independently? [ ] Yes / [x] No
* If yes, by whom (add if multiple):
- name:
- address:
- affiliation:
- e-mail:

Data Storage Fact Sheet 3

Name/identifier study: Chapter 5 (Study 3)
Author: María Helen Camacho
Date: April 2020

1. Contact details

1a. Main researcher

- name: María Helen Camacho
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1b. Responsible Staff Member (ZAP)
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data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational
Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the data sets to which this sheet applies

* Reference of the publication in which the data sets are reported:
Camacho, M. H., Chiluiza, K., & Valcke, M. (2020). Research based learning in a Rural Development graduate course. Manuscript submitted for publication.

* Which data sets in that publication does this sheet apply to?
All data sets used in the study.

3. Information about the files that have been stored

3a. Raw data

* Have the raw data been stored by the main researcher? [X] Yes / [ ] No
If No, please justify:
* On which platform are the raw data stored?
[X] researcher PC
[X] research group file server
[ ] other (specify):

* Who has direct access to the raw data (i.e., without intervention of another person)?

[X] main researcher
[X] responsible ZAP
[ ] all members of the research group
[ ] all members of UGent
[ ] other (specify):

3b. Other files
* Which other files have been stored?
[x] File (s) describing the transition from raw data to reported results. Specify: The coding scheme used for the content analysis of the interview questionnaires
[x] File(s) containing analyses. Specify: SPSS-output file and reports about the results of the data analysis.
[x] File(s) containing analyses. Specify: NVIVO-output file and reports about the results of the qualitative data analysis.
[x] Files(s) containing information about informed consent
[ ] A File specifying legal and ethical provisions
[ ] File(s) that describe the content of the stored files and how this content should be interpreted. Specify: ...

* On which platform are these other files stored?
[x] individual PC
[x] research group file server
[ ] other: ...

* Who has direct access to these other files (i.e., without intervention of another person)?
[x] main researcher
[x] responsible ZAP
[ ] all members of the research group
[ ] all members of UGent
[ ] other (specify): ...

4. Reproduction
* Have the results been reproduced independently? [ ] Yes / [x] No
* If yes, by whom (add if multiple):
- name:

- address:
- affiliation:
- e-mail: