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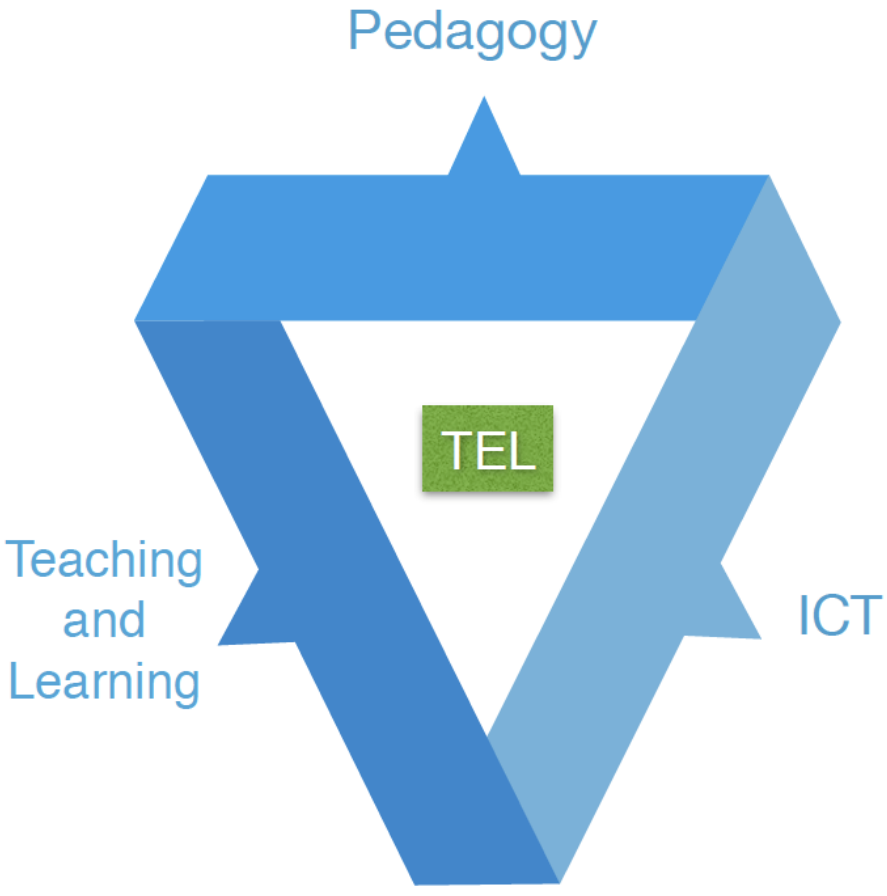
Technology-enhanced formative assessment in higher education

An intervention design of scaffolding student self-regulated learning

Bernard Bahati



Doctoral Thesis in Information Society at Stockholm University, Sweden 2019

Technology-enhanced formative assessment in higher education

An intervention design of scaffolding student self-regulated learning

Bernard Bahati

Academic dissertation for the Degree of Doctor of Philosophy in Information Society at Stockholm University to be publicly defended on Monday 11 March 2019 at 13.00 in L50, NOD-huset, Borgarfjordsgatan 12.

Abstract

As online learning is increasingly adopted in higher education institutions, many instructors are faced with the challenges of devising and implementing effective pedagogical practices that advance student learning. One of the challenges points to the design and development of assessment activities that truly inform the teaching and learning process. Despite the fact that both formative and summative assessment are important in teaching and learning, summative assessment has been dominating instructional processes in higher education at the expense of formative assessment. In higher education, in many countries including Rwanda, efforts that are made to practice formative assessment are hampered by a variety of factors that lead to ill-practices. Using technology-enhanced instructional interventions, this study attempted to address these factors. The study aimed at developing technology-enhanced instructional interventions to support student-based formative assessment that promote self-regulated learning. Additionally, this study proposes the design guidelines for the development of such instructional interventions. The study was guided by the following general research question: What are the characteristics of technology-enhanced formative assessment activities that promote student self-regulated learning? This research question was addressed using three specific research questions: (1) How do lecturers and students understand and practice formative assessment and feedback? (2) How can technology-enhanced formative assessment activities help students develop self-regulated learning skills? (3) What design guidelines should be followed in order to develop technology-enhanced formative assessment activities that promote student self-regulated learning? This study used Educational Design Research approach. Technology-enhanced instructional interventions were formatively developed, iteratively tested and evaluated in order to help students develop their self-regulated learning skills. Based on the findings of this study, three improved formative e-assessment packages are proposed as a practical research contribution: online knowledge survey, online peer-scaffolding through student-generated questions and peer-responses, and electronic reflective journals. In addition, based on the findings, this dissertation suggests a set of design guidelines and lessons learned in order to inform other educational practitioners who would like to develop technology-enhanced formative assessment activities that promote student self-regulated learning.

Keywords: *Technology-enhanced learning, formative e-assessment, self-regulated learning, blended learning.*

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To my late Mom. I wish you were still alive to witness the radical transformation I went through: from an unhinged and difficult boy to a responsible father and PhD holder.

Abstract

As online learning is increasingly adopted in higher education institutions, many instructors are faced with the challenges of devising and implementing effective pedagogical practices that advance student learning. One of the challenges points to the design and development of assessment activities that truly inform the teaching and learning process. Despite the fact that both formative and summative assessment are important in teaching and learning, summative assessment has been dominating instructional processes in higher education at the expense of formative assessment. In higher education, in many countries including Rwanda, efforts that are made to practice formative assessment are hampered by a variety of factors that lead to ill-practices. Using technology-enhanced instructional interventions, this study attempted to address these factors. The study aimed at developing technology-enhanced instructional interventions to support student-based formative assessment that promote self-regulated learning. Additionally, this study proposes the design guidelines for the development of such instructional interventions. The study was guided by the following general research question: What are the characteristics of technology-enhanced formative assessment activities that promote student self-regulated learning? This research question was addressed using three specific research questions: (1) How do lecturers and students understand and practice formative assessment and feedback? (2) How can technology-enhanced formative assessment activities help students develop self-regulated learning skills? (3) What design guidelines should be followed in order to develop technology-enhanced formative assessment activities that promote student self-regulated learning? This study used Educational Design Research approach. Technology-enhanced instructional interventions were formatively developed, iteratively tested and evaluated to help students develop their self-regulated learning skills. Based on the findings of this study, three improved formative e-assessment packages are proposed as a practical research contribution: online knowledge survey, online peer-scaffolding through student-generated questions and peer-responses, and electronic reflective journals. In addition, based on the findings, this dissertation suggests a set of design guidelines and lessons learned to inform other educational practitioners who would like to develop technology-enhanced formative assessment activities that promote student-regulated learning.

Keywords: Technology-enhanced learning, formative e-assessment, self-regulated learning, blended learning.

Sammanfattning

Eftersom online-lärande i allt högre grad används i högre utbildning, ställs många lärare inför frågan hur man bäst utformar och genomför effektiva pedagogiska metoder som främjar studenters lärande. En av utmaningarna handlar om hur man bäst designar och utvecklar online-baserade bedömningsaktiviteter som stödjer undervisningen och lärandeprocessen. Trots att både formativ bedömning och summativ bedömning är viktiga för undervisning och lärande, har summativ bedömning dominerat undervisningsprocesserna inom högre utbildning på bekostnad av formativ bedömning. I många länder, bland annat Rwanda, har insatser för att använda formativ bedömning i högre utbildning inte fått genomslag på grund av ett antal olika begränsande faktorer. Med hjälp av teknikförstärkt lärande har denna studie försökt lösa en del av dessa problem. Studien syftade till att utveckla insatser för att stödja studentcentrerad formativ examination som främjar ett själv-reglerat lärande. Denna studie föreslår också riktlinjer för utvecklingen av sådana aktiviteter. Studien baserades på följande övergripande forskningsfråga: hur bör man designa teknikförstärkta formativa examinationsaktiviteter som främjar student-centrerat lärande? Denna övergripande forskningsfråga undersöktes med hjälp av tre specifika forskningsfrågor: (1) Hur förstår och använder lärare och studenter på University of Rwanda formativ examination och feedback? (2) Hur kan teknikförstärkta formativa examinationsaktiviteter hjälpa studenter att utveckla sitt själv-reglerade lärande? (3) Vilka designriktlinjer bör följas för att utveckla teknikförstärkta formativa utvärderingsaktiviteter som främjar studenters själv-reglerade lärande? Denna studie baserades på Educational Design Research och teknikförstärkta interventioner som utvecklades och utvärderades för att hjälpa studenter att utveckla sina förmåga till själv-reglerat lärande. Baserat på resultaten av denna studie, föreslås tre olika formativa examinationsmetoder: online-baserade kunskapsundersökningar, online-baserade peer-reviews, samt elektroniska reflekterande journaler. Baserat på avhandlingens resultat, föreslås också en uppsättning riktlinjer för design av teknikförstärkta formativa examinationsaktiviteter som främjar student-centrerat lärande.

Nyckelord: Teknikstödd inlärning, formativ e-bedömning, själv-reglerat lärande, blended learning.

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List of Abbreviations

- **AaL :** Assessment AS Learning
- **AfL :** Assessment FOR Learning
- **AoL :** Assessment OF Learning
- **DBR :** Design-Based Research
- **EDR :** Educational Design Research
- **FA :** Formative Assessment
- **ICT :** Information and Communication Technologies
- **JISC :** Joint Information Systems Committee
- **KS :** Knowledge Survey
- **LMS :** Learning Management System
- **MINEDUC :** Ministry of Education
- **MKO :** More Knowledgeable Other
- **RQ :** Research Question
- **SITE :** Society for Information Technology and Teacher Education
- **SRL :** Self-Regulated Learning
- **T/L :** Teaching and Learning
- **TEFAA :** Technology-Enhanced Formative Assessment Activities
- **TEL :** Technology-Enhanced Learning
- **TELE :** Technology-Enhanced Learning Environment
- **UR-CE :** University of Rwanda - College of Education
- **UR :** University of Rwanda

1 Introduction

Society is changing at a rapid pace and "we live in exponential times" (Jukes, McCain, & Crockett, 2010). Advancements in digital technologies are changing the way people live and work. Technology is changing all our lives (House of Lords (UK), 2015). Technology is pervasive and has brought about radical changes (Pathak, 2012) to every aspect of life. Traditionally, one of the fundamental functions of education has been about equipping people with necessary and enabling skills, knowledge and competencies for successful social integration. Like all sectors of modern life, education is undergoing changes because of technological innovations (Clough, Olson, & Niederhauser, 2013). Therefore, the question is not whether education should adapt to these technological advancements. Education delivery is already being transformed and altered in light of these changes. The real issue rather points to how education practitioners would take advantage of technological solutions to further "improvements in reach and delivery, content, learning outcomes, management of systems, teaching, and pertinence" (Haddad & Draxler, 2002). However, if the use of technology in education were to advance education goals, an interdisciplinary approach, not a utopian technology determinism (Oliver, 2011), has to prevail.

Technology is not an autonomous and revolutionary force which is inherently good (Kollias & Kikis, 2005) and susceptible to bringing about desired positive changes in education. Merely providing ICTs to educational institutions (Haddad & Draxler, 2002) or equipping schools with teaching/learning technologies that are superior to existing ones: technological superiority (Kollias & Kikis, 2005) may not necessarily transform the teaching and learning process. To succeed, there must be profound educational reform, a shift from traditional teacher-centred instruction where the teacher acts as the "sage on the stage" to student-centred instruction where the teacher plays the role of the "guide on the side" (King, 1993). This thesis embraces this shift in teaching and learning philosophy. It is a culmination of a research project where technology was used to break the routines in assessment practices and enable formative assessment practices that were otherwise unlikely at the University of Rwanda.

1.1 Definition of key terms

Instruction

Throughout this thesis, the terms instructional activities, instructional intervention, instructional assessment, and instructional packages are repeatedly used. A commonality for all these terms points to the concept of instruction. This concept

was used in this thesis to refer to a "deliberate arrangement of activities (including presentation, practice, feedback, and assessment) designed to facilitate the achievement of specific learning outcomes" (Stepich, Chyung, & Smith-Hobbs, 2009, p. 1764) or simply "anything that is done purposely to facilitate learning" (Reigeluth & Carr-Chellman, 2009, p. 9). Thus, in this thesis:

Instructional activities refer to teaching and learning-related activities.

Instructional intervention refers to a "planned set of procedures (or activities) that are specifically designed at teaching a specific academic skill to an individual or group of students" (Campbell, 2015, p. 137). Instructional interventions in this thesis are planned learning activities that aimed to help students develop their self-regulated learning skills.

Instructional assessment refers to assessment activities that are carried out in a teaching and learning process. Instructional assessment can take various forms including diagnostic, formative, and summative. This study focused on formative assessment.

Instructional package refers to a set of materials, resources and procedures that tell the students what they need to do and how to do it to realise a specified learning objective.

Technology-Enhanced Formative Assessment Activities (TEFAA)

Assessment activities that are jointly conducted by the instructor and the students throughout the teaching and learning process. They are intended to collect information based on which the teaching and learning can be modied to further student learning. These assessment activities are carried out in and facilitated by a digital learning environment.

Blended learning

Simply put, the blended learning that is referred to in this thesis points to the "thoughtful integration of classroom face-to-face learning experiences with online learning experiences" (Garrison & Kanuka, 2004, p. 96).

Enriched virtual course

A course that is delivered following an enriched virtual mode of a blended approach to teaching and learning (Picciano, Dziuban, & Graham, 2014). In this approach, the students take a few face-to-face learning sessions with the instructor and then are free to accomplish most of the remaining coursework remotely via a digital learning environment.

Technology

Wherever technology is used in this thesis, it denotes digital technology that refers (based on Haelermans, 2017) to a range of electronic tools, systems, devices and resources that can generate, store or process data and information. Those include devices and means of communication, such as computers, tablets and digital learning tools, and all educational applications that can be found on the Internet.

1.2 Research papers

Throughout this PhD research project, five sub-studies were conducted during the three main research phases.

Paper 1

The first sub-study was conducted during an exploratory research phase. An exploratory sub-study was carried out to fine-tune the understanding of an educational problem that required intervention. The results of this sub-study helped clearly identify and frame the research problem and constituted the foundation on which the entire research blueprint was based. This sub-study explored the practices of feedback in formative assessment in Rwandan higher education, specifically at the University of Rwanda – College of Education (UR - CE).

Bahati, B., Tedre, M., Fors, U., & Evode, M. (2016). Exploring feedback practices in formative assessment in Rwandan higher education: A multifaceted approach is needed. *International Journal of Teaching and Education*, 4(2), 1-22. doi: 10.20472/TE.2016.4.2.001. Open access. Copyright © 2016, Bernard BAHATI et al.

Papers 2, 3 and 4

These sub-studies were conducted during the constructive research phase and focused on problem-solving that aimed at developing and implementing solutions to practical problems identified and analysed during exploratory research. During this phase, the solutions to formative assessment-based problems were developed and iteratively tested. This was done by designing and implementing technology-enhanced formative assessment activities driven by three SRL strategies and using online knowledge surveys, online student-generated questions and peer-responses, and electronic reflective journals. Three sub-studies resulted from this constructive research phase.

Paper 2

Bahati, B., Fors, U., & Tedre, M. (2017). Can student engagement in online courses predict performance on online knowledge surveys? *International Journal of Learning, Teaching and Educational Research*, 16(3), 73–87. Open access, distributed under a Creative Commons Non-Commercial and Non-Derivative License (CC BY-NC-ND).

Paper 3

Bahati, B., Fors, U., & Hansen, P. (2017). Using student-generated questions and peer-responses as a formative e-assessment strategy: Students acting as more knowledgeable others. In J. Dron S. Mishra (Eds.), *Proceedings of eLearn: World Conference on e-Learning in Corporate, Government, Healthcare, and Higher Education 2017* (pp. 108–117). Vancouver, British Columbia, Canada: Association for the Advancement of Computing in Education. Copyright by AACE. Reprinted from http://www.aace.org by permission of AACE.

Paper 4

Bahati, B., Fors, U., Hansen, P., & Benegusenga, A. (2018). Using structured learning e-journals as a formative e-assessment strategy: Guiding student-teachers to reflect on their learning through the mirror, microscope, and binoculars. In E. Langran & J. Borup (Eds.), *Proceedings of Society for Information Technology Teacher Education International Conference 2018* (pp. 1124–1133). Washington, D.C., United States: Association for the Advancement of Computing in Education. Copyright © 2018 by the Association for the Advancement of Computing in Education (AACE). Reprinted from http://www.aace.org by permission.

Paper 5

This sub-study was conducted during the follow-up research phase. Before formally suggesting the design guidelines of the formative e-assessment strategies, I deemed it necessary to measure the extent to which the students were satisfied with these strategies. A survey follow-up sub-study was conducted to measure student satisfaction with online knowledge surveys, online student-generated questions, and electronic reflective journals.

Bahati, B., Fors, U., Hansen, P., Nouri, J., & Mukama, E. (in press). Measuring learner satisfaction with formative e-assessment strategies. *International Journal of Emerging Technologies in Learning (iJET)*.. Authors' copyright.

1.3 Situating the study

This dissertation is positioned within the intersection (see Figure 1.1) of different topics that provide ground for further exploration. The three main topics that frame the background of this research are technology-enhanced learning, formative assessment (FA), and self-regulated learning (SRL).

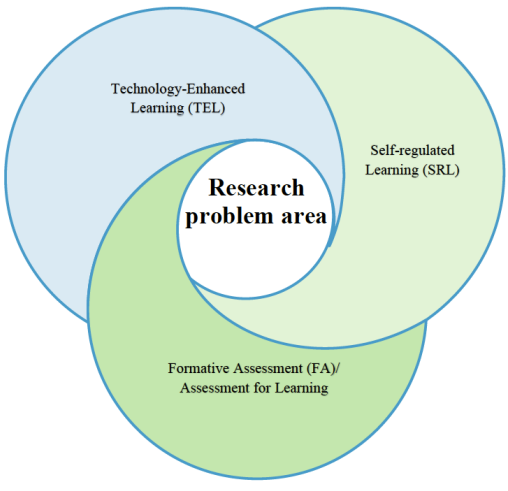


FIGURE 1.1: Positioning the research study

This study was conducted in the area of technology-enhanced learning (TEL) and technology was used to help students develop SRL skills through formative assessment.

1.3.1 Technology-enhanced learning

Technology-enhanced learning is a "multifaceted and multidisciplinary topic" (Balacheff, de Jong, Barnes, Ludvigsen, & Lazonder, 2014). This concept is used to describe the application of information and communication technologies to teaching and learning (Kirkwood & Price, 2014); learning which is enhanced through the use of technology and the Internet (Khosrow-Pour, 2018); the support of teaching and learning through the use of technology (O'Donnell & O'Donnell, 2015); or the provision of socio-technical innovations for learning practices, regarding individuals and organizations (Wang, 2011). Despite the different authors' descriptions of technology-enhanced learning (TEL), three key terms serve as their common denominator: technology, teaching and learning. However, these descriptions do not include what constitutes "enhanced learning". Kirkwood & Price (2014) argue that enhancement implies something which is improved or superior in some way and the clarifications about what is improved should be provided regarding whether the enhancement is concerned with:

- Operational improvement (e.g. providing greater flexibility for students; making resources more accessible)
- Quantitative changes in learning (e.g. increased engagement or time-on-task; students achieving improved test scores or assessment grades)
- Qualitative changes in learning (e.g. promoting reflection on learning and practice; deeper engagement; richer understanding)

For the purpose of this study, the descriptions of TEL by Pombo & Moreira (2016) which, more or less, answer the questions of "what is" and "how it is" enhanced is adopted. TEL, according to these authors, refers to:

> "a teaching and learning strategy where technology facilitates the efficiency of learning for individuals and groups, providing the transfer and sharing of knowledge in organizations, and understanding of the learning process by exploring connections among human learning, cognition, collective intelligence and technologies, and even artefacts" (p. 328).

1.3.2 Research trends in TEL

Through a data-content analysis of 555 abstracts of published articles, Badia (2015) identified three main research themes in TEL: technology environments and applications (the studies focused on online learning environments, mobile learning, game-based learning, computer-supported collaborative learning and computer mediated communication); learning processes and outcomes (focusing on learner motivation, learning outcomes, learning achievement and learning assessment); and learning activities (focusing on reading, writing, problem-solving and simulation).

From a learning perceptive, Balacheff et al. (2014) identied five research areas from which TEL has grown: the design, computational, cognitive, social-cultural and epistemological areas. Research studies in the *design area* explore the design and evaluation of new types and conditions of learning activities. In the *computational area*, the focus is on connecting TEL and computer science to create technology-related representational formats to promote efficient and effective learning. The *cognitive area* explores how new technology-based instructional designs and tools can change the conditions for cognitive performance. The *social-cultural research area* focuses on increasing awareness of how technologies can be adapted and used in different settings. The *epistemological* research area of TEL offers knowledge on how domain-related peculiarities impact the design and use of technologies.

Kirkwood & Price (2014) reviewed existing research on technology for teaching and learning in higher education and identied three types of research-related interventions in TEL: replicating existing teaching practices, supplementing existing teaching, and transforming teaching and/or learning processes and outcomes. The first type of TEL research-based interventions replicated existing teaching practices and focused on using technology to replicate and partially or wholly deliver the different elements of conventional teaching. Increasing flexibility for learners was the focus of the second type of TEL research studies that focused on supplementing existing teaching. Learner flexibility was increased, for example, with regard to "when and/or where students undertook their learning activities" through recorded course components and lectures that were made available online. The third TEL research-based intervention aimed towards transforming teaching and/or learning processes and outcomes. These studies were concerned with "structural changes in the teaching and learning processes". In this category, researchers targeted qualitative changes in student performance and achieved outcomes

Throughout this research project, technology was used to enable and support innovative formative assessment practices in real classroom settings. New types of learning activities were designed and evaluated (TEL design research area) and these technology-enabled instructional activities aimed at transforming formative assessment practices to advance student learning.

1.4 Formative assessment

Formative assessment has been described differently from different perspectives. Fisher & Frey (2015) characterize formative assessment as checking for understanding. For them, checking for understanding is a very important step in teaching and learning because (a) unless you check for understanding, it is difficult to know exactly what students are getting out of the lesson, and (b) research suggests that an important part of the learning process in all content areas is identifying and confronting misconceptions that can interfere with learning. Brookhart's (2010) understanding of formative assessment puts forward the learning goals. She describes formative assessment as an ongoing process students and teachers engage in when they:

- Focus on learning goals
- Take stock of where current work is in relation to the goal
- Take action to move closer to the goal

The emphasis is put on the involvement of both students and teachers in a sort of recursive assessment process that takes place throughout the teaching and learning process. Involvement of both students and teachers is one of the main characteristics of formative assessment. It is something teachers do with and for students rather than to students (Green, 1998). Teachers involve students in assessment process, thus students and teachers are partners and they both share responsibility for learning (Heritage, 2010; Black & Wiliam, 1998). According to Black & Wiliam (1998), formative assessment is a process and not a thing. It is not a single test given to students to see what they have learned for the purpose of grading, placement, or classification. Before they are graded, argues Brookhart (2010), students need – and deserve – an opportunity to understand how well they have learned. In the same vein, Fisher & Frey (2015) insist that checking for understanding (formative assessment) is not the final exam or achievement test that serve the purpose of summative assessment; from which formative assessment is distinguished as follows:

	Formative assessment	**Summative assessment**
Purpose	To improve instruction and provide student feedback	To measure students' competency
When administered	Ongoing throughout the unity or course	End of unit or course
How students use the results	To monitor their understanding and progress	To gauge their progress towards the course or grade level goals and benchmarks
How teachers use the results	To check for student understanding	For grades, promotion

TABLE 1.1: Comparison of formative and summative assessment (Fisher & Frey, 2015, p. 3)

1.4.1 Formative assessment as assessment for learning

Many authors (Gardner, 2012; Hargreaves, 2005; McDowell, Sambell, & Montgomery, 2012; Wiliam, 2011b; Berry, 2008; Black, Harrison, & Lee, 2003) describe formative assessment as an assessment for learning. Assessment for learning aims to promote worthwhile, long standing student learning, encouraging learners to take responsibility for and exercise control over their own learning (McDowell et al., 2012). A cornerstone of assessment for learning, argues (Berry, 2008, p. 1), is that:

> " the decisions that matters most in the classroom are those made by the students themselves and for them to make good decisions, they need continuous information about their learning. They also need information that describes what they are succeeding at, where they should pitch their efforts and what strategies they may need to consider in moving their learning forward. "

Wiliam (2011b) suggests that assessment for learning is a move from some views of assessment that prevailed for many years whereby the word "assessment" was used primarily to describe the processes of evaluating the effectiveness of instructional activities when a given learning sequence was completed. However, the author notes, more recently, there has been an increasing tendency to seek understanding of activities that are intended to guide the learning towards the intended goal, and that takes place during the learning process.

Hargreaves (2005) conducted a survey of eighty-three teachers, to explore the concepts of assessment for learning and produced six groups of definitions that are described under the following summary definitions:

- Assessment for learning is about monitoring pupils' performance against targets or objectives (p. 214)
- Assessment for learning means using assessment to inform next the steps in teaching and learning (p. 215)
- Assessment for learning means teachers giving feedback for improvement (p. 215)
- Assessment for learning means (teachers) learning about learners' learning (p. 216)
- Assessment for learning means learners taking some control of their own learning and assessment (p. 217)
- Assessment for learning is defined as turning assessment into a learning event (p. 217)

Drawing on this brief review of the literature on formative assessment, it is noticeable that formative assessment/assessment for learning foregrounds several features of modern theories of learning that emphasise the active involvement of students in the teaching and assessment processes.

1.4.2 Background and ethos of learning theories and their influence on instructional assessment

Learning theories aim to explain how knowledge or information is gained, absorbed, and processed during a learning process. The field of education has seen many learning theories come and go over the years. Although these theories differ in many ways, learning theories can be discussed and understood by trying to find answers to the following questions proposed by Schunk (2012, p. 27): *How does learning occur? Which factors influence learning? What is the role of memory? How does transfer occur?* and *What types of learning are best explained by the theory?*. From an instructional design perspective, Ertmer & Newby (2013, p. 46) added the following two questions: *What basic assumptions/principles of this theory are relevant to instructional design?* and *How should instruction be structured to facilitate learning?*

As Ertmer & Newby (2013) put it, three prominent positions on learning seek to provide insight into the act of learning: behavioural, cognitive, and constructivist). Learning theories are thus analysed as they link to two opposing positions on the origins of knowledge – empiricism and rationalism – as illustrated in Table 1.2.

Origin of knowledge	*Empiricism (knowledge derives from experience)*	*Rationalism (knowledge derives from reason)*	
Position on learning	*Behaviourism*	*Cognitivism*	*Constructivism*
How does learning occur?	Changes in observable performance or behavior	Changes in, mental structures within the mind.	Creation of meaning, from experiences
Which factors influence learning?	Environmental conditions	Environmental conditions and the learner	Environmental conditions and the learner
What is the role of memory?	Little attention is paid to memory and the mind is a "black box"	Memory is key: learning happens when information is meaningfully stored and organized in memory	Memory is viewed as the repository, not for intact knowledge, but for flexible threads of information that can be reorganized in various ways
How does transfer occur?	Through generalisation	Transfer is a function of how information is stored in memory	When learners complete authentic tasks within a meaningful context
What types of learning are best explained by the theory?	Recalling facts, defining and illustrating concepts, applying, explanations, and performing a specified procedure.	Reasoning, problem-solving, information-processing	Advanced knowledge acquisition: dealing with complex and ill-structured problems
What basic assumptions/principles that are relevant to instructional design?	An emphasis is put on behavioral objectives; task analysis; criterion-referenced assessment; learner analysis; sequencing of instructional process; tangible rewards; and informative feedback.	An emphasis is put on the active involvement of the learner in the learning process, learner control, metacognitive training; use of relevant examples and analogies	Making connections between facts and fostering new understanding in students
How should instruction be structuredto facilitate learning?	Facilitate the link of stimulus-response pairs through the use of cues and reinforcement	Organise information in such a manner that learners are able to connect new information with existing knowledge.	Encourage students to analyse, interpret, and predict information; use of open-ended and extensive dialogue among students

TABLE 1.2: Background and ethos of learning theories: Source of knowledge vis-à-vis positions on learning (based on Ertmer & Newby, 2013)

Although Table 1.2 illustrates the link between the positions on the origin of knowledge and positions on learning, the influence of these positions on instructional assessment is not well established. For a better theoretical contextualization of formative assessment, it is important to understand how these main positions on learning have influenced instructional assessment over time. Berry (2008) proposed three types of assessment associated with each position on learning.

The first type of assessment described by Berry (2008, p. 9) is **Assessment OF Learning (AoL)**. This type of assessment is associated with behaviourist views of learning and aims to check whether the learners have met the set requirements. A judgement will be made by comparing the predetermined learning targets and the ultimate performance of the learner. This view of assessment places a major focus on the *product of learning*.

The second type of assessment described by Berry (2008, p. 10) is **Assessment FOR Learning (AfL)**. This type of assessment is associated with constructivist views of learning. In this case, assessment aims to understand how the learner learns, what the learner can or cannot do, and makes some deliberations and decisions on how to help the learner learn. This view, which is more closely linked to contemporary (modern) theories of learning, places more emphasis on the *process of learning*.

The third type of assessment described by Berry (2008, p. 11) is **Assessment AS Learning (AaL)**. This assessment is associated with cognitive science views of learning. In this case, assessment aims to enable learners to become autonomous learners. It requires that learners be aware of what is required from them and monitor and assess their own learning during the learning process. With the information obtained, they can regulate their learning to meet the goals they set earlier. This view of assessment stresses the learner's *active role in learning*.

Drawing on Berry's (2008) classification, two types of instructional assessment concur with what was described earlier as formative assessment and shape the basic theoretical setting for this study: Assessment FOR learning and Assessment AS learning. Throughout this study, efforts were made to use assessment activities to analyse and understand how learners were learning and eventually use this analysis' results to create learning opportunities that help them learn well. In addition, the learners were involved in assessment activities that helped them monitor, assess, reflect on and regulate their learning process.

Although formative assessment is potentially expected to increase the quality of student learning, many issues and challenges (that are described in the following section) beset its implementation in real classroom settings.

1.4.3 Issues and challenges associated with formative assessment practices

Black & Wiliam's (1998) comprehensive review of more than 250 articles and books led to a conclusion that formative assessment can lead to improvements in student learning. However, like any other teaching and learning event, formative assessment is a complex endeavour which calls practitioners' attention to some issues and challenges associated with it. According to Andrade & Cizek (2010), these issues and challenges point to purpose, resources, preparation, validity, compliance, and time.

Purpose

The strength of formative assessment lies in its non-evaluative nature (Andrade & Cizek, 2010). The purpose of formative assessment is not the grading that delivers a summative judgement by providing an evaluation of learning. Feedback in form of teacher's comments – not grades – is key in formative assessment. A research study by Butler (1987) demonstrated that grades alone or comments along with grades did not lead to student learning gains but comments alone did. In view of this, for effective formative assessment, teachers are challenged to provide timely, specific, corrective feedback, not resorting only to quizzes and assignments (Andrade & Cizek, 2010).

Resources

Unlike some teachers' impression that FA is easy to carry out, it does require much more investment in resources, tenacity, and time (Keeley & Harrington, 2010). Depending, on the nature of the formative assessment activity, teachers will be challenged to make additional costs for supplies, space or other tangible

items or materials available (Andrade & Cizek, 2010) if formative assessment is to be done well.

Preparation

The lack of teacher preparedness and understanding of formative assessment has been documented in several research studies (Wiliam, 2006; Hill, Ell, & Eyers, 2017). To successfully implement formative assessment, teachers are challenged to be prepared and well-versed in key skills such as creating classroom conditions that are conducive to successful assessment, guiding and supporting the students on how to assess and interpret their own learning and that of their peers, and help students to match the gap between current learning status and the learning targets (Heritage, 2007).

Validity

Validity is key to any type of assessment, whether it is formative or summative. Validity is concerned with how assessment results are interpreted and used. As Gardner (2012) put it, an assessment cannot be valid without knowing what the intention was in using it and how well this intention was met. The main purpose of formative assessment is to gather, analyse, interpret and use information to improve the teaching and learning process. If the purpose of formative assessment is to improve further learning, then validity refers to the degree to which this is achieved (Gikandi et al., 2011; Gardner, 2012; Hargreaves, 2007). In view of this, in order to achieve its potential, teachers are challenged to ascertain whether and how effectively the use of formative assessment resulted in improved learning in subsequent instructional process (Heritage, 2007).

Compliance

Teachers have been traditionally known to obey, adhere to, and comply with formal school regulations and guidelines regarding curriculum delivery. However, as Andrade & Cizek (2010) observe, as far as instructional assessment is concerned, most of the existing school regulations and legislation have been developed primarily within summative assessment frame of reference. It is, therefore, challenging for teachers to effectively use formative assessment in a school where the questions about the purpose, administration, monitoring, bench-marking, validating and follow up (Heritage, 2010) have been exclusively considered for summative assessment.

Time

To develop rich and relevant formative assessment activities, the teacher will have to invest substantial amount of time. Formative assessment is known for its time-consuming nature and labor-intensiveness (Taras, 2005; Green & Johnson, 2010; Adamson, Kwan, & Chan, 2000; Gioka, 2007). Gathering information about student learning may seem easy. However, analysing, interpreting and using this information to inform the next instructional steps will require substantial investment in time and efforts. A major challenge for teachers is executing an effective reallocation of time and effort (already allocated to other instructional activities) to accommodate and support formative assessment activities (Andrade & Cizek, 2010).

1.5 Technology-enhanced formative assessment

As online learning is increasingly adopted and implemented in educational institutions, many educators are faced with the challenge of devising and implementing effective pedagogical practices that truly advance student learning. Online learning requires a profound pedagogical shift “from systems of teaching and supervision of learning to systems of learning and facilitation of learning” (Haddad & Draxler, 2002, p. 14). Both online learning and formative assessment require a complete review of students’ and instructors’ roles, relations and practices (Vonderwell, 2004; Coppola, Hiltz, & Rotter, 2002). To be effective in online learning, an instructor needs to change from "teacher-centred to student-centred, low-interactor to high-interactor, and low-initiator to high-initiator" (Dennis & Ferdig, 2008), from being the sole expert to facilitator, coach or mentor (Smith, 2009). The students are no longer passive recipients of knowledge and information. They are, instead, co-creators of knowledge and information with the help of an instructor playing the role of a facilitator (Alias & Luaran, 2016). Likewise, for an effective formative assessment, the teacher takes on the role of facilitator and coach and "no teacher will discover how empowering formative assessment is, until s/he begins to act in a way that involves the students in their learning" (Black et al., 2003, p. 99). In a sense, formative assessment would be better facilitated and delivered through online or blended learning environments that are effectively designed and deployed. Conversely, using effective formative assessment activities would enhance student learning in online or blended learning environments.

1.5.1 Defining technology-enhanced formative assessment

Feedback is at the heart of formative assessment. Formative feedback helps learners consolidate their strengths, identify their weaknesses (Brown, Bull, & Pendlebury, 1997) and informs them about the necessary actions to be taken for achieving the learning goals (Sadler, 1989). When technology is used to enable and facilitate the provision of formative feedback in the context of formative assessment, this process is referred to as formative e-assessment (Pachler, Daly, Mor, & Mellar, 2010; Pachler et al., 2009), online formative assessment (Gikandi et al., 2011; Koç et al., 2015; Baleni, 2015), web-based formative assessment (Costa, Mullan, Kothe, & Butow, 2010; Henly, 2003), computer-based formative assessment (Peat & Franklin, 2002; Bull, Quigley, & Mabbott, 2006; Timmers, Braber-van den Broek, & van den Berg, 2013), or simply technology-enhanced formative assessment (Beatty & Gerace, 2009; Feldman & Capobianco, 2008; Spector et al., 2016).

Despite this variation in terminology, technology-enabled formative assessment denotes "the application of formative assessment within online and blended learning settings where the teacher and learners are separated by time and/or space and where a substantial proportion of learning/teaching activities are conducted through web-based ICT" (Gikandi et al., 2011, p. 2337). Or "the use of ICT to support the iterative process of gathering and analysing information about student learning by teachers as well as learners and of evaluating it in relation to

prior achievement and attainment of intended, as well as unintended learning outcome" (Pachler et al., 2010, p. 716).

The close analysis of these two descriptions of technology-enabled formative assessment (TEFA) reveals some important features: ICT application, teachers and learners, gathering, analysing, evaluating information, and student learning. Drawing on these two definitions of TEFA and on the prime aim of formative assessment described in the previous sections, TEFA was defined in this study as the use of technology-based tools by both teachers and students to continuously create, gather, analyse, and use information about the ongoing teaching and learning process for the betterment of student learning.

1.5.2 Potentials of adding in technology

Understanding more about the "tight interplay between assessment, learning and feedback" (Dann, 2002, p. 121) preludes any efforts to devise assessment practices that advance student learning. Technology can offer new venues through which this relationship can be furthered (JISC, 2010). Technology can play a variety of roles in this complex relationship. Technology has the potential of providing students with flexibility of completing assessment tasks anytime anywhere. This enables them to measure their understanding when and how often they want (Rabinowitz, Blumberg, & Everson, 2004). It also allows students to freely review their weaknesses and make mistakes without exposing themselves to the instructor or peers (Challis, 2005). The existing literature shows that there is considerable potential for technology to make formative assessment much more effective through promoting (a) immediacy of feedback, (b) meaningful and deep learning, and (c) inclusiveness.

The longer the delay in feedback, the less likely the student will learn from it (Shirran, 2006), and, to some extent, feedback delayed is feedback denied (Kuo, Wible, & Tsao, 2001). To foster student engagement, improve achievement, motivation and self-regulation (Crisp & Ward, 2008; Zimmerman & Labuhn, 2012), formative feedback needs to be immediate; online learning environments support and facilitate this immediacy. In their study on the use of ICT to facilitate instant and asynchronous feedback for supporting student learning, Wong & Yang (2017) demonstrated the capacity of ICT for “generating instant and asynchronous” feedback that allowed students to become more engaged, collaborative knowledge builders, active and autonomous.

Technology, especially online and blended learning environments provide a variety of opportunities, for both teachers and learners to flexibly collect, analyse, document and use information about "how students are developing understanding of new material" (Osmundson, Chung, Herl, & Klein, 1999). The use of ICT can also help teachers by taking over some aspects of the role of assessing and providing feedback to learners so that the instructor saves enough time to concentrate on other ways of supporting student learning (Tzuriel & Shamir, 2002). In other words, technology supports and enhances student engagement with formative assessment activities. This enhanced engagement can, according to Gikandi et al.

(2011), foster learners' engagement with critical learning experiences including active, interactive, contextual, collaborative, reflective, multidimensional perspectives, and self-regulated aspects of meaningful learning, which ultimately support the development of robust and transferable knowledge. In addition, Harlen et al. (2003) carried out a systematic review of the use of ICT for assessing creative and critical-thinking skills and found out that new technologies created both the need and opportunity to teach and assess higher-level thinking skills.

Students differ in their learning styles (Wehrwein, Lujan, & DiCarlo, 2007). One of the aims of formative assessment is to promote student learning by encouraging both active and passive learning styles and by influencing the student's choices of learning strategies (Bell & Cowie, 2001). Formative assessment empowers individual learners and holds the view that all learners can potentially be considered as experts (Sorensen, 2005). In Gikandi et al.'s (2011) view, technology can facilitate responsive teaching and assessment that accommodates varying learning capabilities and styles. In his famous theory of "multiple intelligence", Gardner (2018, p. 114) suggested the use of technology to deliver educational programs within a multiple intelligence theory perspective:

> " It is not easy for teachers to provide individualized curricula and pedagogy. Happily, we have in our grasp today technology that should allow a quantum leap in the delivery of individualized services for both students and teachers that addresses the different intelligences and that allows students to exhibit their own understandings in diverse symbol systems (linguistic, numerical, musical, graphic, and more). "

The potentials of adding technology to formative assessment practices are widely discussed in literature and were succinctly summed up by Pachler et al. (2010) in the following benefits that technology can offer:

- Greater variety and authenticity in the design of assessments
- Improved learner engagement, for example, through interactive formative assessments with adaptive feedback
- Choice in the timing and location of assessments
- Capture of wider skills and attributes not easily assessed by other means, for example, through simulations, e-portfolios and interactive games
- Efficient submission, marking, moderation and data storage processes
- Consistent, accurate results with opportunities to combine human and computer marking
- Immediate feedback
- Increased opportunities for learners to act on feedback, for example, by reflection in e-portfolios
- Innovative approaches based on the use of creative media and online peer and self-assessment
- Accurate, timely and accessible evidence on the effectiveness of curriculum design and delivery

It worth mentioning though, that potentials do not necessarily lead to effectiveness. Technology is not, and never will be, transformative on its own (Haddad & Draxler, 2002). Turning these ICT potentials into formative assessment effects will require teachers who not only can devise appropriate formative assessment activities which can be supported by technologies but also who are aware of the

various issues and challenges associated with formative assessment as they were described in Section 1.4.3 of this dissertation.

1.6 Context of the study

This study was carried out in Rwanda, a country which is still sailing through a multifaceted recovery era following the 1994 genocide against the Tutsis. During this tragedy, Rwanda was brought to its knees. Its identity, economy, and a great deal of its human capital were nearly wiped out. Reversing this massive devastation will take many years and rebuilding the shattered Rwandan economy presents a daunting enough challenge in itself (Waugh, 2004). After the genocide, a number of challenging questions were being raised: " How do Rwandans envision their future? What kind of society do they want to become? How can they construct a united and inclusive Rwandan identity? What are the transformations needed to emerge from a deeply unsatisfactory social and economic situation? " These questions form the basis of the introductory statement of the Rwandan Vision 2020 document in which the country's strategic pillars for achieving envisioned objectives were defined.

Central to the Rwandan vision 2020 was the intention to transform Rwanda from an "agriculture-based economy" to a "knowledge-based society" and a "middle-income country" by the year 2020. The Rwandan vision 2020 is considered as unrealistic and overambitious, perhaps excessively so by some (Brown & Harman, 2013; Davis, 2013). However, others could do with having a vision that is overambitious, rather than not having one at all (Davis, 2013). The recent Rwandan development goals are detailed in the vision 2020. In this vision, education is considered one of the key sectors for successful social and economic transformations and the use of ICT in education is seen as the strategic lever for achieving this (MINEDUC, 2006). Following the adoption of this vision, almost all Rwandan sectors of life started to reform and re-position themselves to accommodate the vision 2020 agenda.

It is in this context that Rwandan public higher education has been undergoing a series of drastic reforms aimed at improving the quality of graduates' skills over the last decade. Among other outcomes, these reforms culminated in the merger of all public higher learning institutions into one University of Rwanda (UR) in 2013. The integration of ICT in teaching and learning activities is considered one of the driving forces that supports these reforms at UR. ICT is supposed to form the backbone of academic practices and services delivered by UR and support innovations in teaching and assessment (UR, 2015).

This study was conducted at one of the colleges of the University of Rwanda – College of Education – amid these profound reforms, with ICT meant to be one of the driving forces. However, despite these good intentions, a close analysis of the current level of ICT uses for academic purposes can be summed up by what Mukama (2016) suggested in his *Baseline Study on the Status of Open and Distance Learning in Rwanda*. He observed that Rwandan education institutions use ICT (in

the case of online courses) only to promote their "institutional visibility" and "environmental friendliness". In fact, the current situation is not quite different from what Bahati (2010) observed eight years ago – that the use of ICT for academic purposes at the UR was still sporadic. This situation was a result of the lack of shift in the practices of teaching and learning with ICT (Rubagiza et al., 2011). This study was carried out in the context of breaking the assessment routines and attempted some ICT-based solutions to enable and support formative assessment practices.

1.7 Shaping the research problem

Recent developments in technology have changed how people work and live. In teaching and learning, technology is changing pedagogical practices and, with the advent of e-learning solutions, the Internet is revolutionising instructional delivery methods. Higher learning institutions are under pressure (van der Zanden, 2009) to partially or wholly move the teaching, learning and assessment activities online.

One important pedagogical factor to consider when designing online courses in higher education is to create a learning environment where the content and assessment are integrated into the learning experience and knowledge building (Rourke & Coleman, 2011). There is a close association between teaching, learning and assessment. As Wiliam (2011a) puts it, teaching, learning, and assessment are increasingly viewed as functioning in symbiotic relationships. Assessment is fundamental to the learning and teaching process. "What is assessed defines what is taught and how it is learnt. The process of assessment, in turn, shapes instructional practices and affects the learner's view of the value of engaging in learning" (JISC, 2007, p. 7).

Although formative assessment (assessment to support learning) and summative assessment (assessment for accreditation and validation) (Gikandi et al., 2011) are both important matters, there has always been tension between them (Wiliam & Black, 1996). Summative assessment has been dominating instructional processes in higher education at the expense of formative assessment (Shieh & Cefai, 2017; Asghar, 2012; Gikandi et al., 2011; Northcote, 2003). For this reason, some authors (e.g. Koç et al., 2015) advocated for a shift from focusing heavily on summative assessment to developing instructional assessment activities that not only assess the end-product or the performance but also provide ongoing feedback about the student learning.

In the case of UR, the new policies that govern formative (continuous) assessment are seen as more challenging for both the teachers and the students. As per the 2016 academic regulations, continuous assessments are described as "assignments, tests, quizzes, and practical work carried out during the teaching progress of the module" (article 99.) "The 'final continuous assessment marks must be made available to students not less than one week before the beginning of the examination period" (article 100).

These new academic regulations put lecturers and students under pressure of meeting the deadlines. This adds to the lecturers' heavy workload at UR which, is increasing as the student numbers and class sizes become larger. Consequently, most teachers tend to focus more on the structure and progression of the module than they are preoccupied by matters relating to the status of student learning progress and development, which is the main purpose of formative assessment (Yorke, 2003). On the students' side, there is a feeling that this new formative assessment policy exacerbated what Mugisha (2010) had earlier identified as assessment practices that takes place under contextual pressure, which "creates fear of repetition" or retaking the module.

Formative assessment and feedback are still largely controlled by and seen as the responsibility of teachers; and feedback is still generally conceptualized as a transmission process (Nicol & Macfarlane-Dick, 2006). As a result, the a priori analysis of the practice of formative assessment at UR could be conceptualised as illustrated in Table 1.3.

The focus was put on...	**At the expense of...**
Product-oriented formative assessment	Process-oriented formative assessment
Assessment for compliance (meeting deadlines and submitting marks on time)	Assessment for learning (for helping learners to learn well)
teacher-centred formative assessment	Learner-centered formative assessment
Marks-oriented formative assessment	Formative feedback-oriented formative assessment

TABLE 1.3: The a priori conceptualisation of formative assessment practices at the University of Rwanda.

These a priori observations, which were based on the researcher's personal teaching experience, were confirmed and claried upon completion of the preliminary phase of this PhD research project whereby an exploratory sub-study (see Bahati et al., 2016) was carried out to analyse formative assessment and feedback practices at UR. In view of this, the problem this study wanted to address was a practical educational problem that needed a research-based practical solution. The problem was the ineffective practices of formative assessment and feedback at UR. There was a need to act and address this problem, and technology-enhanced solutions were used as recommended by Bahati et al. (2016).

1.8 Research aim and research questions

In view of what was described in the previous section, the aim of this PhD research project was twofold. The first aim was to develop technology-enhanced

instructional interventions to support student-based FA that promote SRL. The second aim was to propose the design guidelines for developing these interventions. The study was guided by the following overall research question: ***What are the characteristics of technology-enhanced formative assessment instructional activities that promote student self-regulated learning?***

Because this study was carried out at UR, there was a need to primarily explore and analyse formative assessment practices at UR and the following specific research question needed to be answered:

- *How do UR lecturers and students understand and practice formative assessment and feedback?*

The second specific research question was related to the entire process of developing and iteratively testing technology-enhanced formative assessment activities driven by student-regulated learning principles. This specific research question was stated as follows:

- *How can technology-enhanced formative assessment activities help students develop self-regulated learning skills?*

One of the aims of this study was to propose design guidelines to inform other educational practitioners who would like to develop technology-enhanced formative assessment practices that promote student-regulated learning. In doing so, this study contributed to the creation and extension of the current knowledge in this domain. This aim was addressed through answering the third specific research question that was formulated as follows:

- *What design guidelines should be followed in order to develop technology-enhanced formative assessment activities that promote student self-regulated learning?*

The introductory chapter of this dissertation was about the contextualisation of this PhD research study. From the outset, it was argued that this study was carried out amid profound and global educational changes due to technological innovations. It is in this chapter where the study was situated within the wide research context of technology-enhanced learning. Several types of research-related TEL interventions were described. It was mentioned that the present study embraces the transformative approach to research-based TEL interventions. In this chapter, the focus was also put on the description and understanding of the three main concepts that form the backbone of this study: technology-enhanced learning, formative assessment, and technology-enhanced formative assessment. The context of the study was presented towards the end and the chapter was completed by the description of the research problem, aim, and questions.

2 Theoretical underpinnings

Formative assessment strategies are wide in scope and appear in a variety of formats that are rooted in different theoretical models of learning. Instructional activities that promote formative assessment can be centered on one or many of the following key formative assessment strategies advanced by Wiliam (2011a, p. 2):

- Clarifying, sharing, and understanding learning intentions as well as criteria for success
- Engineering effective classroom discussions, activities, and learning tasks that elicit evidence of learning
- Providing feedback that moves learning forward
- Activating learners as instructional resources for one another
- Activating learners as owners of their own learning

Although any formative assessment activity can reflect many of these strategies, this research study was mainly driven by a theoretical background that focused on "activating learners as owners of their own learning" through the use of technology-enabled formative assessment activities that promote self-regulated learning. As a result, the description of the theoretical underpinnings in the next section will focus on student SRL, formative assessment and student SRL, and the three SRL strategies (progress self-assessment, help-seeking and peer-scaffolding, and the student retrospective reection) that guided the design and implementation of technology-enabled formative assessment activities.

2.1 Student self-regulated learning

Research has demonstrated that when students are involved in learning activities that allow them to self-assess and self-monitor during a learning process, they feel empowered and autonomous. This feeling can lead them to own their learning and, ultimately, to improved learning performance. Although the definitions of self-regulated learning may differ based on different researchers' theoretical orientations (Zimmerman, 1990), self-regulated learners are commonly conceptualized as "metacognitively, motivationally, and behaviorally active participants in their own learning process" (Zimmerman, 1986, p. 308). *Metacognitively* self-regulated learners are those students who are actively involved in planning, organizing, and self-instructing, monitoring, and evaluating at various stages of an instructional process. *Motivationally* self-regulated learners have a self-perception of being competent, self-efficacious, and autonomous. *Behaviorally* self-regulated learners

are those students who can handle the selection, structure, and creation of the environments that optimise their learning.

From another perspective, Carneiro, Lefrere, Steffens, & Underwood (2012) suggested that successful self-regulated learners should be able to: recognise a need to learn (for example, by being able to identify gaps in in their knowledge); make wise choices in relation to that need (about what to learn, how, when and with whom); and satisfy that need efficiently and affordably (for example, by gathering information about other learners' learning experience and then using that information to fix and realise their own learning goals).

Zimmerman's (1986) and Carneiro et al.'s (2012) descriptions of self-regulated learners can be synthesised by Schunk & Zimmerman (2008, p. 1) who – after an extensive review of research studies – established that in comparison to students with poor self-regulation skills, students with good self-regulation skills,

> " set better learning goals, implement more effective learning strategies, monitor and assess their goal progress better, establish a more productive environment for learning, seek assistance more often when it is needed, expend effort and persist better, adjust strategies better, and set more effective new goals when present ones are completed. "

2.2 Self-regulated learning and related concepts

Several concepts have been used to describe the students' monitoring and control of their learning activities. Although self-regulated learning is usually considered an important one, Carneiro et al. (2012) have identified several other related concepts that exist in the literature: metacognition, self-directed learning, personalised learning and self-regulated personalised learning.

Metacognition is one of the concepts that have been mostly associated with SRL. According Livingston (2003), metacognition refers to higher-order thinking, which involves active control over the cognitive processes engaged in learning. Activities such as planning how to approach a given learning task, monitoring comprehension, and evaluating progress toward the completion of a task are metacognitive by nature. Two important processes have been distinguished in describing metacognition: (1) knowledge about one's cognitive processes and (2) monitoring and regulating these processes (Hacker, Dunlosky, & Graesser, 1998). The students' knowledge of their own cognition involves understanding the task involved and being aware of their skills, abilities, weaknesses, strengths, and learning styles and preferences while the regulation of cognition involves planning, monitoring and evaluating. Metacognition and SRL are usually overlapped or used interchangeably in the literature to the extent that it is difcult to distinguish between them. For example, Winne & Hadwin (1998) used the concept "metacognitively powered self-regulation" and Azevedo (2009) suggested that SRL includes metacognitive monitoring and regulation.

The concept of *self-directed learning* is traced back to Knowles (1975, p. 18) who defined it as a process "in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating their learning

goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes". Recent definitions of self-directed learning (see Boles, 2014) also emphasise on the students' full responsibility of their learning when they make choices about where they are going and weigh options and move forward. In the same vein, Gibbons (2002, p. 2) defines self-directed learning as "an increase in knowledge, skill, accomplishment or personal development that an individual selects and brings about by his or her own efforts using any method in any circumstances at any time".

Another concept which is usually related to self-regulated learning is *personalised learning*. Personalised learning is an approach to learning and teaching that promotes the learning setting which is specifically tailored to individual learners. It is a highly structured and responsive approach that enables every learner to participate, progress and achieve the learning goals (Carneiro et al., 2012). Personalised learning and self-regulated learning are two concepts that are not only related to each other but also interdependent. The shift from teacher-controlled to learner-controlled learning (SRL) can only be initiated by setting learning environments that can be personalised and individually adapted or created instead of using "one size fits all" learning environments (Kroop, Berthold, Nussbaumer, & Albert, 2012).

Self-Regulated Personalized Learning is also among the concepts that are associated with self-regulated learning. It was developed in the context of iClass' pedagogical model developed by Aviram, Ronen, Somekh, Winer, & Sarid (2008). Three main educational goals are targeted in their model: personalisation, self-regulation and intrinsic motivation. In view of these authors, these educational goals support, complement, and enhance each other, and one cannot meaningfully develop without the others.

In summary, self-regulated learning and the related concepts seem to refer to a set of overlapping teaching and learning principles. The common denominator of these learning principles points to the student's ability to responsibly own and shape their learning process. In this study, self-regulated learning was referred to as the teaching and learning approach that promotes the learning environments which give room for students' active participation in deciding on the shape of learning through self-planning, self-monitoring, self-assessment, and self-evaluation.

2.3 Models of self-regulated learning

Although different theorists have proposed a variety of models for student SRL, five models (based on empirical evidence) have been widely used in most research studies that have been carried out in the area: the socio-cognitive model, the Top-Down/Bottom-Up model, the metacognitive perspective model, the motivation perspective model, and the collaborative learning perspective model.

From a socio-cognitive perspective, three different models were developed by Zimmerman, who is among the first authors on SRL. In the first model, referred to as "triadic reciprocality" (Zimmerman, 2005), SRL is analysed as a function of the interaction of three types of SRL: personal, environmental and behavioural. Zimmerman's (2005) second SRL model focused on individual level (metacognitive and motivational) processes and is structured on three cyclical phases: forethought, performance and self-reection. The third model of SRL Zimmerman (2005) developed is referred to as a "multi-level" model and is structured on four stages through which the students develop their self-regulatory competency: evaluation, emulation, self-control and self-regulation. For the present study, the Cyclic Phases Model was considered and analysed.

The cyclic phases model as Zimmerman (2005, p. 14) named it, is based on the cyclical nature of self-regulation. For him, self-regulation consists of "self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals." As mentioned earlier, the cyclical phases model of SRL is structured on three phases that include forethought, performance and self-reflection.

The *forethought phase* refers to a preparatory phase where the students perform a task analysis, fix the goals and make a plan to achieve them. In the *performance phase*, volitional control phase, the students move to the actual execution of the learning tasks and monitor their progress at the same time. They also use self-control mechanisms to keep themselves engaged and motivated. In the *self-reflection phase*, the students look back and assess how they performed the task. The phase involves two processes: self-judgement, which refers to the students' self-evaluation of their own performance, and self-reaction that includes self-satisfaction (perceptions of satisfaction or dissatisfaction) with their performance.

The Top-Down/Bottom-Up model of SRL was developed by Boekaerts (2011). This dual-processing model of self-regulation indicates that self-regulation develops from a dynamic interaction between top-down regulatory processes and bottom-up influences on behaviour (Zelazo & Lyons, 2012). According to Jarvela (2011), the top-down self-regulation refers to the goal pursuit that is driven by the students' own needs, values, interests and goals. At this point, the students' learning intention is firmly in place and they engage themselves actively in the learning process (Damon, Lerner, Renninger, & Sigel, 2006). The bottom-up self-regulation occurs when specific cues in the learning environment create a mismatch with the students' current learning intention (Jarvela, 2011). Once the mismatch is created, the students will try to explore other environments for further cues rather than continue devoting their attention on the learning environment that created a mismatch (Damon et al., 2006).

The metacognitive perspective of SRL was proposed by Winne & Perry (2000) who distinguished "studying" from "learning" by the fact that learning seems to convey a passive enterprise while studying essentially compels students to engage in complex goal-directed and motivational processes to get studying done. These processes are viewed as instances of metacognitively powered SRL (Winne, 1995). According to Winne & Hadwin (1998), the studying process involves four linked phases of SRL. Those stages that are open, recursive and

comprehended in a feedback loop (Panadero, 2017) are (a) task definition: the students develop an understanding and perception of the learning task; (b) goal setting and planning: the students generate, reframe and fix the learning goals and make a plan for realizing them; (c) enacting study tactics and strategies: the student devise relevant study strategies and put them into actions to reach the learning goals; and (d) metacognitively adapting studying: this will occur as a culminating phase whereby the students decide to make long-term changes regarding their motivations, beliefs and strategies to use in the future.

The motivation perspective model emphasises the integration of motivational constructs in SRL (Puustinen & Pulkkinen, 2001). This SRL model was developed by Pintrich (2000) and is structured on four phases: forethought, planning and activation; monitoring; control; and reaction and reflection. Each of these phases has three different areas of regulation (cognition, motivation/affect, behaviour and context). During the *forethought*, planning, and activation phase, the students identify and re-frame the learning goals and strategies, make time and space planning, and determine the motivational effects. At the *monitoring* stage, the students try to make sense of their own cognitive awareness and implement the planned actions. In the *control* phase, the students have identified, reframed, and implemented the chosen learning strategies and actions. During this phase, the students re-evaluate these strategies and actions and decide to change or maintain them. The students make cognitive judgements and self-evaluation during the *reaction and reflection* phase. It is the time when the students assess whether there is a difference between the fixed goals and targets and the actual performance.

Models of SRL have traditionally characterised SRL as an individual, cognitive-constructive activity emphasising on individual differences associated with SRL (Winne, 1996), such as setting goals, metacognition and self-efficacy. As new perspectives and models of learning that promote shared knowledge construction evolved, models of SRL rooted into social constructivist approach to learning emerged (Meyer & Turner, 2002). Hadwin, Järvelä, & Miller (2011, p. 67) explored the social and interactive aspects in the regulation of learning and contrasted three types of regulation in a collaborative learning setting: "self-regulated learning, co-regulated learning, and socially shared regulation of learning". Self-regulation of learning refers to the student's deliberate planning, monitoring, and regulation of individual cognitive, behavioural, and motivational process for completing an academic task. The Co-regulation of learning is the emergent coordination of self-regulation amongst oneself and others. Regulatory strategies are distributed among different students. In socially shared regulation of learning, there are interdependent or collectively shared regulatory processes that are deployed to achieve a shared learning outcome.

What can be concluded from this brief review of different SRL models is that, in general, all models are built on three main identiable phases. The first phase is the *preparatory* phase in which the learner analyses the learning tasks, sets and re-frames the learning goals, makes an action plan and devises strategies to achieve those goals. The second phase is the *implementation* phase during which the learner performs the learning tasks while monitoring and controlling the learning process. After the actual performance of the learning task, the learner

assesses, evaluates, and reflects on the entire learning process and outcome during the third phase, which is the *appraisal* phase.

2.4 Formative assessment and self-regulated learning

According to Nicol & Macfarlane-Dick (2006), one of the recurring themes that emerges from research studies on formative assessment is the proper use of formative assessment to assist students in becoming better self-regulated learners. The goal of formative assessment is to identify a gap in learning, provide feedback to the student about the gap and closing the gap (Heritage, 2007). Learners who are self-regulated through formative assessment are more persistent, resourceful, confident, and higher achievers than those students who are not self-regulated (Nicol & Macfarlane-Dick, 2006). In the same vein, Heritage (2007) argues that, in formative assessment, students learn the skills of self and peer assessment, develop mechanisms for regulating their learning and adapt their learning tactics to meet their learning needs. Formative assessment can be seen as a unifying theory of instruction which, when used properly, improves student learning by developing SRL skills among learners (Clark, 2012). For Clark, formative assessment encapsulates SRL and Irving (2007, p. 13) suggests that "students may benefit from formative assessment by developing SRL behaviors in the classroom".

Some relatively recent research studies (e.g. Andrade, 2010; Nicol & Macfarlane-Dick, 2006) have established a direct link between formative assessment and SRL. After a review of several research studies conducted on formative assessment, Nicol & Macfarlane-Dick (2006, p. 205) identified seven principles of good formative feedback practice that can help students take control of their own learning and become self-regulated learners. For these authors, good formative feedback,

- Helps clarify what good performance is (goals, criteria, expected standards)
- Facilitates the development of self-assessment (reflection) in learning
- Delivers high quality information to students about their learning
- Encourages teacher and peer dialogue around learning
- Encourages positive motivational beliefs and self-esteem
- Provides opportunities to close the gap between current and desired performance
- Provides information to teachers that can be used to help shape teaching

Andrade (2010) established a link between FA and SRL (see Figure 2.1) by drawing on a three-phase model of self-regulation (described earlier) developed by Zimmerman (2005) and on the three questions proposed by Hattie & Timperley (2007) and that are addressed in any formative feedback, wich effectively closes the gap between current learning status and the learning targets.

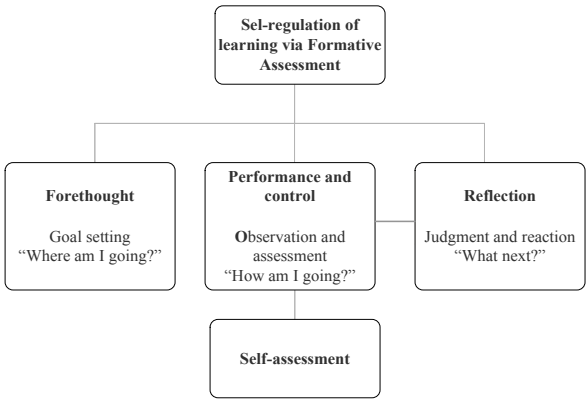


FIGURE 2.1: Self-regulated learning and formative assessment (Andrade, 2010, p. 96)

Figure 2.1 portrays a synthesis of Zimmerman's (2005) model of SRL and three FA questions advanced by Hattie & Timperley (2007). In the forethought phase, the student is asking "Where am I going?" and "What are my learning goals?" During the performance and self-reflection phases, the student is involved in self-assessment and asks her/himself "How am I doing? How am I progressing towards my learning goals?" and "Where to next? What should be done to improve my progress?" Linking the performance, control, and reflection phases will allow the student to perceive the gaps and deficiencies in their learning and eventually revisit and revise their learning strategies.

The use of the different self-regulated learning models can be beneficial under different teaching and learning contexts and environments. In addition, SRL models can be applied in various research contexts. Thus, researchers can choose to utilise those that better suit their research goals and focus (Panadero, 2017). The self-regulated learning model that was used in this study was informed by the obvious fact that "self-regulation is not a skill that automatically develops as people get older, nor is it passively acquired during environmental interactions" (Zimmerman & Schunk, 2001, p. 13). Fortunately, self-regulation is learnable (Andrade, 2010). SRL skills develop gradually over time with repeated practice and teachers can help students develop these skills (Ramdass & Zimmerman, 2011) through encouraging students to use self-regulated learning strategies in classroom. There exist a variety of SRL strategies proposed (for example by Butler, 1998; Schraw & Moshman, 1995; Winne & Hadwin, 1998; Zimmerman & Pons, 1986). The proposed strategies can be classified under one of the three general phases of SRL that are commonly identified from different SRL models: preparatory phase, implementation phase, and appraisal phase. Three SRL strategies that were used in this study are described in the following section: progress self-assessment, help-seeking, and retrospective reflection. The choice of these three SRL strategies was informed by various factors including the reviewed literature, recommendations from sub-study 1 (see Bahati, Tedre, Fors, & Mukama, 2016),

consultation with other co-instructors, class-size, availability of ICT infrastructures (computer labs), the status of Internet connections, ICT skills level for the participants (student-teachers), and the research time frame.

2.4.1 Progress self-assessment

The process of supporting students to become self-regulated learners involves a variety of strategies, including self-assessment activities, that can be used to activate the students as the owners of their own learning (Black & Wiliam, 2009). Self-assessment was mentioned by both Andrade (2010) and Nicol & Macfarlane-Dick (2006) as one of the features of formative assessment that help students to self-regulate their learning and is one of the crucial processes that are implied in self-regulation (Puustinen & Pulkkinen, 2001). The link between self-assessment and SRL has been established in a number of research studies. For example, in their meta-analysis, Panadero, Jonsson, & Botella (2017) concluded that self-assessment interventions have a positive influence on students' SRL strategies. Topping (2003) suggested that evidence of the effect of self-assessment on SRL was "encouraging" while (Kostons, van Gog, & Paas, 2012) who trained the students on a variety of self-assessment skills, found that self-assessment played an important role in self-regulated learning.

2.4.2 Help-seeking

Help-seeking can be defined as "the process of seeking assistance from other individuals or other sources that facilitate accomplishing desired learning goals, that may consist of completing assignments or satisfactory test performance" (Karabenick & Berger, 2013, p. 238). Help-seeking is one of the important self-regulated learning strategies. In their assessment of how students use self-regulated learning strategies, Zimmerman & Pons (1986) suggested that self-regulated students clearly relied extensively on seeking help and assistance from more capable others (peers, parents and teachers) to accomplish their academic tasks. Self-regulated learners distinguish themselves from their peers by seeking advice from others and do so with the aim of increasing their degree of autonomy (Ryan, Pintrich, & Midgley, 2001). To regulate their learning, the students seek help through a number of successive stages (Karabenick & Berger, 2013): (1) determining whether the problem exists, (2) determining whether help is necessary, (3) deciding whether to seek help, (4) deciding on the type of the help needed, (5) deciding whom to seek help from, (6) asking for help, (7) obtaining the asked help, and (8) processing the obtained help. During the first five stages, the student is operating in the forethought phase of SRL; the sixth and seventh stages correspond to the performance phase of SRL, and in the eighth stage, the student conducts self-reflection.

2.4.3 Retrospective reflection

Reection is an important tool and skill that can help further high quality learning. McNiff & Whitehead (2005) define reflection as thinking in a systematic and active way by structuring one own's thinking – by asking questions about what one does and why – to improve practical action in the future. There is a need for students to have time and space within the teaching and learning process to reflect because "reflective activities in the classroom help students to take time to think about their learning. They learn to pause and let things in their lives matter and discover who they are as learners" (Douillard, 2002, p. 99). Both "reflection-in-action" and "reflection-on-action" (Schon, 1987) are important.

Reflection-in-action occurs through the process of observation in the midst of an action, adjusting the action, and applying the new action (Giaimo-Ballard & Hyatt, 2012). In the midst of learning process, the learners can stop and think about their learning and, if necessary, change the learning strategies for further improvement. Reflection on-action, also called retrospective reflection (Loughran, 2002) or reflection-after-action (Stefl-Mabry, Dequoy, & Stevens, 2012), is a process in which individuals reflect on actions and thoughts after they have taken place (Schon, 1987) and learning lessons from what did or did not work (Moore & Woodrow, 2009). In their analysis of an "expert learner", Ertmer & Newby (1996) presented reflection-on-action (retrospective reflection) as the double link between the learners' metacognitive knowledge and the regulatory control of the learning process. For them, retrospective reflection is an active process of making sense of/extracting meaning from past learning experiences for the purpose of orienting oneself for current and/or future thought and action.

Based on the models of SRL that were reviewed in this chapter and their relationship with formative assessment, the theoretical framework that guided this research could be schematically illustrated by the following Figure 2.2.

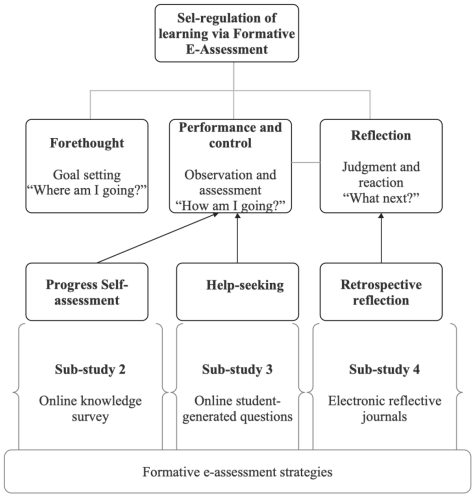


FIGURE 2.2: Theoretical framework

Further details about how the framework was implemented in this study are provided in the methodology chapter, specifically in the section about the research design.

2.5 TEL solutions that support self-regulated learning

This study was about the use of technology-enhanced formative assessment activities to scaffold the development of students' SRL skills. It was therefore worthwhile to review the different TEL solutions that can support self-regulated learning. Technological advancements facilitate the design of technology-enhanced learning environments, many of which can potentially foster SRL (Bartolomé & Steffens, 2012). It has been widely reported that learning through a technology-enhanced learning environment (TELE) can provide students with opportunities to enhance their SRL skills, while e-learning environments require self-regulation for effective learning (Lim & Park, 2015). Some previous research studies (e.g. Bartolomé & Steffens, 2012; Dabbagh & Bannan-Ritland, 2005; Dettori & Persico, 2008; Nussbaumer, Dahn, Kroop, Mikroyannidis, & Albert, 2015) have analysed and reviewed TEL solutions to support SRL from different research perspectives.

Bartolomé & Steffens' (2012) analysis of technologies for self-regulated learning was driven by three important criteria each TELE should meet in order to be capable of supporting SRL (summarised in Table 2.1)

Supporting digital technology	Rationale	Criteria		
		Learners should be encouraged to plan their learning activities	Learners should receive appropriate feedback so they can monitor their learning	Learners should be given criteria so they can evaluate their own learning outcomes
ePortfolios	To register and save students' activities and products and the instructors' feedback.	–	✓	✓
Blogs	Blogs are used as students' personal diaries	✓	✓	–
Wikis	Wikis are used as a simple, flexible tools for collaboration and sharing learning resources.	–	✓	–
Virtual learning environments (VLE)	By providing students with experiences they would otherwise not be able to experience in the physical world, VLE enhance active participation, high interactivity and individualisation.	✓	✓	✓
Personal learning environments (PLE)	PLE provide each student with opportunities to build his/her own working space, connected with the resources offered from educational institutions, web services and his/her own social network.	✓	✓	✓
Web 2.0	Web 2.0 facilitates collective intelligence, administration of information and social, authorship.	✓	✓	✓

TABLE 2.1: Digital technology solutions for self-regulated learning (based on Bartolomé & Steffens, 2012)

In their discussion of the TELEs which can potentially support the practice of SRL, Dettori & Persico (2008) focused on two e-learning teaching and learning

approaches: online collaborative learning and online individual learning environments. According to these authors, when an online collaborative TELE is designed with the SRL objective in mind, this can provide students with good opportunities to practice and develop self-regulation. One way whereby online collaborative learning environments can support self-regulation is through computer-mediated communication (CMC) platforms. Well-designed CMC platforms "allow course designers and teachers to work out configurations and activities that support SRL" (Dettori & Persico, 2008, p. 5). Some potential benefits of CMC platforms vis-à-vis SRL were proposed by Dettori, Giannetti, & Persico (2005) and Persico (2005):

- A reduced cognitive overload that results from an easy and intuitive interface allows students to concentrate on learning rather than on the use of the environment
- A variety of communication tools and modes (public and private, textual, audio and video, synchronous and asynchronous) can enhance the development of individual initiatives and improve motivation
- CMC tracking functions and automatic reminders can support planning and facilitate performance monitoring
- Peer review and self-assessment tools and features within CMC platforms can inform and encourage monitoring and self-evaluation

Dabbagh & Kitsantas (2013), Nussbaumer et al. (2015), and Vovides, Sanchez-Alonso, Mitropoulou, & Nickmans (2007) analysis focused on the TEL solutions (that can support SRL) inbuilt in learning management systems (LMS).

An LMS is defined by Dabbagh & Bannan-Ritland (2005, p. 298) as a "collection of Web applications that integrate technological and pedagogical features of the Internet and the Web into a single, template-based authoring and presentation system that facilitates the design, development, delivery, and management of Web-based courses and online learning environments." Some web-based pedagogical tools integrated into LMSs can potentially foster SRL by allowing learners to have more freedom and autonomy Nussbaumer et al. (2015).

In their study of the use of LMSs to support self-regulation in higher education contexts, Dabbagh & Kitsantas (2013) suggested that specific LMS- web-based pedagogical tools can support specific processes of self-regulation (see Table 2.2).

Type of LMS Web-based pedagogical tools	*Functions*	*Supported self-regulatory processes*
Administrative tools	Managing students, student information, teaching, and administrative course components	Self-monitoring, help-seeking
Collaborative and communication tools	Enabling and facilitating one-to-one, one-to-many, and many-to-many learning interactions through a different time/real time-different place modes	Goal setting, help-seeking, time management
Content creation and delivery tools	Enabling instructors to deliver course content and resources and tools, enabling students to interact with course content resources, and activities	Self-evaluation, task strategies, goal setting
Learning tools	Also called hypermedia tools, learning tools allow students to explore Web-based resources and create personalized learning experiences	Task strategies
Assessment tools	Supporting both the creation of traditional tests and the development of more authentic performance-based assessments	Task strategies, self-monitoring, self-evaluation

TABLE 2.2: Web-based pedagogical tools-supported self-regulatory processes (adapted from Dabbagh & Kitsantas, 2013)

This study was about designing and implementing TEFAA driven by three SRL strategies (self-progress assessment, help-seeking through peer-scaffolding, and retrospective reflection) and by means of online knowledge survey, online student-generated questions, and electronic reflective journals. The TEL solutions that were used in this study are Web-based pedagogical tools integrated in the Moodle Learning Management System. The use of LMSs in higher education is growing rapidly and there is a plethora of LMS-based solutions developed and offered by a variety of vendors. Therefore, selecting, evaluating and eventually choosing an LMS to use in a given educational setting is a complex process that requires a lot of knowledge, time, and effort (Zaharias & Pappas, 2016).

Although some previous research studies (e.g. Kasim & Khalid, 2016; Konstantinidis, Papadopoulos, Tsiatsos, & Demetriadis, 2011; Stewart et al., 2007) have attempted to analyse, evaluate and provide guidance on how to choose an LMS that can suit a particular teaching and learning context, the choice of an LMS that was used in this study was, by default, dictated by the research context and setting. The research was conducted at UR through hybrid courses that were delivered via the UR online learning platform (Moodle). However, this research's aim was not about using LMSs, per se. There may be other better alternative

LMSs, and Moodle was used as a channel to facilitate the delivery of the hybrid courses, not because it is the best LMS out there but for practical reasons.

In view of this, some web-based pedagogical tools (see Table 2.3) integrated into the Moodle Learning Management System were used to develop and deliver TEFAA to help students develop their SRL skills.

SRL strategy	*Implementation strategy*	*TEL solutions as Web-based pedagogical tools inbuilt in Moodle*
Progress self-assessment	Online knowledge survey	Moodle Feedback Module Lesson Objectives Moodle block Level up! Moodle block
Help-seeking through peer-scaffolding	Online student-generated questions and peer-responses	Lesson Objectives Moodle block Moodle Forum
Retrospective reflection	Structured electronic reflective journals	Lesson Objectives Moodle block Moodle Blogs

TABLE 2.3: TEL solutions that supported the implementation of SRL strategies in this study

The Moodle feedback module is an important tool that allows teachers to design and deliver surveys to seek feedback from the students using various types of questions (multiple choices, yes/no, text answers) that can be further re-used multiple times. This Moodle module "offers opportunities for the generation of summarised and statistical reports about the poll result only within a specific course and its participants" (Gaftandzhieva, 2016, p. 33). Moodle fora have been extensively used in e-learning and, when effectively used, they can be a desirable place for seeking help, asking questions and exchanging ideas Deng & Tavares (2013). In their review of the reflection support in the context of technology-enhanced learning, Kori, Pedaste, Leijen, & Mäeots (2014) concluded that blogs and portfolios – supported with a predefined guidance in terms of prompts and guiding questions – can help students improve their reflection skills and facilitate peer interaction.

3 Methodology

3.1 Research design

This study used Educational Design Research (EDR) or Design-Based Research (DBR) in Education. EDR stems from the notion that scientific understanding should be used to solve or at least gain a better understanding of practical problems (McKenney & Reeves, 2014). According to these authors, EDR aims at (1) solving an educational problem facing educational practitioners and simultaneously (2) discovering new knowledge to inform the work of other practitioners who face the same problem. An educational problem is solved through the design and development of an intervention that can take the form of programs, teaching and learning strategies and materials, or products and systems (Plomp & Nieveen, 2010).

3.1.1 Educational Design Research

van den Akker (1999) classified EDR under the type of research approaches that are related to design and development work. Other research approaches include design studies, design experiments, design research, developmental research, formative research, formative inquiry, formative experiments, formative evaluation, action research, and engineering research. Despite the various terminologies and possibly slight differences in their focus, these research approaches have a similar underlying goal: "understanding the messiness of real-world practice, with context being a core part of the story and not an extraneous variable to be trivialized" (Easterday, Lewis, & Gerber, 2014, p. 3). The emergence of EDR was motivated by two main reasons (see van den Akker, 1999; Easterday et al., 2014).

The first motive stemmed from the fact that traditional research approaches that focus on descriptive knowledge struggle to come up with appropriate solutions for a variety of practical educational problems. These traditional approaches provide answers that are "too narrow to be meaningful, too superficial to be instrumental, too artificial to be relevant , and, on top of that, they usually come too late to be of any use" (van den Akker, 1999, p. 2). The emergence of EDR resulted from a search by educational researchers for adequate research methods to develop "empirical insights" and "theoretical advancements" supported by the kind of knowledge that is created in the complex "laboratories" of everyday learning environments such as classrooms or online courses (Easterday et al., 2014).

The second reason that motivated the emergence of EDR points to the complex nature of many educational policy reforms that are initiated worldwide. These ambitious and sometimes radical reforms, especially those related to the integration of ICT in education require educational radical revolutions. Such reforms cannot be developed at "drawing tables in government offices"; rather they require an implementation process supported by a systematic research in various contexts (Plomp & Nieveen, 2010). Therefore, the use of more evolutionary research approaches that are interactive, cyclic, spiral is preferred to inform those endeavours that aim at exploring and exploiting the potential of such reforms (van den Akker, 1999).

3.1.2 Distinctive nature of Educational Design Research

EDR distinguishes itself from other types of inquiry in both aims and context. Some of these features are explored and those include an absolutely necessary collaboration with practitioners and the nature of knowledge from EDR.

Unlike other research approaches, EDR attends to both problem solving: *practical contribution* and knowledge creation: *scientific contribution* (McKenney & Reeves, 2019; van den Akker, 1999). The development of appropriate and innovative solutions to real educational problems requires researchers to interact with various practitioners, including teachers, students, policy makers, developers to construct workable interventions (van den Akker, 1999). To make substantive change possible and feasible, educational design researchers have to work hand in hand with these practitioners (Wang & Hannafin, 2005; McKenney & Reeves, 2014). Another reason that compels researchers who apply EDR to collaborate is that, without involving practitioners, it is almost impossible to have a clear understanding of the potential educational problems that need research-based measures to solve them. New interventions, however perfect their design, require collaboration with different stakeholders not only for building users' commitment and ownership (social reason) but also for their fitness (interventions) and survival (technical reason) in real educational settings (van den Akker, 1999).

As already mentioned, one of the aims of EDR is the creation of scientific knowledge to inform the work of other practitioners. One of the main – and difficult – tasks is to make knowledge claims based on EDR. Apart from yielding usable and effective interventions, educational design researchers are challenged to capture and make "explicit" the "implicit" decisions taken during a design process by transforming them into generalisable design guidelines (van den Akker, Nieveen, & Mckenney, 2006). The knowledge generated from EDR endeavour, also called "intervention theory" or "design theory" (Wademan, 2005), is about whether and why an intervention works in a certain context. This knowledge is presented in a form of *heuristic statements* for which (van den Akker, 1999, p. 9) proposed the following format:

"*If you want to design intervention X [for the purpose/function Y in context Z], then you are best advised to give that intervention the characteristics A, B, and C [substantive emphasis], and to do that via procedures K, L, and M [procedural emphasis], because of arguments P, Q, and R.*"

3.1.3 Challenges and dilemmas in EDR

The fact that EDR combines both scientific and practical research aims leads to some challenges and dilemmas that are typical to this type of research. Some of these problems that were advanced by van den Akker, Nieveen, & Mckenney (2006) are discussed.

The first dilemma is related to the role of the researcher, who at the same time plays the role of designer, implementer, and evaluator. Educational design researchers are firmly involved in conceptualising, designing, developing, implementing, and researching pedagogical strategies throughout the entire research process. This can raise ethical issues which, if not dealt with properly, can undermine the credibility of the research claims (Easterday et al., 2014). To alleviate this potential conflict, Plomp (2009, pp. 30-31) proposes the following measures:

- Make research open to professional scrutiny and critique by people outside the project
- The researcher applies the following rule of thumb: shift from a dominance of "creative designer" perspective in the early stage towards the "critical researcher" perspective in later stages
- Have a good quality of research design: strong chain of reasoning, systematic documentation, analysis and reflection of the design

The second problem that is peculiar to EDR points to the fact that this type of research is carried out in real-world settings, which are potentially susceptible to real-world complications (van den Akker, Nieveen, & Mckenney, 2006). In most cases, this problem can occur when the researcher comes from outside the research environment and is seen as a "cultural stranger" (Thijs, 1999) by the research participants for example, teachers and students who can hesitate or completely refuse to cooperate and collaborate (Plomp, 2009). To address this problem and gain participants' trust and understanding, van den Akker, Nieveen, & Mckenney (2006) suggest collaboration and shared beneficial activities between the researcher and the research participants.

EDR is cyclical and each cycle has to take into account the findings from the previous cycles. The research design evolves, changes, and develops throughout successive cycles and this "ever-changing research design" can be perceived as weak (Plomp, 2009). This problem can be addressed through evolutionary planning which is "a planning framework that is responsive to field data and experiences as acceptable moments during the course of the study" (van den Akker, Nieveen, & Mckenney, 2006, p. 84).

3.1.4 Characteristics of EDR

The characteristics of EDR have been extensively discussed in the literature (e.g. McKenney & Reeves, 2014; van den Akker, Gravemeijer, et al., 2006; Wang & Hannafin, 2005) and the analysis of the different descriptors of EDR points to an agreement: EDR is interventionist, pragmatic, theory-oriented, iterative,

integrative, contextual, collaborative, and adaptive. These characteristics and the corresponding explanations are summarised in Table 3.1.

Characteristics	Explanations
Interventionist	EDR is carried out to bring about changes in a given educational context.
Pragmatic	EDR refines both theory and practice and produces usable knowledge and usable solutions to practical problems.
Theory-oriented	The design and development of interventions are grounded in a given theory, but also the findings contribute to a general scientific understanding.
Iterative	EDR processes are iterative cycles of analysis, design, implementation, and redesign.
Integrative	Mixed research methods are used in EDR to maximize the credibility of ongoing research. The methods vary during different phases as new needs and issues emerge.
Contextual	EDR not only recognises the importance of local contexts but also treats changes in these contexts. Heuristics are always developed in a certain context and therefore provide no guarantee for success in other contexts.
Collaborative	EDR requires partnership of multiple stakeholders (researchers, practitioners, and others) who work in a collaboration.
Adaptive	The design of educational interventions is sometimes modified and adapted to the emerging insights. The initial plan is usually insufficiently detailed so that designers can make deliberate changes when necessary.

TABLE 3.1: Characteristics of Educational Design Research (based on McKenney & Reeves, 2014; van den Akker, Gravemeijer, et al., 2006; Wang & Hannafin, 2005)

3.1.5 EDR Process

There is no one-size-fits-all process for conducting EDR (Plomp, 2009), which is according to Bell (2004), a "manifold enterprise" with regard to research focus, practice, and underlying epistemology. Bannan-Ritland & Baek (2008) proposed the questions and methods of EDR by integrating them into four phases: exploration, enactment, local impact evaluation and broader impact evaluation. Drawing on the fact that EDR is a complex process, Ejersbo (2007, p. 37) proposed an "osmotic model" of EDR into four moves: a) from problem to design and from problem to hypothesis; b) from design to intervention and from hypotheses to data; c) from intervention to artefact and from data to theories; and d) from artefact to markets and from theories to peers. The Reeves' (2006) minimalist model highlights the EDR process into four phases: problem analysis, solution development, iterative refinement, and reflection, while van den Akker, Nieveen, & Mckenney's (2006) model is more concept-oriented than process oriented and focuses on professional development of participants, the designed intervention, and design principles.

Despite the differences in terminology and contents of the EDR process, coherence tends to emerge from the existing body of work. The EDR process consists of at least three main phases: *analysis/orientation phase*, *design/development phase*, and *evaluation/retrospective phase* (McKenney & Reeves, 2014). From a technological

perspective, there is a testing and refinement phase that precedes evaluation and retrospective phase, as illustrated in Figure 3.1.

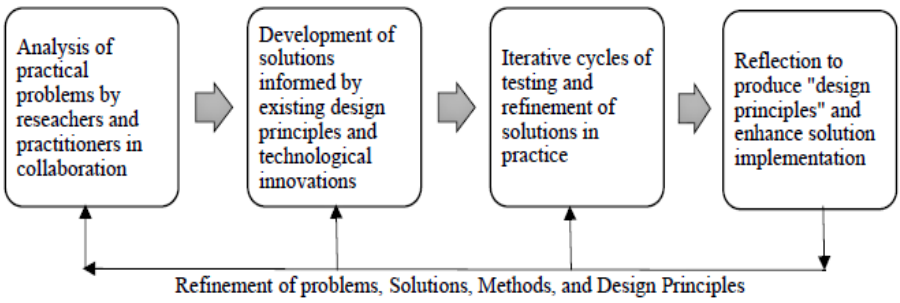
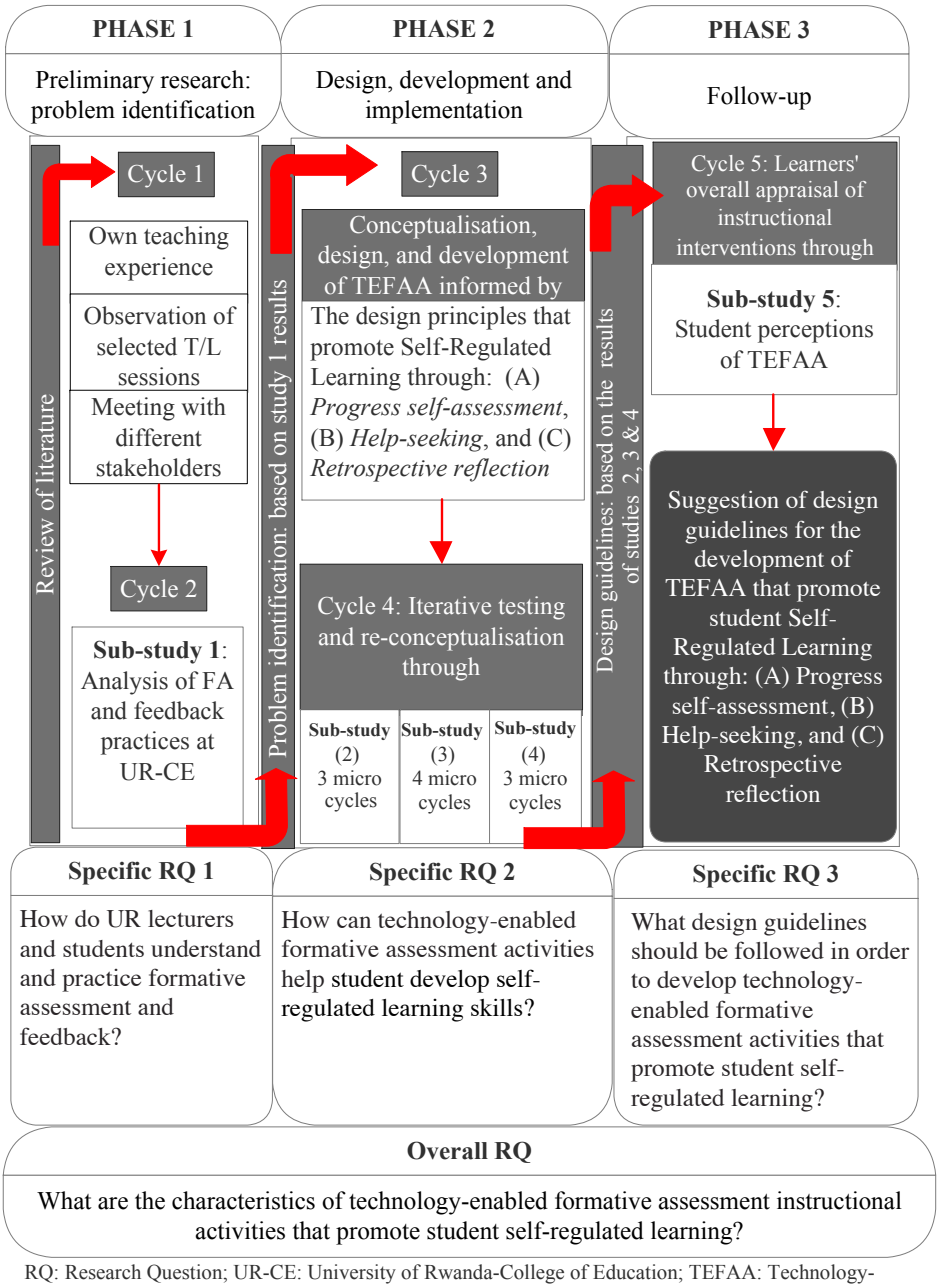


FIGURE 3.1: Predictive and design research approaches in educational technology research (Reeves, 2006, p. 59)

As mentioned before, the problem addressed in this study was a practical educational problem that needed a research-based practical solution. This problem was the ineffective practices of formative assessment and feedback at UR. There was a need to act and address it and technology-enhanced solutions were used as it was recommended by Bahati et al. (2016). In addition, Reeves (2006) proposed EDR as an alternative model for inquiry to study teaching and learning practices through technology. This is because, according to Reimann (2013), design research is helpful in understanding deep problems of learning and in shedding light on the process through which technology gets interpreted and appropriated by teachers and students.

The present study was about introducing new teaching and learning strategies at UR. It focused on developing, iteratively testing, and evaluating teaching/learning technology-enhanced strategies to scaffold self-regulated learning through formative assessment. In view of this, the study's research design, which was interwoven with the research procedure, was based on EDR and is conceptualised in Figure 3.2.



RQ: Research Question; UR-CE: University of Rwanda-College of Education; TEFAA: Technology-Enabled Formative Assessment Activities, FA: Formative Assessment; T/L: Teaching and learning.

FIGURE 3.2: Research design and procedure

Phase 1 : ***Preliminary research for problem identification***

The exploration phase began in spring semester and ended in autumn semester 2015. The main activities that were conducted during this phase were related to the literature review, observations of some selected teaching/learning sessions, and meeting with different stakeholders.

To inform the early framing of this study, the literature about formative assessment and student-regulated learning was reviewed.

During *Cycle 1* of this study, planning meetings were held with different people who were going to directly or indirectly shape the course of this study. UR authorities were approached and permission to conduct research within the institution was sought from them and obtained. During this phase, several meetings were held with four lecturers who were part of the teaching team of the modules EDC 301 (Integration of ICT in Education) and ECE 204 (Social Studies in Early Childhood Education). Later, the researcher participated in the teaching activities of these modules as a co-instructor. The TEFAA were iteratively implemented and tested during the teaching and learning of these modules. Necessary working arrangements were discussed and adopted.

During this cycle, the researcher also carried out in-class observations of some selected teaching and learning sessions. During these observations, the researcher could gather useful information that – coupled with his own teaching experience – helped frame the previously described a priori conceptualization of the practices of formative assessment and feedback at UR-CE. These a priori observations were somewhat confirmed and fine-tuned in an exploratory study that was carried out about formative assessment and feedback practices at the UR-College of Education (see Cycle 2).

During *Cycle 2*, an exploratory sub-study (see Bahati et al., 2016) was carried out to fine-tune the understanding of an educational problem that required intervention. The results of this sub-study helped clearly identify and frame the research problem and constituted the foundation on which the entire research blueprint was based. This sub-study 1 (see paper 1) was carried out during autumn semester 2015 to explore the practices of feedback in formative assessment in Rwandan higher education specifically at UR - CE.

Phase 2 : ***Design, Development and Implementation of TEFAA***

The conceptualisation, design and development of the instructional interventions were carried out during *Cycle 3* from autumn semester 2015 to spring semester 2016. The decision about the type and nature of the TEFAA that help students to develop SRL skills was informed by various factors:

- Literature review
- Recommendations from sub-study 1
- Consultation with other co-instructors
- Class-size
- Availability of ICT infrastructures (computer labs)
- The status of Internet connection
- ICT skills level for the participants (student-teachers)

- The research time frame

The design principles that guided the design and development of TEFAA were driven by Self-Regulated E-Learning Design Principles (Lim & Park, 2015). Several strategies and processes can be used to promote self-regulated learning in classrooms, including: goal setting, planning, self-motivation, attention control, flexible use of learning strategies, self-monitoring, self-reflection, appropriate help-seeking, and self-evaluation (Zumbrunn, Tadlock, & Roberts, 2011). Based on the contextual research determining factors mentioned above, three SRL learning strategies were used in this study to guide the design and development of TEFAA: progress self-assessment, help-seeking, and retrospective reflection. Details of the guiding design principles, implementation strategies and tools are illustrated in the Table 3.2.

	Design principles (Lim and Park, 2015)	Design guidelines	Implementation strategies and tools	Implementation settings
Progress self-assessment (sub-study 2: see paper 2)	I. Use LMS (Learning Management System) to enable students to easily and continually check their performance. II. Inspire students to recognize and utilize self-efficacy.	• Learning objectives are clear, displayed on LMS, and shared with the students • Set an engaging enough (breadth) and structured self-assessment task based on learning objectives and different levels of cognitive domain (depth) • Piloting self-assessment learning task • Clarifying and discussing the goal of the self-assessment task with students and displaying it on LMS • Allowing multiple trials • Assuring a self-paced self-assessment process (set open completion time) • Set clear guidelines and how-tos • Seek, receive, and react to students' feedback throughout the entire self-assessment process • Assuring that "anytime, anywhere" principle is adhered to throughout the student self-assessment process • Minimizing the impact of the "decay effect" • Monitoring student engagement	• Online Knowledge Surveys • Moodle Feedback Module • Lesson Objectives Moodle (LMS) block • "Level up!" Moodle block • Revised Bloom's taxonomy of learning objectives	• Real teaching and learning settings • Enriched virtual course: EDC 301 delivered through UR E-learning platform (Moodle)
Help-seeking (sub-study 3: see paper 3)	III. Construct/design online help-seeking corner or help agents to encourage students to ask and give help while learning. IV. Encourage students to self –(metacognitive) - questioning to comprehend the learning problems and solve them.	• Learning objectives are clear, displayed on LMS, and shared with the students • Set a structured instructional task through which the students will seek and give help from/to each other • Piloting help-seeking learning task • Clarifying and discussing the goal of the help-seeking task with students and displaying it on LMS • Encouraging open and unlimited exchanges between help seekers (students) and help givers (students) • Display, explain the help-seeking process and make sure it is followed • Set clear guidelines and how-tos • Seek, receive, and react to students' feedback throughout the entire help-seeking process • Assuring that "anytime, anywhere" principle is adhered to throughout the student help-seeking process. • Minimizing the impact of the "decay effect" • Encouraging students to ask thought-provoking questions	• Online student-generated questions and peer-responses • Lesson Objectives Moodle (LMS) block • Moodle Forum	• Real teaching and learning settings • Enriched virtual course: EDC 301 delivered through UR E-learning platform (Moodle)

	Design principles (Lim and Park, 2015)	Design guidelines	Implementation strategies and tools	Implementation settings
Retrospective reflection (sub-study 4: see paper 4)	V. Present e-journals forms to students to freely write down reflections on their learning. VI. Provide students with opportunities for reflection about self-efficacy and learning process.	• Learning objectives are clear, displayed on LMS, and shared with the students • Set a structured instructional task through which the students will retrospectively reflect on their learning experience • Piloting retrospective reflection learning task • Clarifying and discussing the goal of the retrospective reflection learning task with students and displaying it on LMS • Allowing open and unlimited students' arguments and observations • Assuring a self-paced retrospective reflection process (set open completion time) • Set clear guidelines and how-tos • Seek, receive, and react to students' feedback throughout the entire retrospective reflection process • Assuring that "anytime, anywhere" principle is adhered to throughout the student retrospective reflection process. • Minimizing the impact of the "decay effect" • Encouraging "self-honesty"	• Structured electronic learning journals. • Lesson Objectives Moodle (LMS) block • Moodle Blogs • Reflection rubric	• Real teaching and learning settings • Enriched virtual course: ECE 204 delivered through UR E-learning platform (Moodle)

TABLE 3.2: SRL strategies, design principles, design guidelines, implementation strategies/tools, and implementation settings

After the design of TEFAA, they were iteratively tested during *Cycle 4* of this PhD study. The testing of TEFAA, the re-design and re-conceptualisation of design guidelines were carried out from autumn semester 2016 to spring semester 2017 at UR-CE. The implementation was done in real teaching and learning settings and resulted in three research papers: papers 2, 3, and 4. The re-conceptualisation of the design guidelines and re-design of TEFAA were carried out via three *micro cycles* for sub-studies two and four and four *micro-cycles* for sub-study three (see Figure 3.2).

Phase 3 : ***Students' overall appraisal of the instructional interventions***

The students' overall appraisal of TEFAA was done during *cycle 5* by measuring the students' satisfaction with the three formative e-assessment strategies (online knowledge survey, online student-generated questions, and structured electronic journals) through paper 5.

The different phases of this PhD research project are graphically illustrated in Figure 3.3, which portrays the entire research timeline.

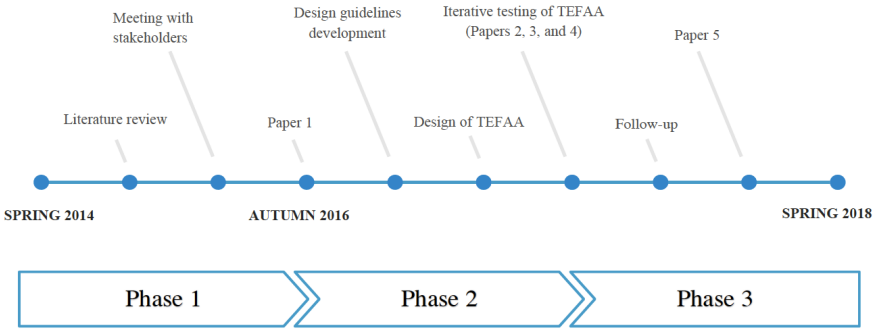


FIGURE 3.3: Research timeline

3.2 Research methods

EDR is not a research method, per se. EDR draws on a variety of both qualitative and quantitative research methods. The combination of different methods and data obtained from multiple sources increases the objectivity, validity and applicability of the research (Wang & Hannafin, 2005). Qualitative and quantitative research methods were used either during *exploratory research* (phase 1), *constructive research* (phase 2), or *follow-up research* (phase 3).

3.2.1 Exploratory research

According to Stebbins (2001), research in any field begins with curiosity. The aim of exploratory research is to investigate issues or topic to develop understanding, insight and ideas about its underlying nature (McNabb, 2015). Exploratory research topics are, most of the time, a problem or an issue that requires further research endeavor to address or solve it. In EDR, an "intensive and systematic" preliminary investigation of an educational problem is needed (van den Akker, 1999) to analyse available current practices in order to specify and better understand the problem under study (Plomp & Nieveen, 2010).

An exploratory sub-study was carried out during research phase 1 to fine-tune the understanding of an educational problem that required intervention. This sub-study was carried out to explore the practices of feedback in formative assessment in Rwandan higher education specifically at UR-CE. It aimed at gaining lecturers' and students' perspectives on formative assessment and feedback and exploring different ways formative assessment and feedback were practised. The sub-study used a qualitative approach and data was collected by means of lecturers' interviews, students' focus group, and document analysis.

3.2.2 Constructive research

Constructive research focused on problem solving which could potentially change the prevailing teaching and learning practices. Constructive research aims at production of solutions to practical problems while contributing to academic knowledge creation. The solutions can involve "constructs, processes, practices, tools, etc." (Lukka, 2003). In EDR, constructive research is considered a research phase during which solutions to problems – identified and analysed during exploratory research – are developed (Plomp, 2009). One necessary and indispensable method that is used during constructive research in EDR is *formative evaluation*. Formative research is "research activities performed during the entire development process of a specific intervention, aimed at optimization of the quality of the intervention as well as testing design principles" (van den Akker, 1999, p. 6). Tessmer (1993) provides a variety of possible formative evaluation methods including:

- Screening or self-evaluation: members of the design research team check the design with checklists of important characteristics of an intervention
- Expert appraisal: a group of experts (for instance, subject matter experts, instructional design experts, teachers) reacts on an intervention
- Walk-through: the design researcher and one or a few representatives of the target group go through the setup of an intervention
- Micro-evaluation: a small group of target users (e.g. learners or teachers) uses parts of the intervention outside its normal setting
- Try-out: a limited number of the user group (e.g. teachers and learners) uses the materials in the day-to-day user setting

Although formative evaluation methods are crucial during constructive research, they do not help ED researchers progressively generate knowledge about learning

cognition, context and culture of their use. They only provide a limited focus on the judgement of the effectiveness, appeal, and efficiency of a particular technological system of instruction (Plomp, 2009). Formative research methods ask such questions as "What is working?", "What needs to be improved?", and "How can it be improved?" (Fitzpatrick et al., 2004). In EDR, formative evaluation methods are "subsumed" as part of a "meta-methodological" approach that involves a variety of research methods (Plomp, 2009). Those methods address the research questions that explore issues extending beyond the question of whether a given intervention is working as effectively as expected. To create scientific knowledge, ED researchers employ a variety of other additional empirical research methods to test the practicability and effectiveness of the proposed solutions (Easterday et al., 2014).

As far as this PhD study is concerned, the solutions to FA-based problems were developed and formatively and iteratively tested during the research phase 2. Formative evaluation methods were used during the testing process through three or four micro-cycles (Figure 3.2) for each intervention. The formative evaluation was based on three criteria (effectiveness, efficiency and appeal) for evaluating constructive research suggested by Reigeluth & Frick (1999). *Effectiveness* refers to the extent to which the application (or guideline or method) realised the intended goal in a given situation. *Efficiency* points to the cost: in money, time, or both and other costs. In this study, the student time, effort, and energy that were required, as well as other additional resources they needed to complete TEFAA were considered. *Appeal* is related to how enjoyable the application (guideline or method) is. This included how the student-teachers were interested in and enjoyed completing TEFAA and how motivated they were to continue learning through them (TEFAA).

Apart from formative evaluation, traditional empirical research methods (see Table 3.3) were used to study and learn from the different formative e-assessment strategies that were being implemented.

3.2.3 Follow-up research

According to Salkind (2010), follow-up studies can be a component of a particular research design and are conducted for a variety of reasons, such as furthering an end in a given research study, re-orienting the study, fulfilling a research promise, ensuring that targeted goals are being realised, etc. Before formally suggesting the design guidelines of the three formative e-assessment strategies, I deemed it necessary to measure the extent to which the students were satisfied with the strategies they were involved in. A survey follow-up sub-study was conducted during the fifth and last research phase. A survey-questionnaire was used to collect data about students' satisfaction with online knowledge survey, online student-generated questions, and electronic reflective journals.

Table 3.3 presents a summary of the methods that were used throughout the three research phases.

Research phase	*Methodological approach*	*Research output*	*Aim*	*Participants/ respondents*	*Data collection*
Exploratory research: Phase 1	Empirical research	Paper 1	Understanding lecturers' and students' perspectives on formative assessment and feedback; and exploring formative assessment and feedback practices	Lecturers, Heads of Departments, subject leaders, and student-teachers	Lecturers' interviews, students' focus group, and document analysis
Constructive research: Phase 2	Formative evaluation	Reports and records from Screening, Co-lecturers' and participants' appraisal, and walk-through	What is working? What needs to be improved? and "How can it be improved?	Researcher, Co-lecturers, student-teachers	Checklists, structured conversations, and plenary classroom sessions
	Empirical research	Paper 2	Providing students with opportunities (through online knowledge survey) to critically assess their own learning progress	Student-teachers	Online knowledge surveys delivered via Moodle Feedback Module
		Paper 3	Providing students with opportunities (through online student-generated questions) to seek help from more knowledgeable peers through peer scaffolding	Student-teachers	The students were asynchronously generating questions and receiving peer-responses through the Moodle Forum.
		Paper 4	Providing student with opportunities (through electronic reflective journals) to record their ideas, personal thoughts, and experiences, as well as their reflections and insights they had during the teaching and learning process	Student-teachers	Students' electronic reflective journals
Follow-up research: Phase 3	Empirical research	Paper 5	Measuring students' satisfaction with formative e-assessment strategies (online KSs, online student-generated questions, and electronic reflective journals	Student-teachers	Survey questionnaire

TABLE 3.3: Summary of methods, research participants, and data collection tools

The first sub-study that was carried out during research phase 1. The sub-study used third-year student-teachers and lecturers as research participants using qualitative research approach. Data was collected by means of lecturers' interviews, students' focus group, and document analysis. The coding was carried out by using qualitative data analysis software MAXQDA12.

In the second sub-study, online KS was used as a formative e-assessment strategy. One hundred nine third-year student-teachers participated in this sub-study. A KS was implemented through a hybrid course delivered via an LMS. By completing the KS, students were expected to predict their ability to perform in various activities of the course but also monitor their level of mastery and understanding. The sub-study used a quantitative research approach and examined the relationship between the students' experience points in a hybrid course and students' scores on online KS. Using rated multiple-choice KS questions, the correlation between these two measurements was calculated using SPSS 23.

In the third sub-study, online student-generated questions and peer-responses were used as a formative e-assessment strategy. One hundred nine third-year student-teachers participated in this sub-study. The sub-study used a quantitative research approach and analysed the relationship between the thinking levels exhibited in student questions and their corresponding peer-responses. The sub-study also examined the extent to which the students were satisfied with their colleagues' scaffolding efforts. The sub-study's data was the students' generated questions and peer-responses. After each section of the course, the student-generated questions and answers were retrieved from the LMS for analysis, which was done by means of an assessment rubric, MAXQDA 12 and SPSS 23. The assessment rubric was developed based on Bloom's taxonomy of learning objectives.

The fourth sub-study used structured electronic reflective journals as a formative e-assessment strategy. Nine-two second-year student-teachers participated in this study. The sub-study used a quantitative research approach and examined the extent to which the student-teachers reflected on their learning and how their reflective skills evolved through e-journal keeping. The sub-study's data was the students' journals. After each section of the course, the students' e-journals were retrieved from the learning management system for analysis. The analysis was performed by means of an analytical reflection rubric, MAXQDA 12 and SPSS 23. The analysis of the presence or absence of reflective thinking from students' e-journals was performed by means of a double-entry analytical reflection rubric which integrates the reflection phases and levels.

The fifth sub-study aimed at measurement of the students' satisfaction with formative e-assessment strategies that were implemented in three instructional interventions: online knowledge survey, online student-generated questions and peer responses, and structured electronic reflective journals. One hundred nine third-year student-teachers participated in this study. This sub-study used a self-rating survey questionnaire. The questionnaire was created using Google Forms, and the link was sent to the respondents via email. Through Google Forms, the respondents' answers were automatically saved in a computer file at the time of collection. These data were subsequently exported into Excel sheets that are compatible with SPSS analysis using the predefined codes. Descriptive statistics

were used first and included the measurement of means and standard deviations. Additional statistical tests (Cronbach's alpha reliability test, a One-Way ANOVA test, and a Pearson's r data analysis) were also run in SPSS 23.

3.3 Delimitation

The scope of the present PhD study points to a number of research delimitations in relation to theoretical background, methodology and research outputs, and participants and research context.

As mentioned earlier in the introductory chapter of this dissertation, this study is situated at the intersection of three topical areas: technology-enhanced learning, formative assessment, and self-regulated learning. The potential benefits of using formative assessment in the teaching and learning process are suggested in the existing literature on FA (e.g. Fisher & Frey, 2015; Greenstein, 2010; Wiliam & Black, 1996) through a number of teaching and learning principles. Those principles include keeping track of learning goals, increasing learning rigour, enhancing student motivation, increasing student engagement, effective feedback, personalised learning experience, SRL, and data-driven instructional decisions. The present study focused on only one principle: self-regulated learning. In addition, the theoretical scope of SRL is wide and researchers approach it from different research perspectives. This study stems from the premise that self-regulation skills do not develop automatically. Rather, teachers can help students learn and develop SRL skills by encouraging them to use SRL strategies in classroom. This study used only three SRL strategies, namely progress self-assessment, help-seeking, and retrospective reflection.

EDR was used in this study and the design of instructional interventions was only limited to online instructional products using existing tools inbuilt in the Moodle LMS. Therefore, this research output is made of three online instructional packages: an online knowledge survey package, a student-generated questions package, and an electronic reflective journals package. These packages are not in the form of design science-based artefacts that are part of the software development process. These instructional packages – not software gadgets nor computer systems – were designed and iteratively tested throughout the teaching and learning of two specific modules in a specific teaching and learning context at UR-CE.

The research was carried out with two groups of student-teachers who were completing a bachelor of education degree programme at UR-CE. These students were taking semester-long enhanced virtual modules through the UR online learning platform. The design and testing of online instructional packages were done in strict compliance with UR policies and academic regulations. In view of this, this research' s outcomes can eventually be best applied in learning design and development within Rwandan public higher education and possibly in other East African contexts.

3.4 Ethical considerations

This research focused on the use of TEFAA at the University of Rwanda and used EDR as a research design. This study's possible ethical dilemmas relate to the fact that the researcher conducted it (researcher role) at the higher learning institution where he is employed, and the object of the study was within his professional activities (practitioner role). In addition, the researcher coached and guided (coach role) the research participants and stakeholders regarding different LMS-based technology tools that were used. In this study, the researcher held ongoing researcher, practitioner and coach role and thus had to manage and harmonize a sort of three different voices or practices from three persons in one (Reason & Bradbury, 2008).

To deal with this dilemma, the key strategy lay in making sure that the choices and decisions that were taken were clear and transparent to both the researcher himself and those with whom he was collaborating.

The researcher made sure that both collaboration and participation in the performed studies were voluntary, and participants were informed at every stage of the study that they were autonomous and free to participate or withdraw from the study at any time without any consequences. In other words, the researcher committed himself to democratic research participation and process (Coghlan & Brydon-Miller, 2014) and did not impose his own agenda to collaborators. The mechanisms were put in place for both informal and regular discussions and reviews with the lecturers/collaborators and other stakeholders about the research process, emerging issues and outcomes.

Although the researcher made sure that both collaboration (with other lecturers) and participation (by the student-teachers) was voluntary and autonomous, the teacher-researcher's authority combined with the students' obligation of participating in the course may apparently – unwillingly, unknowingly, and unintentionally – undermine the students' voluntary participation in and withdrawal from the study. To manage this ethical issue, the researcher followed a fundamental ethical principle proposed by Brooks et al. (2014): the student-participants have to be protected, to the best of the researcher's ability, from any negative consequences that should result from participation or non-participation.

The student-participants were informed about their voluntary participation and consent was sought from them and obtained. In addition, the researcher made it clear to all participants that even if they were compelled to take and complete the courses, this did not mean they were obliged to participate in the study and that any withdrawal from it would not have any negative consequences on their course completion or grades.

In EDR, every collaborator counts and, without collaboration and cooperation, the ED researcher cannot deliver. However, this can raise some ethical issues related to authorship and ownership of the research outputs. In this study, there were cases where collaborators demanded to be considered as co-authors in some research outputs. To deal with this issue, the researcher followed a simple rule for authorship and ownership suggested by Green et al. (2006, p.62): "those who produce research are both its authors and its owners. People achieve ownership of

the research products by mixing their labour with it." In view of this, the question of ownership and authorship was discussed, and a consensus was reached where one of the research partners was guaranteed co-authorship in one sub-study.

To summarise, this study was carried out after official permission was obtained from the UR research directorate. The research process followed common ethical procedures. Informed consent was sought and obtained from the research participants. Participants were informed that their participation was voluntary and that they could, at any time, decide to discontinue their participation, decline to be involved in any research-related learning activities, or stop participating for any reason without penalty. In addition, they were assured that confidentiality and anonymity were to be maintained. No names or personal information were divulged and the data were kept confidential and used for research purposes only. After transcribing interviews and students' focus group discussions (for sub-study 1), the recordings were kept in a safe place. After this sub-study was completed and the paper published, the recordings were destroyed. The subsequent sub-studies (2, 3, 4) used the data that were retrieved from the LMS and Google Forms (for sub-study 5). Before analysis, the data were anonymised and were also destroyed after the corresponding papers were published.

This chapter described the methodology that was used in this study. Different features of EDR were described and characterised in this chapter as the research design that guided the present study. The chapter also focused on indicating how EDR informed the research process throughout the research phases distributed on a clear timeline. In addition, because EDR is not a research method per se, different research methods and approaches, participants and data collection tools were presented alongside the three main research phases: exploratory research, constructive research, and follow-up research. The study delimitations were discussed towards the end of the chapter and, finally, issues relating to ethical considerations were explained as well.

4 Results

This chapter presents the results and findings from three consecutive and interrelated research phases that constitute this dissertation. First, the results from an exploratory research – that aimed at analysing and framing the research problem – are presented. Second, the chapter proceeds with the presentation of the results from the constructive research where instructional interventions were developed and iteratively tried in real classroom settings. Third, the chapter ends with the presentation of the results of the follow-up research that measured the learner satisfaction with formative e-assessment strategies.

4.1 Exploratory research: Exploring feedback practices in formative assessment in Rwandan higher education – Sub-study 1

An exploratory sub-study was executed and aimed at analysing, understanding, and clearly framing an educational problem that required intervention. The research problem was initially conceptualised in an a priori analysis (see Table 1.3) of the practices of FA at UR. These a priori observations needed to be weighed against empirical evidence. Therefore, an exploratory sub-study (see paper 1: Bahati et al., 2016) was conducted; its results helped clearly identify and frame the research problem and constituted the foundation of this entire PhD research project. The results of this sub-study helped answer the first specific research question about how UR lecturers and students understood and practised formative assessment and feedback.

This sub-study was carried out to explore the practices of feedback in formative assessment in Rwandan higher education at UR, specifically at the College of Education. The sub-study used a qualitative approach with the aim of gaining lecturers' and students' perspectives on formative assessment and feedback; and exploring different ways formative assessment and feedback were practised. The data were collected through semi-structured interviews that were conducted with eight lecturers (4 heads of department and 4 subject leaders), students' focus group interviews, and students' marked assignments. This sub-study resulted in 5 major findings that corroborated the general and initial a priori observation that FA was not effectively practised at UR. These findings were summarised as follows:

[a] *Limited understanding of formative assessment and feedback*

Lecturers' understanding of formative assessment and feedback was contextualized within the binding UR instructional assessment policies. Their

limited understanding of FA and feedback was confined within the boundaries of academic regulations: formative assessment referred to coursework (assignments, tests, quizzes, and practical work carried out during the teaching weeks) and feedback denoted the student performance (scored marks).

[b] *Lecturers were the main – or the sole – actors involved in the formative assessment-related practices*

The lecturers portrayed themselves as information providers, mastery checkers, and performance appraisers. They were in full charge of formative assessment efforts and their focus was mainly put on auditing student learning in such way that they (lecturers) acted as auditors while students played the role of the audited. As a result, assessment was carried out by the lecturers for the students, and students were not given opportunity to assess themselves or each other.

[c] *Marks were feedback and feedback was about marks*

Lecturers gave feedback to students in the form of marks only, and comments were very few or even absent.

[d] *Very limited in-class oral feedback*

Due to practical constraints related to limited class time and large class size.

[e] *Unclear lecturers' written feedback and comments*

The students portrayed lecturers' written feedback and comments as unclear. The students affirmed that they had difficult capturing the real meaning behind lecturers' written comments. This was due to the use of indecipherable marking symbols and the lack of clarity observed in the messages conveyed by lecturers' written comments.

Based on these findings, it was concluded that FA and feedback were not understood nor practised correctly at UR-CE. This sub-study recommended three moves that informed the sub-studies 2, 3, 4, and 5, that were done subsequently.

In the *first* recommendation, the sub-study suggested moving away from perceiving formative assessment and feedback as it is prescribed in academic regulations to a more divergent view which requires lecturers to think outside of the academic regulations box.

The *second* recommendation was about moving from considering coursework, assignments, and CAT (Continuous Assessment Tests) as the only formative assessment tools and explore other venues such as self-assessment, peer assessment and discussion.

Third, the sub-study recommended abandoning a *teacher-does-it-all* culture to try formative assessment activities that will involve learners and the use of technology (by both lecturers and students) in formative assessment and feedback practices to mitigate the practical constraints related to limited class time and large class sizes. Limited class time and large class sizes were found to be the leading factors that hindered the effective practice of FA and feedback in face-to-face teaching and learning sessions.

4.2 Constructive research: Instructional interventions

As mentioned earlier in the methodology section, the constructive research focused on designing and trying out the solutions to FA-based problems that were identified during preliminary/exploratory research. This was done by designing and implementing technology-enhanced formative assessment activities driven by three SRL strategies (see Figure 2.2) and using online knowledge survey, online student-generated questions, and electronic reflective journals. Three sub-studies resulted from this constructive research phase and the findings helped answer the second specific research question related to how technology-enhanced formative assessment activities could help students develop self-regulated learning skills.

4.2.1 *Intervention 1*: Helping students develop SRL skills through progress self-assessment by means of online knowledge surveys – Sub-study 2

The development of TEFAA that help students develop SRL skills through progress self-assessment aimed at designing instructional activities that provided students with opportunities to critically reflect and assess their own progress against clearly stated learning objectives and make judgements about their progress vis-à-vis these learning objectives. Given the fact that the students were not used to self-assessment learning activities, there was a need to design a structured self-assessment learning task: an online KS.

The participants in this sub-study were selected through convenience sampling. The study sample consisted of third-year student-teachers at UR-CE. The selection of the students who were invited to participate in this study was based on them being conveniently and readily available. Each and every third-year student-teacher was required to take the Integration of ICT in Education course (EDC 301). In view of this, 109 students were enrolled in the course and were ipso facto conveniently considered as research participants; and they all gave their consent to voluntarily participate in this sub-study. This 10-credit module was taught during the first semester of academic year 2016 – 2017 at UR-CE and was delivered through the UR online learning platform (Moodle).

KSs that were used in this study aimed at serving formative assessment purposes by helping students monitor their understanding and progress throughout the EDC 301 module delivery. Prior to the KS delivery, students were given explanations on how and why KSs were going to be used in the EDC 301 module; it was emphasised that the KS was not an exam and thus they were not expected to know and give all the correct answers. Rather, for each KS question item, students were asked to rate their confidence in ability to answer the question on a scale of 1 to 5, where 1 means "not confident at all" and 5 means "absolutely confident."

Online knowledge surveys for EDC 301 were designed basing on three key elements: learning objectives, the module content, and the revised Bloom's Taxonomy of learning objectives. The KSs were used in 4 of the 5 sections of the module. After each module section, a formative evaluation (through screening, co-lecturers' appraisal, participants appraisal, and walk-trough) was done and

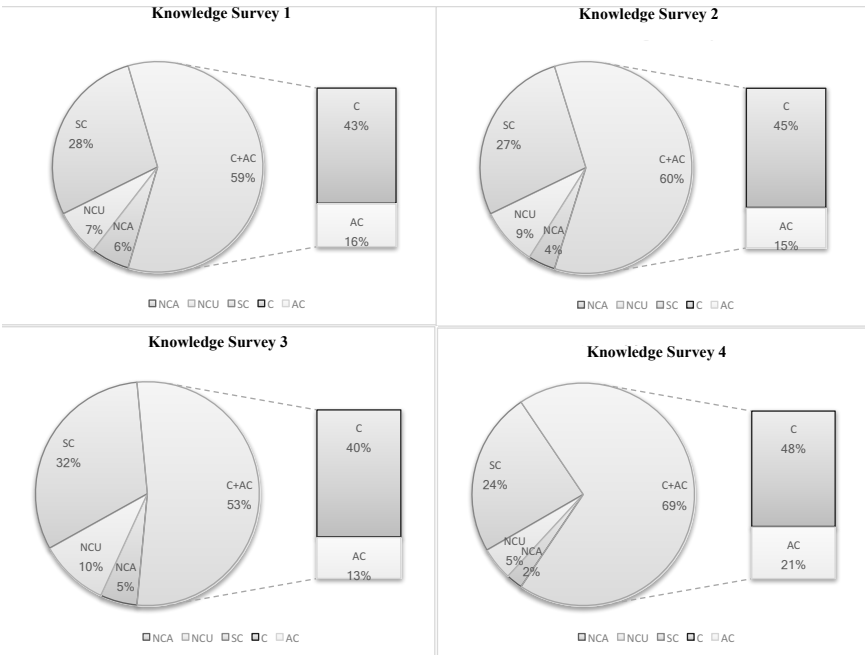
the design guidelines (see table 3.2) were re-adjusted (see Table 4.1), which led to the progressive restructuring of the KS.

SRL strategy:	Progress self-assessment			
Implementation tool:	Online knowledge survey			
Initial design guidelines	(1) learning objectives are clear, displayed on LMS, and shared with the students; (2) Set an engaging enough (breadth), and structured self-assessment task based on learning objectives and different levels of cognitive domain (depth); (3) Piloting self-assessment learning task; (4) Clarifying and sharing the goal of the self-assessment task; (5) Allowing multiple trials; (6) Assuring self-paced self-assessment process; (7) Set clear guidelines and how-tos; (8) Seek, receive, and react (to) students' feedback throughout the entire self-assessment process; (9) Assuring that "anytime, anywhere" principle is adhered to throughout the student self-assessment process; (10) Minimizing the impact of the "decay effect"; (11) Monitoring student engagement.			
Readjustment of the design guidelines and restructuring of KS		After section 1 (Micro-cycle 1)	After section 2 (Micro-cycle 2)	After section 3 (Micro-cycle 3)
	What is working well?	(3), (6), (7), (9), (10), (11)	(1), (3), (4), (5), (6), (7), (9), (10), (11)	(1), (2), (3), (4), (5), (6), (7), (9), (10), (11)
	What needs to be improved?	(1): Learning objectives were not discussed with students (2): Predominance of higher-order question items in KS, and too many questions items (4): Students could not clearly understand the rationale behind doing KS (5): Limited access time to computer labs (reduced number of trials) (8): Limited lecturer's feedback on students' performance on KS	(2): Imbalance of of KS question items in terms of depth and breadth was still perceived (8): A one-way feedback/ discussion (lecturer to students) about students' performance on KS	(8): A limited number of students reacted to the lecturer's feedback on their performance on KS
	How can it be improved?	(1): Not only posting learning objectives on LMS but also discuss them with the students (2): Balancing KS question items in terms of depth and breadth (4): Not only posting the aim of KS on LMS but also discuss it with the students (5) encourage offline-online working pattern (8) Create an LMS-based feedback/discussion venue regarding students' performance on KS	(2): Further balancing of KS question items in terms of depth and breadth (8): Using discussion venues outside LMS	(8): Further encourage students to react to lecturer's feedback about their performance on KS
Suggested design guidelines after 3 micro-cycles	(1) Set clear learning objectives, display them on LMS, but also discuss them with the students; (2) Balancing KS question items in terms of depth and breadth; (3) Piloting KSs before actual implementation; (4) Clarifying, sharing but also discussing the goal of the KS with the students; (5) Encourage offline-online working pattern to accommodate multiple trials on KS; (6) Assuring self-paced KS process; (7) Set clear guidelines and how-tos; (8) Diversify discussion venues about students' performance on KS; (9) Allow students to complete KS "anytime, anywhere" they want; (10) Minimizing the impact of the "decay effect"; (11) Monitoring student engagement.			

TABLE 4.1: Intervention 1: Iterative implementation of online knowledge surveys

As illustrated in Table 4.1, some of the initial KS design guidelines worked well throughout the three testing cycles. Those included piloting of the KS, assuring self-paced KS process, setting guidelines and how-tos, allowing "anytime, anywhere" KS completion, minimizing the impact of "decay effect" (KS survey was completed immediately at the end of each module section while students still had a fresh memory of the learned material), and monitoring student engagement. However, a number of KS design guidelines were re-conceptualised and readjusted based on the information gathered through formative evaluation of the KSs at the end of each testing cycle. The KS design guidelines that were re-conceptualised or readjusted were related to learning objectives, the depth and breadth of the KS questions, the clarication of the KS aim, KS multiple trials, and feedback/discussion about the students' KS performance.

The design and structure of KS in each module section was informed by information gathered through formative evaluation of the previous section's KS (what is working well? What needs to be improved, and how can it be improved?). The re-conceptualisation of KS design guidelines and the corresponding redesign and restructuring of KS led to a variation in the students' perception of their confidence level in their ability to perform in various module learning activities (see Figure 4.1).



NCA: Not Confident at all, **NCU**: Neither Confident nor Unconfident, **SC**: Somewhat Confident, **C**: Confident, **AC**: Absolutely Confident

FIGURE 4.1: Online knowledge survey results (Bahati, Fors, & Tedre, 2017, p. 81)

The number of students who perceived themselves as confident and absolutely confident in their ability to answer KS questions increased from 59% in module section 1 to 69% in module Section Four, even if the increase did not follow a uniform pattern as the students progressed in the course. In general, the students' confidence increased in Section Two, decreased in Section Three and then increased again dramatically in Section Four.

A uniform pattern in increase was however observed in the correlation between the student performance on the KS (as measured by students' scores in KSs) and student engagement (as measured by students' experience points) as illustrated in Figure 4.2. In other words, the correlation between the student performance on the KS and the student engagement increased progressively as the design guidelines were re-conceptualised and as the KSs were redesigned and restructured.

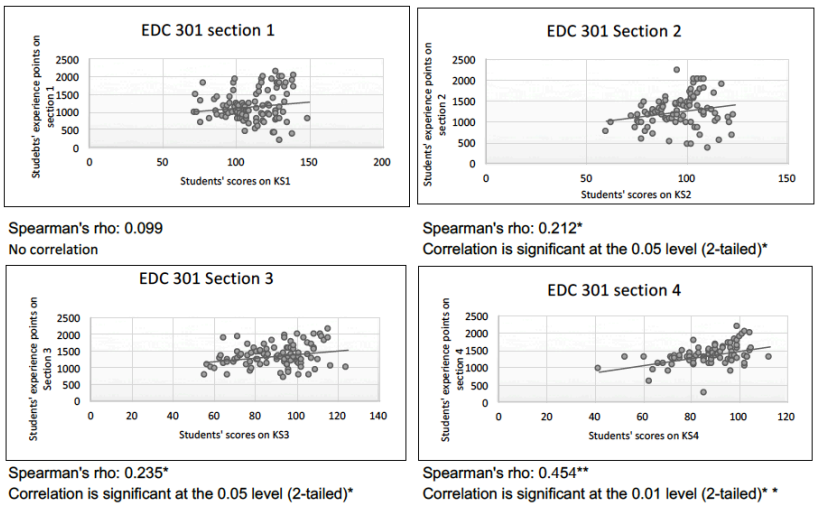


FIGURE 4.2: Plot of the relationship between students' performance on KSs and students' experience points (Bahati, Fors, & Tedre, 2017, p. 82)

Figure 4.2 shows that although the student performance on online KS was positively—but weakly—related to student engagement, the strength of this relationship increased progressively as the course unfolded. The correlation between students' scores on KS1 and students' experience points in Section One of the course was Spearman's rho: 0.099. The correlation coefficients for Section Two and three (with Spearman's rho: 0.212 and Spearman's rho: 0.235) increased slightly but were relatively negligible, and a significant crease was observed in Section Four (with Spearman's rho: 0.454).

4.2.2 *Intervention 2*: Helping students develop SRL skills through help seeking by means of online peer-scaffolding – Sub-study 3

The development of TEFAA that help students develop their SRL skills through help-seeking aimed at designing instructional activities that provided students with opportunities to seek help from more knowledgeable others (MKO) through peer scaffolding. The students played the role of MKO and provided support to each other. The purpose of this sub-study was to use innovative pedagogical practices in the area of formative assessment by involving students in the question generation process in an educational environment – such as UR – where instructional questioning is normally seen as the lecturer's privilege.

The sub-study was done through the teaching of a 10-credit module that took place at the UR – CE during the first semester of 2016 – 2017 academic year. An enriched virtual mode of blended approach to teaching and learning was used in this course. Students were taking a few face-to-face learning sessions with their lecturers and then were free to accomplish most of the rest of the coursework remotely and online. The students were asynchronously generating questions and receive peer-responses through the Moodle Forum. The help-seeking process was structured on five consecutive steps as it is illustrated in Figure 4.3.

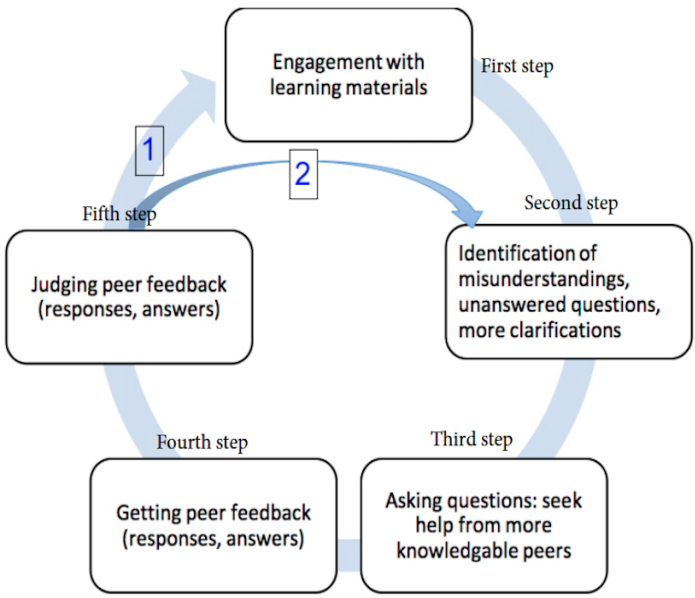


FIGURE 4.3: Help-seeking process (Bahati, Fors, & Hansen, 2017, p. 110)

The *firs*t step is the engagement with the learning materials or coursework where the learner deals with the different instructional activities and the course contents. During the *second* step, the student realises that there are some gaps, misconceptions or misunderstandings related to the learning materials and activities s/he

is dealing with. The student is perplexed, puzzled and for her/him to be able to advance, s/he needs help, support and more clarification. In the *third* step, the student seeks help and asks a question to someone who can help her/him understand. In the *fourth* step, a more knowledgeable peer replies with a response s/he thinks is relevant, informative, comprehensible, and true. However, it is up to the student who asked the question (the questioner) or the instructor to decide – after deliberation and judgement – whether the question has been answered satisfactorily or not. This judgement is done in the *fifth* step. Depending on whether the questioner is satisfied by the respondent's reply, two actions are possible: the questioner will decide either to move forward (when the reply is satisfactory: see number 1 on Figure 4.3) and engage her/himself with other learning materials or go back to the puzzling issues (when the reply is unsatisfactory: see number 2 on figure 4.3) and seek help and support again.

After each section of the module, the student-generated questions and answers were retrieved from the learning management system for analysis which was done by means of a Bloom's taxonomy-based assessment rubric. The rubric was structured on three levels of thinking: basic, medium, and high. Each rubric level was assigned a score and each student's question and answer was rated as basic (one point), medium (two points), or high (three points). Before the rubric was used for actual analysis, it was introduced and presented to other faculty members both within and outside the department for peer review and commentary.

The students were involved in help-seeking exercise throughout five sections of the module. After each module section, a formative evaluation (through screening, co-lecturers' appraisal, participants appraisal, and walk-through) was done, and the design guidelines for help-seeking activity (see Table 3.2) were re-conceptualised (see Table 4.2), leading to the progressive restructuring of the help-seeking exercise.

SRL strategy:	Help-seeking				
Implementation tool:	Online student-generated questions and peer-responses				
Initial design guidelines	(1) Learning objectives are clear, displayed on LMS, and shared with the students; (2) Set a structured LMS-based help-seeking corner through which the students will seek and give help from/to each other; (3) Piloting help-seeking learning exercise; (4) Clarifying and sharing the goal of the help-seeking learning task; (5) Assuring a self-paced KS process; (6) Encouraging open and unlimited exchanges between help seekers (students) and help givers (students); (7) Display, explain the help-seeking process and make sure it is followed; (8) Set clear guidelines and how-tos; (9) Seek, receive, and react to students'feedback throughout the entire help-seeking process; (10) Assuring that "anytime, anywhere" principle is adhered to throughout the help-seeking process; (11) Minimizing the impact of the "decay effect"; (12) Encouraging students to ask thought-provoking questions.				
Readjustment of the design guidelines and restructuring of the help-seeking corner	*What is working well?*	After section 1 (Micro-cycle 1)	After section 2 (Micro-cycle 2)	After section 3 (Micro-cycle 3)	After section 4 (Micro-cycle 4)
		(3), (5), (6), (10), (11)	(1), (3), (4), (5), (6), (7), (9), (10), (11)	(1), (2), (3), (4), (5), (6), (7), (8), (10), (11), (12)	(1), (2), (3), (4), (5), (6) (7), (8), (10), (11),(12)
	What needs to be improved?	(1): Learning objectives were not discussed with the students (2): The help-seeking corner was not detailed enough to effectively guide the students (4): Some students were considering seeking help from "any-who-can" as unproductive (6): Most of the help-seekers could not complete the 5th step of the help-seeking process (7): The guidelines and how-tos were too brief (8): Limited lecturer's feedback on the students' help-seeking process (11): Most of the student-questions and peer-responses were at the lower thinking level	(2): Additional supporting help-seeking details were still needed (7) and (11): The suggested introductory question-prompts were not effectively used	(8): The student-questions and peer-responses at higher thinking level were still few	(8): The student-questions and peer-responses at higher thinking level were still few

	How can it be improved?	(1): Not only posting learning objectives on LMS but also discuss them with students (2): Restructure the help-seeking corner and provide additional supporting details (4): Not only posting the aim of the help-seeking activity on LMS but also discuss it with the students (6): Assign "conditional completion" to help-seeking exercise (7): Add question-prompts to guidelines and how-tos (8): Set the lecturer's feedback as a condition for help-seeking activity completion (11): Use introductory question-prompts that reflect various thinking levels	(2): Supplement help-seeking supporting details (7) and (11): Set examples about how to formulate questions at various thinking levels	(8): Continue scaffolding the question-generation exercise by means of case-examples	(8): continue scaffolding the question-generation exercise by means of case-examples
Suggested design guidelines after 4 micro-cycles	(1) Set clear learning objectives, display them on LMS, but also discuss them with the students; (2) Set a structured LMS-based help-seeking corner with all necessary supporting details; (3) Piloting help-seeking learning exercise before actual implementation; (4) Not only posting the aim of the help-seeking task on LMS but also discuss it with the students; (5) Encouraging open and unlimited exchanges between help seekers (students) and help givers (students); (6) Assuring a self-paced help-seeking process; (7) Display and explain the help-seeking process and make sure it is followed by setting "conditional completion" to help-seeking activity; (8) Set clear guidelines and how-tos; (9) use question-prompts; (10) Create a feedback venue in order to seek and react (to) students' feedback throughout the entire help-seeking process and set the instructor's feedback as a condition for help-seeking activity completion; (11) Assuring that "anytime, anywhere" principle is adhered to throughout the help-seeking process; (12) Minimizing the impact of the "decay effect"; (13) Encouraging students to ask thought-provoking questions (at various thinking levels) through the use of question-prompts case-examples.				

TABLE 4.2: Intervention 2: Iterative implementation of online peer-scaffolding

As illustrated in Table 4.2, some of the help-seeking corner design guidelines worked well throughout the four implantation cycles and other were readjusted and re-conceptualised. Those design guidelines that worked well included piloting help-seeking learning exercise before actual implementation, encouraging open and unlimited exchanges between help seekers and help givers, assuring that "anytime, anywhere" principle is adhered to throughout the help-seeking process, and minimizing the impact of the "decay effect" (because the help-seeking activity covered the entire module section, the students were completing this activity immediately at the end of each module section while they were still having fresh memory of the learned material).

The rest of the help-seeking design guidelines were re-conceptualised and readjusted based on the information that resulted from the formative evaluation.

To effectively regulate their learning, learners need to be aware of, understand and sometimes fix the learning goals and objectives and plan how to achieve them. It was realised – through formative evaluation – of the help-seeking activity that the students were neither aware of nor conversant with the learning objectives. It was not enough to display the learning objectives (by means of Moodle lesson objectives plugin) on the LMS. This issue was addressed by creating a learning objectives discussion forum. A forum was also created to discuss the aim of the help-seeking exercise since some students were considering seeking help from "any-who-can" – and not from the person of their choice – as unproductive.

The formative evaluation that was done after the first implementation cycle showed that the students were struggling to effectively formulate relevant help-seeking questions. The reason was that the help-seeking guidelines and how-tos needed to be revisited and supplemented with additional supporting details. Figure 4.4 shows an example of how the guidelines and how-tos changed during the second implementation cycle which was done in Section Two of the module. The question-prompts were added to guide the students to properly formulate their help-seeking questions. Adding the question-prompts was helpful but not enough. Introductory question-prompts that reflect various thinking levels and concrete case-examples were added respectively during Section Three and Four of the module.

A well-designed help-seeking activity invites learners to follow an ordered process and it is up to the instructor to make sure that the process is followed. After the first implementation of the help-seeking activity, it was realised that most of help-seekers could not complete the fifth step of the help-seeking process, that is, judging whether the received peer-response was relevant and satisfactory and why. This issue was attended to by setting the instructor's feedback as a required condition for help-seeking activity completion. Among other things, the instructor's feedback included comments about whether the help-seeker followed and completed the help-seeking process.

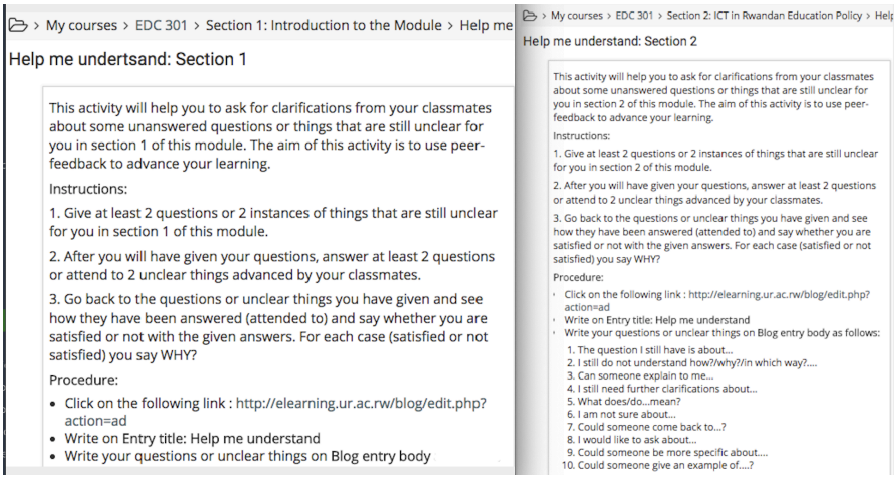


FIGURE 4.4: Changes in guidelines and how-tos from Cycle 1 to Cycle 2 of help-seeking activity implementation

Completing the *fifth* step (see Figure 4.3) of the help-seeking process was critical in this sub-study. A self -regulated learner knows when and how to seek help but also how to judge the relevance of the received help. In this sub-study, the students expressed their needed help through asking questions to their colleagues, who answered with the responses they thought were relevant and true. It was up to the student who asked the question (the questioner) or the instructor to decide – after deliberation and judgement – whether the question has been answered satisfactorily or not. Depending on whether the questioner was satisfied by the respondent's reply, two self-regulatory moves were possible: the questioner decided either to move forward (when the peer-answer was satisfactory) and engage her/himself with other learning materials or go back to her/his unanswered question (when the peer-answer is unsatisfactory) and seek help and support anew.

The question of whether the help-seekers were satisfied or dissatisfied with their peer-responses was analysed in a the third sub-study (see paper 3: Bahati, Fors, & Hansen, 2017). Apart from analysing the students' satisfaction with their peers' scaffolding efforts, the sub-study also looked at the relationship between the levels of thinking found in help-seekers-generated questions and the levels of thinking found in their peer-responses.

The analysis of the help-seekers' judgements of their peers' responses showed that all help-seekers were not immediately satisfied with their peers' responses. The results (see Table 4.3) indicated that some help-seekers were satisfied with their peers' responses after several attempts to answer their questions. Some were not satisfied until the third-party (instructor or another student) intervened and others chose – after some exchanges – to put an end to the discussion, although they were still unsatisfied with their peers' responses.

Course sections \ Satisfactory responses	After the first attempt	After the second attempt	After the third attempt	After the fourth attempt	After third-party intervention	Left unsatisfied	SUM
SECTION I	34	37	12	5	8	2	98
SECTION II	28	23	31	9	11	0	102
SECCTION III	44	27	12	7	4	1	95
SECCTION IV	57	38	6	3	1	0	105
SECTION V	29	21	11	12	2	1	76
SUM	192	146	72	36	26	4	476

TABLE 4.3: Distribution of satisfactory peer-responses across the course sections (Bahati, Fors, & Hansen, 2017, p. 114)

Table 4.3 shows that, throughout the course, more than seventy percent (71%; 338 out of 476) of the responses were judged satisfactory by the student-questioners after the first and the second attempts. But some of the student-questioners were not satisfied with their peer-responses until the third and the fourth attempt with 72 (15.1%) and 36 (7.5%) responses respectively.

In general, it was realised that while student-questioners were in pursuit of meaning, the student-respondents helped them to make this meaning by answering their questions, providing clarifications and exemplifications. In so doing, students helped and supported each other to check, strengthen, adjust, and monitor their understanding and the longer the time for reaching a consensus, the stronger and more significant this exercise became. Peers could support each other to bridge the gap between what they could accomplish on their own and what they could do with help from more capable others: peer scaffolding.

However, as mentioned earlier, the help-seeking formative evaluation showed that most of the student-questions and peer-responses were at the lower thinking level after the first implementation cycle. This trend was also observed across all subsequent course sections. In general, almost fifty-five percent (54.9%) of all student-generated questions were at the basic thinking level, 25.3% were found to be at medium level, while only 19.6% were rated at a high level of thinking. More than sixty percent (60.4%) of peer-responses were in a basic thinking level, 29.4% were rated at the medium level, and only 10% of peer-responses were rated at the high level of thinking.

There is a traditional but still unresolved empirical issue about the relationship between higher/lower order questions and higher/lower order student responses. Some authors (e.g. Westbury & Milburn, 2007) suggested that asking a "foolish question" can lead to student's "foolish answer", while "high-level question", invokes the student's "high-level answer." This sub-study investigated this and tested whether a relationship existed between the levels of thinking found in help-seekers-generated questions and the levels of thinking found in their peer-responses. The results of an *independent t-test* showed no relationship between the thinking levels exhibited in student-generated questions and thinking levels exhibited in their corresponding peer-responses.

In general, it was realised that getting students to be able to formulate higher-level questions can take time and sustained practices. As a results, it is suggested that while designing a help-seeking corner where the students seek help by asking questions, the setting of case-examples about how to formulate questions at various thinking levels should prevails throughout the entire help-seeking process.

In the end, during this sub-study, the students were given an opportunity to seek help from more knowledgeable peers through peer scaffolding. It was suggested that when students are given an opportunity to judge the relevance of the peer-responses to their questions and give value to peer-support, there is a room for fruitful discussions and exchange between the student-questioner and student-respondent. A discussion venue is set in motion by a student-questioner who – explicitly or implicitly – invites the student-respondent to do more and add value to her/his responses. The student-questioner would like the respondent to do so by providing further clarifications, helping in quenching the questioner's curiosity and consolidate or confirm her/his doubtful reasoning, and providing evidence and examples.

4.2.3 *Intervention 3*: Helping students develop SRL skills through retrospective reflection by means of electronic reflective journals – Sub-study 4

The development of TEFAA that help students develop their SRL skills through retrospective reflection aimed at designing instructional activities that provided students with opportunities to record their ideas, personal thoughts, and experiences, as well as the reflections and insights they had during the teaching and learning process. Electronic reflective learning journals were used as an implementation tool and the students were invited to reflect on their learning experience throughout a blended course. The choice of electronic journals was motivated by two interrelated factors that characterised the context in which the sub-study was conducted: large class size and seeking flexible learning. Electronic journals were chosen because they were expected to facilitate reflexive learning in a large size classroom.

An enriched virtual mode of a blended approach to teaching and learning was used in ECE 204: Social Studies in Early Childhood Education. The student-teachers attended some face-to-face learning sessions with their lecturers and then they were allowed to complete most of the remaining coursework online from wherever and whenever they wanted. The students were invited to reflect on their learning experience after each of the four sections of the course by completing an electronic reflective journal. The structured reflective e-journals (Chan, 2009) which used specific guiding questions that students had to answer in each e-journal entry were chosen because they were user-friendly for the participants.

The reflective framework used in this sub-study combined two reflective models proposed by Driscoll (2007) and McCarthy (2013). Driscoll (2007) developed and refined his model structured into three simple questions: *What*? (returning to the context), *Now what*? (understanding the context), and *So what*? (modifying future outcomes). McCarthy (2013) developed another reflection model and called it the three lens of reflection: the *Mirror* (reflection on the influence of the experience on

the self), the *Microscope* (reflection on what happened and how one's role in the events impacted others), and the *Binoculars* (reflection on envisioning the future developments and change in decisions, behaviours and attitudes).

In this sub-study, *What* was combined with *Mirror* to form the first phase of reflection which implies the students' return to the learning experience to reflect on their feelings about what happened. *So what* was combined with *Microscope* to constitute the second phase of reflection. This denotes the students' description of the learning experience and their roles' impact on other students' actions. *Now what* was combined with *Binoculars* whereby the students' reflection focused on future developments, necessary and foreseeable readjustment and changes. The reflection framework used in this sub-study is presented in Figure 4.5

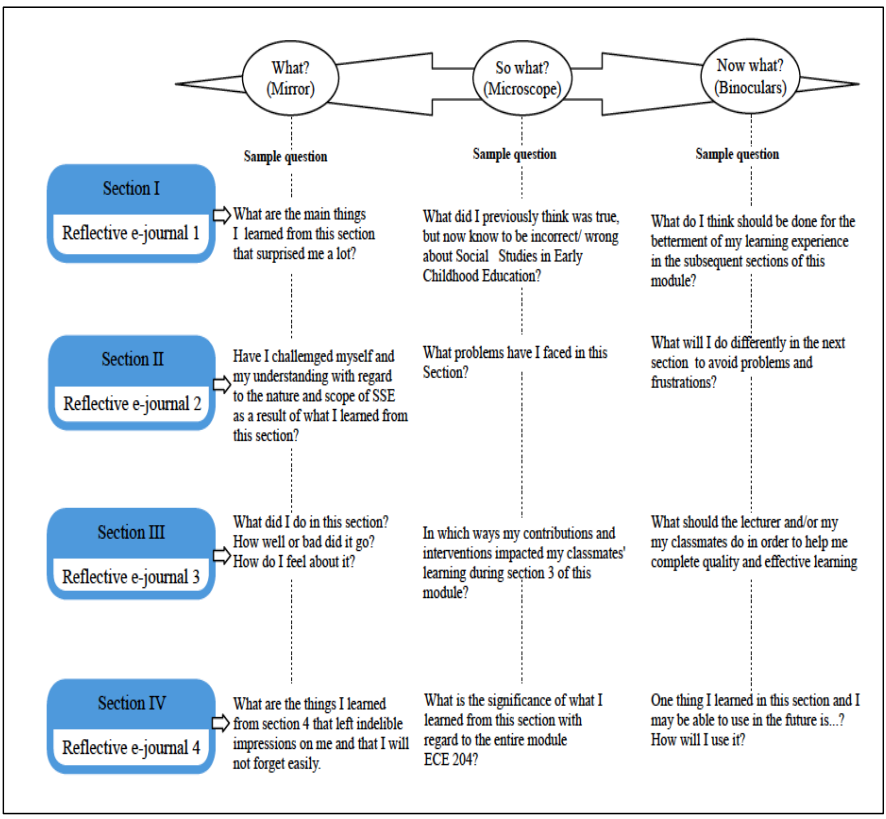


FIGURE 4.5: Framework for learning reflective e-journals (Bahati et al., 2018, p. 1127)

The students reflected on their learning experiences by responding to a series of guiding questions that were distributed among the three phases of reflection. Horizontally, the framework shows that for each section of the course, the reflective e-journal was structured around the guiding questions that were covering

three phases of reflection: what (mirror), so what (microscope), and now what (binoculars). The left-right arrow that passes through the three phases of reflection implies a seamless nature of integration among these phases. In fact, in order to be able to effectively reflect on each phase, it requires integration and use of reflection ingredients of another phase. Vertically, the framework implies that for each phase of reflection, the participants were responding to guiding questions across every reflective e-journal entry that was meant to be completed at the end of each course section.

This sub-study examined the extent to which student-teachers' learning e-journals portrayed reflection levels and how the student-teachers' reflective skills evolved over time through e-journal keeping.

The analysis of the presence or absence of reflective thinking from the students' e-journals was performed by means of a double-entry analytical reflection rubric which integrates the reflection phases and reflection levels. The reflection phases (What/mirror, so what/microscope, and now what/binoculars) were integrated with the reflection levels (non-reflectors, reflectors, and critical reflectors) proposed by Wong et al. (1995) for assessing the level of student reflection in reflective journals. According to these authors, there is no evidence of reflective thinking in non-reflectors' journals; reflectors show some evidence of reflective thinking in their journals but do not demonstrate any critical changes and/or integration, while the critical reflectors show integration, changes and clear evidence of reflective thinking. Each analytical reflection rubric level was assigned a score, and at each reflection phase, the student was classified as beginner (one point), non-reflector (two points), reflector (three points), or critical reflector (four points).

A formative evaluation that was done after each course section led to a progressive re-conceptualisation of the design guidelines (see Table 4.4) and the restructuring of electronic reflective journals.

Table 4.4 shows that there are some structured learning e-journal design guidelines (1, 3, 4, 6, 9 and 10) that were also used during the iterative implementation of both online KS and and online peer-scaffolding. In general, the re-conceptualisation and readjustment of these shared design guidelines followed a similar pattern.

Specific to this sub-study, was the progressive restructuring of the learning e-journals to address some issues that were revealed through the formative evaluation after each micro-cycle of retrospective reflection implementation process.

SRL strategy:	Retrospective reflection			
Implementation tool:	Electronic reflective journals			
Initial design guidelines	(1) Learning objectives are clear, displayed on LMS, and shared with the students; (2) Set a clear and structured instructional task through which the students will retrospectively and critically reflect on their learning experience; (3) Piloting the retrospective reflection learning task; (4) Clarifying and sharing the goal of the retrospective reflection task; (5) Allowing open and unlimited students' arguments and observations; (6) Assuring self-paced retrospective reflection process (set open completion time); (7) Set clear guidelines and how-tos; (8) Seek, receive, and react to students' feedback throughout the entire retrospective reflection process; (9) Assuring that "anytime, anywhere" principle is adhered to throughout the student retrospective reflection process; (10) Minimizing the impact of the "decay effect"; (11) Encouraging self-honesty.			
Readjustment of the design guidelines and restructuring of e-journals		After section 1 (Micro-cycle 1)	After section 2 (Micro-cycle 2)	After section 3 (Micro-cycle 3)
	What is working well?	(3), (5), (6), (9), (10), (11)	(1), (3), (4), (5), (6), (8), (9), (10), (11)	(1), (3), (4), (5), (6), (7), (8), (9), (10), (11)
	What needs to be improved?	(1): Learning objectives were not discussed with students (2): The students could not reflect critically on their learning experience. Most of the students' reflections were categorized under the beginning and non-reflection thinking levels (4): The students could not clearly understand the aim of retrospective reflection task (7): The guidelines and how-tos were not clear enough to help students effectively reflect on their learning experience (8): Limited lecturer's feedback on the student's reflections	(2): Despite obvious improvement many students' reflections were still at the beginning and non- reflection levels (7): The reflection rubric could not be easily understood and applied	(2): Despite further improvements in students' reflections at reflection and critical reflection levels some students need continued practice and help
	How can it be improved?	(1): Not only posting learning objectives on LMS but also discuss them with students (2): Restructure e-journal and supplement it with with additional supporting details (4): Not only posting the aim of e-journal on LMS but also discuss it with the students (7) Provide a guiding reflection rubric and discuss it with the students (8) Use the reflection rubric to appraise and provide feedback to students	(2): Further restructuring of the learning e-journal with additional supporting details by (7): Setting case-examples that reflect the various levels of the reflection rubric	(2): Continue using case-examples and provide lecturer's supporting feedback by means of the reflection rubric
Suggested design guidelines after 3 micro-cycles	(1) Set clear learning objectives, display them on LMS, but also discuss them with the students; (2) Set clear and structured learning journals with enough supporting details to help students reflect on their learning experience at various thinking levels; (3) Piloting learning structured e-journals before actual implementation; (4) Clarifying, sharing but also discussing the goal of learning journals with the students; (5) Allowing open and unlimited students' arguments and observations while reflecting on their learning experience; (6) Assuring self-paced retrospective reflection process (set open completion time); (7) Use illustrated guiding reflection rubric, (8) set clear guidelines and how-tos; (9) Create an instructor's scaffolding feedback venue whereby the students' journals can be continuously appraised by means of a reflection rubric; (10) assuring that "anytime, anywhere" principle is adhered to throughout the student retrospective reflection process; (11) Minimizing the impact of the "decay effect"; (12) Encouraging self-honesty.			

TABLE 4.4: Intervention 3: Iterative implementation of electronic reflective journals

The formative evaluation showed that during Section One, the students could not reflect critically on their learning experience. Most of the students' reflections were categorized under the beginning and non-reflection reflection levels. It was then decided to review the learning e-journals' guidelines and how-tos, and a guiding reflection rubric (see Figure 4.6) was introduced and discussed with the students.

Learning journal reflection rubric

This rubric is meant to help you structure your ideas using various reflection levels. You are advised to aim high and reflect critically on your learning experiences.

	Beginner 1 pts	**Non-reflector 2 pts**	**Reflector 3 pts**	**Critical Reflector 4 pts**
What? Description of the feelings about what happened (the learning experience)	Beginner The feelings about the learning experience are vaguely described or not described at all.	Non-reflector The description of the feelings about what happened is basic. The student tends to focus her/his description on separate learning aspects instead of revisiting the learning experience and analysing it in an integrated manner.	Reflector The description of the feelings about what happened isintegrated but not thorough. The student's description focuses on the relationships between multiple learning aspects. However, the description does not revisit the learning experience and analyse it critically.	Critical Reflector The description of the feelings about what happened isintegrated and thorough. The student's description focuses on the relationships between multiple learning aspects. In his/her description, the student continually revisits the learning experience and his feelings. He/she analyses and examines them critically.

FIGURE 4.6: Excerpt from the learning journal reflection rubric (Bahati et al., 2018, p. 1127)

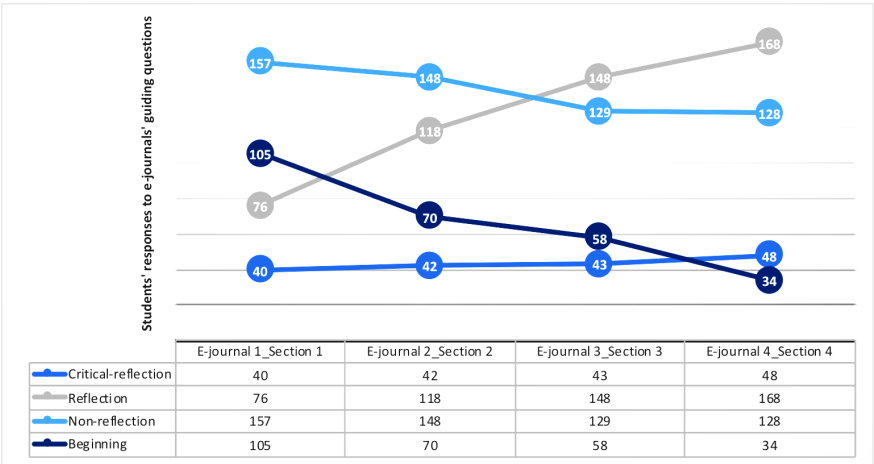
The rubric was introduced in Section Two and was meant to help the students structure their ideas at various reflection levels. The same rubric was also used by the instructors to appraise the students' reflective e-journals and give them scaffolding feedback. Despite the introduction of the rubric as a guiding and appraisal tool for reflection in the second course section, the subsequent formative evaluation showed mixed observations. There were obvious improvements but many students' reflections were still at the beginning and non- reflection levels. In view of this, the guiding reflection rubric was extended with illustrative case-examples that reflected the various levels of the reflection rubric.

This sub-study' s results showed an overall trend that a large number of students (71%) were categorised as either non-reflectors or reflectors. Thirty-seven percent of the responses to e-journals' guiding questions were given by the students who were categorised as non-reflectors. In fact, there was no evidence of reflective thinking in these students' responses. The students whose responses (34%) showed some evidence of reflective thinking were categorised as reflectors. There was no evidence of any critical and integrative thinking that was found in their responses. This evidence was nonetheless found in a few responses (11%) whereby the students were categorised as critical reflectors. It was also noteworthy that a significant percentage of responses (18%) came from the students who were

categorised as beginners, those who did not describe their learning experience at all or did it vaguely.

Despite the fact that only 11% of the students' responses to e-journal guiding questions were categorised under the critical reflection level, the sub-study results showed that the students' reflective skills evolved over time through e-journal keeping.

The re-conceptualisation and readjustment of the design guidelines and the corresponding restructuring of e-journals throughout the four course sections led to an evolution (see Figure 4.7) in the students' reflective skills.



	E-journal 1_Section 1	E-journal 2_Section 2	E-journal 3_Section 3	E-journal 4_Section 4
Critical-reflection	40	42	43	48
Reflection	76	118	148	168
Non-reflection	157	148	129	128
Beginning	105	70	58	34

FIGURE 4.7: Evolution of the students' reflective skills through e-journal keeping (Bahati et al., 2018, p. 1130)

As illustrated in Figure 4.7, the students' reflective skills improved over time throughout the e-journal-keeping journey. This improvement could be justified by two types of continuous changes that were observed in the levels of reflection in the students' responses to e-journal guiding questions. The use of ANOVA with repeated measures with a Greenhouse-Geisser correction indicated that these changes were significant. The first type of change was *incremental* and was observed in the number of student responses that were in the two upper reflection levels: reflection and critical-reflection. The number of student responses in the reflection level increased from 76 (20%) in e-journal 1 to 118 (31%) in e-journal 2. The number of responses in the reflection level also increased to 148 (that is 39%) in e-journal 3 and to 168 (44%) in e-journal 4. The same trend was observed in the number of the student responses in the critical-reflection reflection level. This number increased from 40 (10.5%) in e-journal 1 to 48 (13%) in e-journal 4.

The second type of change was *decremental* and was observed in the number of student responses that were in the two lower reflection levels: the non-reflection

and the beginning reflection levels. The number of student responses in the non-reflection level decreased from 157 (41%) in e-journal 1 to 148 (39%) in e-journal 2. The number of responses in the non-reflection level also decreased to 129 (34%) in e-journal 3 and to 128 (34%) in e-journal 4. The decrease was also observed in the number of student responses in the beginning reflection level. This number decreased significantly from 105 (28%) in e-journal 1 to 34 (10%) in e-journal 4.

In view of these incremental and decremental changes, it could be concluded that the students' reflective skills improved over time and progressively throughout the e-journal-keeping exercise. The number of student responses to e-journal guiding questions increased in the higher-order reflection levels and decreased in the lower-order reflection levels.

4.3 Follow-up research: Measurement of the students' satisfaction with instructional interventions – Sub-study 5

This sub-study aimed at measuring the students' satisfaction with formative e-assessment strategies that were implemented in three instructional interventions described in the constructive research section. The sub-study was conducted during the fifth and last phase of this PhD research project and examined how the students perceived the three formative e-assessment strategies: online knowledge survey, online student-generated questions and peer responses, and structured electronic reflective journals.

This sub-study used a self-rating survey questionnaire where the respondents were invited to indicate their level of satisfaction with the question items' statements on a range of five-point Likert-type satisfaction scale (very satisfied-5; satisfied-4; neither satisfied nor dissatisfied-3; dissatisfied-2; very dissatisfied-1). These items were constructed based on "*the quality of student engagement*" and "*the quality of feedback*", which are considered two important characteristics of any successful assessment that supports students' learning (Gibbs & Simpson, 2005).

According to these authors, the analysis of the quality of student engagement in any successful assessment task should focus on a number of criteria. Those criteria include the sufficiency of assessment tasks, the variation and distribution of assessment tasks across all the course sections, whether assessment tasks are quite engaging (communicating clear and high standards criteria), and whether assessment tasks are engaging students in meaningful learning activities (whether they are worth the time and efforts the students spend on them). They also argue that the analysis of the quality of feedback in any successful assessment task should focus on the sufficiency of feedback, details, timeliness, appropriateness to the purpose of assessment task, and the clarity of feedback (whether the feedback clearly describes what the learner is supposed to do).

In general, this sub-study's results showed that the students were satisfied with the quality of their engagement and the quality of feedback across all the formative e-assessment strategies (see Table 4.5). The highest level of the Likert satisfaction scale that was used was 5 (very satisfied) and the students' satisfaction mean rating was $\geq$ 4.28 (SD = 0.70).

	N = 108	*Mean*	*Std. Deviation*
1.	*Assessment tasks were varied in online Knowledge survey*	4.64	0.60
2.	*Completing the assessment tasks was worth the time and efforts I spent in online knowledge survey*	4.56	0.63
3.	*Sufficient assessment tasks were provided in online knowledge survey*	4.55	0.54
4.	*Assessment tasks were engaging enough in online knowledge survey*	4.45	0.69
5.	*Completing the assessment tasks was worth the time and efforts I spent in online student-generated questions*	4.38	0.67
6.	*Assessment tasks were engaging enough in online student-generated questions*	4.38	0.69
7.	*Assessment tasks were varied in electronic reflective journals*	4.37	0.68
8.	*Sufficient assessment tasks were provided in electronic reflective journals*	4.37	0.73
9.	*Completing the assessment tasks was worth the time and efforts I spent in electronic reflective journals*	4.32	0.71
10.	*Assessment tasks were varied in online student-generated questions*	4.31	0.69
11.	*Assessment tasks were engaging enough in electronic reflective journals*	4.31	0.72
12.	*Sufficient assessment tasks were provided in online student-generated questions*	4.28	0.70

TABLE 4.5: Results of the student satisfaction ratings on formative e-assessment strategies regarding the quality of student engagement

If taken separately, there are variations in students' satisfaction with formative e-assessment strategies regarding the quality of student engagement. The results show that the respondents were, in most cases, dominantly satisfied with the quality of student engagement in formative e-assessment tasks they completed in online KSs. In fact, within KSs, the students' satisfaction mean rating was 4.64 (SD = 0.60) for the variation of assessment tasks, 4.56 (SD = 0.63) for the completion of assessment tasks that were worth the time and efforts the students spent, 4.55 (SD = 0.54) for the sufficiency of assessment tasks, and 4.45 (SD = 0.69) for the fact that assessment tasks were engaging enough.

Based on the extent to which the students were satisfied with the quality of their engagement, an online knowledge survey was an e-assessment strategy the students were mostly satisfied with, followed by online student-generated questions and electronic reflective journals.

Regarding the quality of feedback, the sub-study's results also showed that the students were satisfied with the quality of every feedback criteria in all the formative e-assessment strategies. The highest level of the Likert satisfaction scale used was 5 (very satisfied) and the students' satisfaction mean rating was $\geq$ 4.03 (SD = 0.93)(see Table 4.6).

	N = 108	*Mean*	*Std. Deviation*
13.	*The feedback was appropriate to the purpose of the assignment in online knowledge survey*	4.41	0.74
14.	*The feedback was describing to me what I was supposed to be doing in online knowledge survey*	4.25	0.80
15.	*The feedback was timely in online knowledge survey*	4.23	0.73
16.	*The feedback was describing to me what I was supposed to be doing in electronic reflective journals*	4.22	0.84
17.	*The feedback was appropriate to the purpose of the assignment in electronic reflective journals*	4.21	0.90
18.	*Sufficient feedback was provided often enough in online knowledge survey*	4.20	0.90
19.	*The feedback was provided in enough details in online knowledge survey*	4.19	0.89
20.	*The feedback was appropriate to the purpose of the assignment in online student-generated questions*	4.18	0.82
21.	*The feedback was timely in online student-generated questions*	4.14	0.79
22.	*The feedback was provided in enough details in online student-generated questions*	4.13	0.86
23	*Sufficient feedback was provided often enough in electronic reflective journals*	4.13	0.81
24.	*The feedback was timely in electronic reflective journals*	4.13	0.83
25.	*The feedback was provided in enough details in electronic reflective journals*	4.07	0.84
26.	*The feedback was describing to me what I was supposed to be doing in student-generated questions*	4.06	0.78
27.	*Sufficient feedback was provided often enough in online student-generated questions*	4.03	0.93

TABLE 4.6: Results of the student satisfaction ratings on formative e-assessment strategies regarding the quality of feedback

The results show that the respondents were, in most cases, predominantly satisfied with the quality of feedback of formative e-assessment activities they completed in KSs. KSs have the first three highest mean ratings for student satisfaction with the quality of feedback. The students' satisfaction mean rating was 4.41 (SD = 0.74) for the appropriateness of feedback, 4.25 (SD = 0.80) for the clarity of feedback, and 4.23 (SD = 0.73) for the timeliness of feedback.

The students' satisfaction mean rating was the same for three feedback criteria of formative e-assessment strategies: enough feedback details in online student-generated questions and the sufficiency and timeliness of feedback in electronic reflective journals with the respective mean ratings of 4.13 (SD = 0.86), 4.13 (SD = 0.81), and 4.13 (0.83). Based on the extent to which the students were satisfied with the quality of feedback, knowledge survey was an e-assessment strategy the students were mostly satisfied with, followed by electronic reflective journals and online student-generated questions.

This chapter presented the results and findings from three consecutive and interrelated research phases that constitute this dissertation. First, the results from the exploratory research were presented. Second, the chapter proceeded with the presentation of the results from the constructive research where instructional interventions were developed and iteratively tried in real classroom settings. Third, the chapter ended with the presentation of the follow-up research results that measured the learner satisfaction with formative e-assessment strategies.

5 Research contributions

This research was carried out following the idea of EDR. McKenney & Reeves (2014) suggested two important aims of EDR: (1) solving an educational problem facing educational practitioners while simultaneously (2) discovering new knowledge to inform the work of other practitioners who face the same problem. As a result, EDR yields two types of research outputs that are related to both problem solving (practical contribution) and knowledge creation (scientific contribution). The scientific contribution is considered as the design guidelines, design theories, lessons learned, or design principles. The practical contribution refers to the products (such as learning content, policies, teaching/learning guides or process, online course packages) resulting from educational interventions that are developed, tried and improved throughout the EDR process. These products can be reused in similar instructional contexts within the department for which they are developed. This research's contributions are therefore discussed in accordance with these two interrelated types of EDR output.

5.1 Practical contribution

The instructional interventions that were developed and used in this study were designed by using online learning tools inbuilt in Moodle Learning Management System. Three online educational packages were designed, iteratively tried, and progressively improved in real teaching and learning settings of two semester-long enhanced virtual courses: EDC 301 and ECE 204. Upon completion, this EDR resulted in three improved versions of online educational packages: online knowledge surveys, online peer-scaffolding (through student-generated questions and peer-responses), and structured electronic reflective journals. These online instructional packages were developed for two UR-CE academic departments: Foundations, Management, and Curriculum studies and Early Childhood Education. These online instructional packages can be accessed, used and re-used in the future teaching and learning of the same modules of EDC 301 and ECE 204.

These improved versions of online instructional packages – even if they can still be subject to further improvement through additional trials – were arrived at as a results of progressive restructuring and refinement. In addition, the follow-up sub-study showed that students were generally satisfied with all the quality characteristics of these online instructional packages.

5.2 Scientific contribution

This research's scientific contribution was conceived as an intertwining of both the design guidelines and lessons learned from the three instructional interventions that were carried out. Before suggesting the lessons learned and design guidelines as heuristics statements (proposed by van den Akker, 1999), the design guidelines and lessons learned were presented in an integrative format (see Figure 5.1). Figure 5.1 shows that there are lessons learned and design guidelines that are common to all three formative e-assessment strategies and those that are peculiar to each individual formative e-assessment strategy.

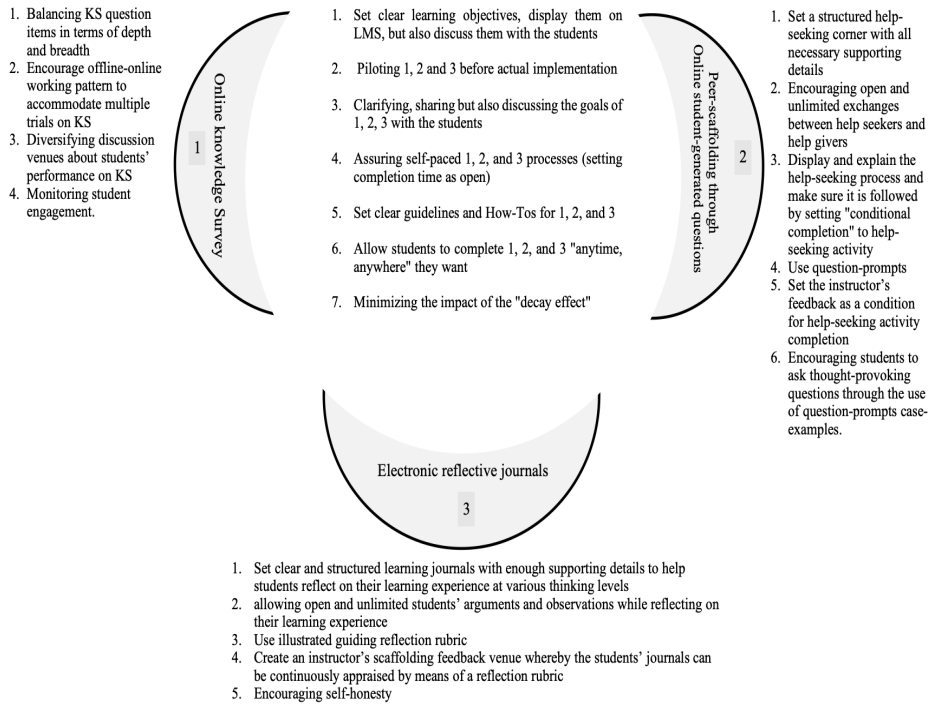


FIGURE 5.1: Suggested design guidelines

5.2.1 Suggested design guidelines and lessons learned from the implementation of online knowledge surveys

From the results of sub-study 2, the following lessons were learned:

In order to design effective TEFAA that help learners develop their SRL skills through self-progress assessment by means of online knowledge survey and in the context of a higher education blended course, ***the KS should be engaging enough, and the KS question-items should be balanced in terms of depth and breadth,***

By:	Because:
• *Setting clear learning objectives, display them on LMS, and discuss them with the students*	In order to effectively regulate their learning, learners need to be aware and understand (sometimes fix) the learning goals and objectives and plan how to achieve them.
• *Piloting KS before actual implementation*	Evaluate the practicability and feasibility of KSs.
• *Clarifying, sharing but also discussing the goal of KS with the students*	Without a clear understanding of the aim of KS, students will neither be engaged nor motivated.
• *Assuring self-paced KS process (set open completion time)*	The deadline pressure may hamper students' sustained efforts to perform well in KSs.
• *Setting clear guidelines and how-tos for KS*	Guiding and showing students how to complete KS will shorten the "trial and error" period.
• *Allowing students to asynchronously complete KS "anytime, anywhere" they want*	Completing KS synchronously would deny the students the opportunity to "think-do-recess-rethink-redo".
• *Minimizing the impact of the "decay effect" (embedded KS)*	The formative impact of KS is effective when KS is completed formatively while students still have fresh memory of the learned material.
• *Setting balanced KS question-items in terms of depth and breadth*	The students should be given an opportunity to predict their performances on various learning tasks and monitor their current levels of mastery and understanding at various thinking levels.
• *Encouraging an offline-online working pattern*	In order to accommodate online KS multiple trials with limited access to computer labs and unstable Internet connection, students can complete KS offline and upload their work when they go online.
• *Diversifying discussion venues (other than LMS-based) about students'performance on KS*	The feedback on the student's performance on online KS is important. Using additional discussion/feedback venues (other than LMS-based) such as social media can widen the instructor's opportunity to timely react to the student's performance on online KS particularly in a blended learning setting where access to computers is limited and connection to the Internet is unstable.
• *Monitoring student engagement*	Performance on knowledge survey does not lead to any academic credit-related decision of pass or fail. Its function is purely formative. However, students tend to focus more on their numerical achievements that have something to do with the course completion requirements. Thus, monitoring student engagement and setting automated reminders to complete KS is key.

TABLE 5.1: Suggested design guidelines and lessons learned from implementation online knowledge survey implementation

5.2.2 Suggested design guidelines and lessons learned from the implementation of peer-scaffolding through online student-generated questions and peer-responses

From the results of sub-study 3, the following lessons were learned:

In order to design effective TEFAA that help learners develop their SRL skills through help-seeking by means of online student-generated questions and peer-responses and in the context of a higher education blended course, ***the help-seeking corner through which the students seek and give help from/to each other should be clear, well-structured with enough supporting details,***

By:	Because:
• *Setting clear learning objectives, display them on LMS, but also discuss them with the students*	In order to effectively regulate their learning, learners need to be aware and understand (sometimes fix) the learning goals and objectives and plan how to achieve them.
• *Piloting the use of the help-seeking corner before actual implementation*	Evaluate the practicability and feasibility of the help-seeking corner.
• *Clarifying, sharing but also discussing the goal of the help-seeking exercise with the students*	Without a clear understanding of the aim of help-seeking exercise, students will neither be engaged nor motivated.
• *Assuring self-paced help-seeking process (set open completion time)*	The deadline pressure may hamper students' initiatives to comfortably seek help (from) and give help (to) others.
• *Setting clear guidelines and how-tos for the help-seeking exercise*	Guiding and showing students how to proceed in order to seek or give help will shorten the "trial and error" period.
• *Allowing students to asynchronously seek and give help "anytime, anywhere" they want*	If the help-seeking exercise is only synchronous, this would deny the students the opportunity to"think-do-recess-rethink-redo."
• *Minimizing the impact of the "decay effect" (embedded help-seeking corner)*	The formative impact of the help-seeking exercise is effective when this is completed formatively while students still have fresh memory of the learned material.
• *Set a structured help-seeking corner with all necessary supporting details*	An effective help-seeking activity should be designed following a structured process that describes in clear details how the student can seek (from) and give help (to) others.
• *Encouraging open and unlimited exchanges between help-seekers and help-givers*	When the help-seeker and the help-giver are engaged in open and unlimited exchanges by discussing and judging the relevance of the answers given to the help-seeker's questions, this will result in consensually and mutually acceptable answers that are much more meaningful and significant.
• *Display and explain the help-seeking process and make sure it is followed by setting "conditional completion" to help-seeking activity*	Seeking help should follow a clear process. Students need to know what to do first, second, etc. Displaying and explaining the help-seeking process will help learners to seek and give help in an ordered and structured manner. It is important to make sure that the help-seeking process is completed only upon the help-seeker's satisfactory judgement of the received help (answers). To do that, the help (answer)-judgement phase of the help-seeking process should be set as a completion requirement to help-seeking exercise.
• *Using question-prompts*	Question-prompts are used as introductory question statements. They guide the help-seekers to effectively word and structure their questions.
• *Set the instructor's feedback as a condition for help-seeking activity completion*	Some students tend to accept their peer-responses just to clear the way for activity completion and get done as soon as they can. Others, due to friendship bias, would not like to tag their peer- responses as unsatisfactory because they think this would embarrass their colleagues. The instructor needs to closely monitor the help-seeking exercise and ascertain that the help-seeking process is followed. Setting instructor's feedback as a condition for help-seeking activity completion will be helpful to address this situation.
• *Encouraging students to ask thought-provoking questions through the use of question-prompts' case-examples at various thinking levels*	Providing students with question-prompts is not enough. In order to help the students to generate thought-provoking questions. The question-prompts should be accompanied by illustrative cases of the questions that reflect various thinking levels, especially the higher order ones.

TABLE 5.2: Suggested design guidelines and lessons learned from the implementation of peer-scaffolding through online student-generated questions

5.2.3 Suggested design guidelines and lessons learned from the implementation of electronic reflective journals

From the results of sub-study 4, the following lessons were learned:

In order to design effective TEFAA that help learners develop their SRL skills through retrospective reflection by means of electronic reflective journals and in the context of a higher education blended course, ***electronic reflective journals should be well-structured with a clear and detailed reflection framework and a sustained scaffolding in order to help the students reflect on their learning experience at various thinking levels,***

By:	Because:
• *Setting clear learning objectives, display them on LMS, but also discuss them with the students*	In order to effectively regulate their learning, learners need to be aware and understand (sometimes fix) the learning goals and objectives and plan how to achieve them
• *Piloting the use of electronic reflective journals before actual implementation*	Evaluate the practicability and feasibility of electronic reflective journals
• *Clarifying, sharing but also discussing the goal of electronic reflective journals with the students*	Without a clear understanding of the aim of electronic reflective journals, students will neither be engaged nor motivated
• *Assuring self-paced retrospective reflection process (set open completion time)*	The deadline pressure may hamper and limit the students' efforts to amply explore and reflect on their learning experience
• *Setting clear guidelines and how-tos for completing electronic reflective journals*	Guiding and showing students how to proceed in order to complete electronic reflective journals will shorten the "trial and error" period
• *Allowing students to asynchronously reflect on learning experience "anytime, anywhere" they want*	If the retrospective reflection exercise is only synchronous, this would deny the students the opportunity to "think-do-recess-rethink-redo"
• *Minimizing the impact of the "decay effect" (embedded electronic reflective journals)*	The formative impact of the retrospective reflection exercise is effective when this is completed formatively while students still have fresh memory of the learning experience
• *Set clear and structured learning e-journals with enough supporting details to help students reflect on their learning experience at various thinking levels*	The design of structured electronic reflective journals should consider the fact that students vary in their reflective skills. Some are beginners, others are non-reflectors, reflectors and critical reflectors. Electronic reflective journal guiding questions should reflect various thinking levels to accommodate all students with their varying reflective skills.
• *Allowing open and unlimited students' arguments and observations while reflecting on their learning experience*	Students should feel free to provide their observations and views regarding any learning experience under consideration. The formative effect of the retrospective reflection will materialise only if the students feel free to openly and unlimitedly advance their views about their learning experience.
• *Use illustrated guiding reflection rubric*	An illustrated reflection rubric helps the students structure their ideas using various reflection levels. It is also used by the instructors to appraise the students' reflective e-journals and give them scaffolding feedback
• *Create an instructor's scaffolding feedback venue whereby the students' journals can be continuously appraised by means of a reflection rubric*	The students' reflective skills evolve over time through e-journal keeping. This evolution results from the students' progressive improvement in completing their journals based on the instructor's progressive appraisal and scaffolding feedback.
• *Encouraging self-honesty*	In some teaching and learning environments where the students are rarely invited to speak up, they tend to please the teacher when they are invited to appraise the learning experience. The student reflection on their learning experience will have an effective formative effect if self-honesty is encouraged and self-censorship is discouraged.

TABLE 5.3: Suggested design guidelines and lessons learned from implementation of retrospective reflection through electronic reflective journals

6 Discussion

In this chapter, the present study's findings are discussed and related to previous research studies. The discussion focuses on this study's constructive research phase where three instructional interventions were carried out. The discussion will start with the findings related to the first intervention where online KSs were used to help students develop their SRL skills. The chapter will proceed with the discussion of the findings related to the second instructional intervention about the students' involvement in online peer-scaffolding by means of student-generated questions and peer-responses. Last, the findings related to the third instructional intervention about helping students develop their SRL skills through retrospective reflection and by means of e-journals will be discussed.

6.1 Helping students develop SRL skills through self-progress assessment by means of online knowledge survey

In this study, knowledge surveys were used as a formative e-assessment strategy throughout an enhanced virtual course delivery. By completing knowledge surveys, students were expected to predict their ability to perform in various course activities, monitor their level of mastery and understanding, and reflect on their learning. The KSs that were used in this study and the corresponding empirical results relate variously to previous research studies in this area.

Consistent with previous studies (e.g. Favazzo et al., 2014; Bell & Volckmann, 2011; Bowers et al., 2005), the KSs used in this study were developed based on two key features: *breadth* and *depth*. The knowledge surveys covered the entire content of the course section and the knowledge survey questions covered the different levels of Bloom's taxonomy of learning objectives.

Unlike the previous studies that sought to examine the relationship between KS and final summative exams by using pre-and post-KSs, this study used KS not in a pre-and post-format but rather as an online formative assessment tool that was implemented throughout the course delivery. This study used KSs not as a diagnostic (pre-KS) and verification (post-KS) assessment tools, but as an assessment for learning tool that was implemented throughout the course to assess the student progress and not the end product (Smith, 2012). This study's KS research focus also differs from that of previous research studies. The KS research in previous studies followed an *output-oriented approach*. For example, Bowers et al. (2005) and Wirth & Perkins (2005) compared pre-and post-knowledge survey results with final examination results to analyse the link between them. The KS research in this study followed a *developmental approach* where the focus was put

on the progressive redesign and restructuring of KS through multiple iterative trials.

The KS was administered after each course section. The design and structure of KS in each subsequent module section was informed by information gathered through formative evaluation of the previous section's KS. Unlike Bowers et al. (2005), who observed a significant increase of students' confidence over the semester in all sections of the course, this study' results show that the students' confidence in ability to answer KS questions was not generally following a uniform pattern as the course progressed. The re-conceptualisation of KS design guidelines and the corresponding redesign and restructuring of KS led to a variation in the students' perception of their confidence level in the ability to perform in various module learning activities. The students' confidence increased in Section Two, decreased remarkably in Section Three and then increased again dramatically in Section Four.

It was suggested that an increase or a decrease in student perceived mastery was dependent upon a number of overlapping factors related to the course content, motivation to learn, teaching strategies, and the learning environment.

For the course content, the students' level of confidence was higher in two sections (Two and Four) where the course content was part of the teacher-prepared course textbooks – over reliance on textbooks (Hickman & Porfilio, 2012) – and low in sections where the course content was taken from other readings.

The student motivation to learn, learning environment, and unfamiliar teaching and learning strategies were critical as well. At the beginning of the semester, the students were experiencing a sort of "academic performance anxiety." Taking an online course for their very first time in a non-conducive learning environment (inadequate ICT facilities) and the student-led assessment practices were putting students in a somewhat uncomfortable situation characterised by "the fear of failing", which affected their motivation to learn. The students' perceived confidence level in Section One (at the beginning of the semester) and three (where unstable Internet connections and a frequently inaccessible UR e-learning platform were observed) was lower and increased in sections Two and Four when the students' motivation to learn and self-assessment skills were improved.

Due to the relatively large amount of data, some previous studies (e.g. Baumgart & Hassemer, 2006) suggested that knowledge surveys that are used for research purposes should not be manually scored. Knowledge surveys should be administered using courseware, LMSs, or any other specific survey packages that can return results in a format that can be easily imported into a spreadsheet for analysis. Although online knowledge surveys were considered as appropriate for data analysis facilitation, the question of how these KSs should be designed was not explicitly addressed in other studies. Some design guidelines for knowledge surveys were only implicitly referred to in a few previous studies, and parallelism with the design guidelines suggested in the present study was attempted as follows:

Design guidelines for KS implicitly suggested in previous studies	Design guidelines of online KS suggested in the present study
A well-designed KS combines both the analysis of content and learning objectives of a course (Nuhfer & Knipp, 2003)	Setting clear learning objectives, display them on LMS, and discuss them with the students
Instructors develop sophistication with knowledge surveys by coding each item according to levels of reasoning, such as those of Bloom (Nuhfer & Knipp, 2003)	Setting balanced KS question-items in terms of depth and breadth
Students take the survey home to complete it with plenty of time for self-reflection (Wirth & Perkins, 2005)	Allowing students to asynchronously complete KS "anytime, anywhere" they want
Instructors should refer frequently to the survey throughout the course (Baumgart & Hassemer, 2006)	Diversifying discussion venues (other than LMS-based) about students'performance on KS

TABLE 6.1: An attempted parallelism between this study's suggested design guidelines for KS and those suggested in previous studies

It is important to note that these guidelines were not referred to as "design guidelines" in the previous studies. They are suggestions, recommendations or lessons learned that emerged from the researcher's scanning of these studies. Therefore, the present study not only attempted to expand on these few suggestions and recommendations but also suggested additional design guidelines for online knowledge surveys.

6.2 Helping students develop SRL skills through help-seeking by means of online student-generated questions and peer-responses

In this study, the student-generated questions and peer-responses were used as a formative e-assessment strategy in an enriched virtual course. Throughout the course, the students were invited to seek and give help to each other by asynchronously generating questions and get peer-responses through the Moodle Forum.

Although, the present study used academic help-seeking as a strategy for promoting SRL (in agreement with some other research studies, for example, Schworm & Gruber, 2012; Aleven et al., 2006; Aleven & Koedinger, 2001; Aleven et al., 2003), two important features demarcate it from other previous studies.

The first feature relates to "*how the help-seeking is initiated*." In this study, the help-seeking process was initiated by the student him/her self and the needed help was expected to be given by the more knowledgeable peers via peer scaffolding (Belland, 2014). Less knowledgeable students brought up questions and asked for clarifications while the more knowledgeable peers provided support. This study used a student-led help-seeking process, while previous studies used a system-led or teacher-led help-seeking process. The help-seeking process was initiated by the

instructor's prompts in Schworm & Gruber's (2012) study. In Aleven et al.'s (2006) and Aleven et al.'s (2003) studies, the help-seeking was proposed to students through an intelligent tutoring system and computational help-seeking model that volunteered help to students.

The second feature relates to the *model of the help-seeking process*. Although, there is no "one size fits all" as far as the design of help-seeking is concerned (Aleven et al., 2003), most of the help-seeking models (for example, the Cognitive Tutor developed by Aleven & Koedinger, 2001) found in the literature build on Nelson-Le Gall's (1981) model. His model, which was later elaborated by Newman (1994) comprises the following five steps: (1) become aware of the need for help, (2) decide to seek help, (3) identify potential helper(s), (4) use strategies to elicit help, and (5) evaluate the help-seeking episode. The first, second, and fifth steps of this model can be respectively matched with the second, third, and fifth steps of the help-seeking model used in the present study. While during the third and fourth steps of Aleven & Koedinger's (2001) model, the student "identifies potentials helpers" and "strategises to elicit help", it was not up to the help-seeker to either identify the potential helper or elicit help in the present study. The help-seeker was transforming his/her perplexity in a formulated and expressed question (van der Meij, 1994) which was put to anyone (another student) who could help. The help-seeking in the present study was based on the premise that every student is potentially more capable of completing a given task than another, and potentially capable of assisting a peer who is less capable of completing the same task. The students responded to explicit requests for help and scaffolded their responses for facilitating and supporting their peers' understanding and learning (Gillies & Ashman, 1998).

A well-designed help-seeking activity is structured on an ordered process and the instructor has to make sure the process is followed. In this study, the help-seeking process was considered as complete upon the help-seeker's judgement of the relevance of the received help by judging whether the asked question has been answered satisfactorily or not. The analysis of the students' satisfaction with their colleagues' scaffolding efforts showed that some students were satisfied with their peers' responses after several attempts. Although the results of this study showed that most of the students were satisfied by their peer-responses after the first and the second attempts to answer their questions, the close analysis of some of the peer-responses that were tagged as satisfactory after the first two attempts showed a different picture. These responses that were arguably satisfactory to some students were not necessarily appropriate or accurate. Some students were accepting their peer-responses to clear the way for activity completion as soon as possible. Some students will always hurry through activities to complete them and move to other things (Donnelly & Donnelly, 2012) or do not want to tag the peer- responses as unsatisfactory because they think this would embarrass their colleagues (friendship bias) (Harris & Brown, 2013).

During the help-seeking activity, the students were encouraged to ask thought-provoking questions (at various thinking levels) and the question-prompts' case

examples were used to guide the students. There is a traditional but still unresolved empirical issue about the relationship between higher/lower order questions and higher/lower student response. Westbury & Milburn (2007) seemed even more radical when they suggested that a "foolish question" can lead to student's "foolish answer", while "high-level question" invokes the student's "high-level answer." This study looked into this and the results concur with Cotton's (2001) observation refuting a traditional wisdom that says: "ask a higher-level question, get a higher-level answer." No relationship was found between the levels of thinking found in student-generated questions and the levels of thinking found in the peer-responses to those questions. The results also showed that most of the student-generated questions and peer-responses were in the category of basic thinking level. These results concur with Christopher et al.'s (2004) findings that revealed that most student responses in an online course forum were in the medium level of thinking but contradict Bates et al.'s (2014) claim that more 75% of student-generated questions were beyond simple recall and of high quality.

The design of help-seeking tools has been examined in previous studies. However, the design guidelines suggested in these studies point to the system-led help-seeking tools, for example, the Brandt et al.'s (2010) *Blueprint*, Chilana et al.'s (2012) *LemonAid*, and Horowitz & Kamvar's (2010) *Aardvark*. Therefore, the present study's results extend the existing knowledge about the design of online help-seeking tools by suggesting the design guidelines and lessons learned as far as the the student-led (not the system-led) help-seeking process is concerned.

6.3 Helping students develop SRL skills through retrospective reflection by means of electronic reflective journals

The use of electronic reflective journals to promote reflective learning has attracted many researchers' and practitioners' attention. Some of the previous research studies on the use of electronic journals to promote reflective learning (e.g. Garza & Smith, 2015; Jones & Ryan, 2014; Tavil, 2014; Dunworth & Scantlebury, 2012) involved student-teachers as research participants. However, these studies focused mostly on having the student-teachers report and reflect on their learning experience in the context of the teaching practicum. In this study, electronic reflective journals were used throughout the teaching and learning process of a blended course where the students were invited to reflect on their learning experience. This study examined the extent to which student-teachers' learning e-journals portrayed reflection levels and how the student-teachers' reflective skills evolved over time through e-journal keeping.

Overall, in accordance with other studies that were conducted before, this study's results indicated that most of the students reflected on their learning experience at the low and medium levels. Dyment & O'Connell's (2011) assessment of the quality of reflection in student journals revealed that 82% of the reviewed studies concluded that students' journals were either not reflective or somewhat reflective. Thorpe's (2004) application of models of reflection to reflective learning journals revealed that many students were labelled as reflectors and only a few

were categorised as critical reflectors. Roberts (2012) classified the nature of the students' reflective writing and concluded that "many students struggle to engage fully with high levels of what might be described as critical reflection."

Although, the results of this study led to a conclusion that the students' reflective skills improve over time through e-journal keeping (see also Lew & Schmidt, 2011; Epp, 2008; Xie et al., 2008; Duke & Appleton, 2008), this improvement does not just happen as a result of an extended e-journal keeping over extended period. To improve their reflective skills, the students need to be provided with sustained and ongoing support throughout their e-journal-keeping journey. This study's results showed that the students' reflective skills evolved as a result of progressive re-conceptualisation and restructuring of the electronic reflective journals throughout the four sections of the blended course.

A reflection rubric (also suggested by Molee, Henry, Sessa, & Mckinney-Prupis, 2011; Ward & McCotter, 2004) that was meant to guide the students in structuring their ideas using various reflection levels was used. The same rubric was also used by the instructors to appraise the students' reflective e-journals and give them scaffolding feedback. Later on, it was realised that the introduction of the rubric was not enough. Despite obvious improvements, many students' reflections were still at the beginning and non- reflection levels. Thus, the guiding reflection rubric was extended with illustrative case examples that portrayed the various reflection levels. The progressive re-conceptualisation and re-adjustment of the design guidelines and the corresponding restructuring of e-journals led to an evolution in students' reflective skills as the course unfolded. The number of student responses increased in the higher-order reflection levels and decreased in the lower-order reflection levels.

Even though the design of reflective learning journals was not extensively explored previously, some research studies suggested some design principles that should guide instructors who are interested in using learning journals to furthering reflective learning. Williams & Wessel (2004) and Varner & Peck (2003) suggested that "clear structure and guidelines" should guide the development of reflective journals. This is in line with two design guidelines suggested in the present study: set clear and structured learning journals with enough supporting details and set clear guidelines and how-tos for reflective learning journals. In the same vein, Andrusyszyn & Davie's (2007) review of studies on the use of e-journals in teaching and learning led them to a conclusion that one of the key characteristics of well-designed journals is clear guidelines "on expectations as well as on how the journals would be used." The creation of an instructor's scaffolding feedback venue whereby the students' journals can be continuously appraised is one of the e-journal design guidelines suggested in this study. This concurs with Palmer & Scribner (2017), who recommended reciprocal exchanges between teachers and students during the journal-keeping exercise. Additionally, the provision of teacher scaffolding was a key characteristic in Ehlers's (2015) online journals study, and Andrusyszyn & Davie (2007) suggested regular student dialogue with the instructor for the provision of "reinforcement, validation, and support as well as prompting and probing."

7 Conclusion

The aim of this PhD research project was twofold. The firsts aim was to develop technology-enhanced instructional interventions to scaffold the student development of SRL skills trough formative e-assessment. The second aim was to propose the design guidelines to inform other educational practitioners who would like to develop TEFAA that promote student-regulated learning. An EDR approach was used and the study addressed a FA practical problem that needed a practical, research-based solution.

The problem that was addressed points to the ineffective practices of formative assessment and feedback at UR. There was a need to act and address this problem, and technology-enhanced solutions were used in this process. New teaching and learning strategies were introduced through the design and iterative implementation of three instructional interventions in real teaching and learning settings. The study was conducted in three research phases. During each research phase, sub-studies were carried out to answer specific research questions.

During the first phase, an exploratory sub-study was carried out and aimed at analysing, understanding, and clearly framing an educational problem that required intervention. The study was aimed at gaining lecturers' and students' perspectives on formative assessment and feedback, and exploring different ways they were practised. The results of this sub-study helped the researcher answer the first specific research question about how UR lecturers and students understood and practised formative assessment and feedback.

How did UR lecturers and students understand and practice formative assessment and feedback?

The answer to this research question can be summed up into five major findings from the exploratory sub-study: (a) UR lecturers and students had a limited understanding of formative assessment and feedback, (b) lecturers were the main or sole actors involved in the formative assessment-related practices, (c) marks were considered as the only type of feedback and feedback was about marks, (d) limited class time and large class size hampered in-class oral feedback, and (e) students' difficulties in capturing the real meaning behind lecturers' written comments.

During the second research phase, a constructive research was carried out to address the problems identified during exploratory research. During this phase, three instructional interventions were designed and iteratively tried. The first intervention aimed at helping students develop SRL skills through self-progress assessment by means of online KSs. The students were provided with opportunities to critically reflect and assess their own progress against clearly stated learning

objectives and make judgements about their progress vis-à-vis these learning objectives. The second intervention was aimed at helping students develop SRL skills through help-seeking by means of online peer-scaffolding. Throughout this intervention, the students were invited to seek and give help to each other through an online question-answer generation process. The third intervention's purpose was to help students develop SRL skills through retrospective reflection by via electronic reflective journals. E-journals were used as reflection channels whereby the students retrospectively reflected on their learning experience. The findings from the three sub-studies that were carried out during the second research phase help the researcher answer the second specific research question related to how TEFAA can help student develop self-regulated learning skills.

How can technology-enhanced formative assessment activities help students develop self-regulated learning skills?

The answer to this question can be traced to the research results from the three sub-studies that were conducted along with the implementation of the three instructional interventions. This research question seems open and can be addressed differently from a variety of research perspectives. There certainly are different ways in which TEFAA can help students develop self-regulated learning skills. However, this study attempted to narrow down the answer to this question to three technology-enhanced formative assessment strategies. In summary, to help students develop their SRL skills, the technology-enhanced formative strategies that can be used include well-designed online knowledge surveys, online peer-scaffolding, and electronic reflective journals that allow learners to assess and monitor their learning progress, seek and give help to each other, and retrospectively reflect on their learning experience.

The follow-up research that was conducted during the third research phase built on the implementation of instructional interventions that took place during the second research phase. During the second phase, the TEFAA were iteratively designed and tried, and the design guidelines were suggested. Before formally proposing the design guidelines of the three formative e-assessment strategies (as part of this research's contribution), the researcher deemed it necessary to measure the extent to which the students were satisfied with these strategies. The results of the follow-up study showed that the students were generally satisfied with all the quality characteristics of these formative e-assessment strategies. These results gave an increased impetus to the researcher to formally and confidently answer the third research question.

What design guidelines should be followed in order to develop technology-enhanced formative assessment activities that promote student self-regulated learning?

The answer to this question lies within this dissertation's research scientific contribution section. Details about the proposed design guidelines and lessons learned were provided for each formative e-assessment strategy. The suggested design guidelines and lessons learned can be briefly summed up as follows:

1. *In order design effective TEFAA that help learners develop their SRL skills through self-progress assessment using online KSs and in the context of a blended higher*

education course, ***the KS should be engaging enough and the KS question-items should be balanced in terms of depth and breadth.***

2. *In order to design effective TEFAA that help learners develop their SRL skills through help-seeking using online student-generated questions and peer-responses and in the context of a blended higher education course,* ***the help-seeking corner through which the students seek and give help from/to each other should be clear, well structured with enough supporting details.***

3. *In order to design effective TEFAA that help learners develop their SRL skills through retrospective reflection using electronic reflective journals and in the context of a blended higher education course,* ***electronic reflective journals should be well-structured with a clear and detailed reflection framework and a sustained scaffolding in order to help the students reflect on their learning experience at various thinking levels.***

7.1 Reflection

Throughout my teaching career in higher education – which I started only eleven years ago – I was fascinated by the widely accepted (by academics, researchers and politicians) rhetoric that the use of ICT can revolutionise teaching and learning for the better. I was recruited as a Tutorial Assistant (the lowest level of the lectureship position ladder in Rwandan public higher education) in 2007, seven years after the Rwandan vision 2020 was officially launched. One of the key pillars of that vision was the integration of technological innovations into all sectors of social and economic development. Capitalising on the then-good political will towards ICT and with the overzealous enthusiasm of a fresh graduate, I took initiatives and used some ICT-based tools in my teaching on a wishy-washy and random basis. Although I could not conduct an empirical study to ascertain whether my initiatives led to any tangible gains in student learning, I was firmly convinced that I was making positive changes because – seemingly – I was doing things differently: *Rightly or wrongly, I was perceived by some as a teacher who teaches differently*.

However, the effective use of ICT in teaching and learning goes beyond what I can describe as bringing about cosmetic changes to the teaching and learning process. I came to realise that these cosmetic changes (for example, moving from hard copies to electronic handouts and notes, from physical library-based referrals to web-based referrals, from outsourcing local experts to resorting to a wide pool of expertise on specialised web portals, e-encyclopaedia, YouTube EDU, etc.) added little or nothing to student learning because they were not premised on sound pedagogical principles. I was using technology as an add-on component rather than as an integrated component (Haddad & Draxler, 2002) of the teaching and learning process. Throughout my initiatives to use ICT in my teaching, the technological tail wagged the pedagogical dog (Callister & Dunne, 1992).

Later on, when I did my master's, this issue of the pedagogical missing link in the process of integrating ICT in teaching and learning was taken beyond the personal level and explored further. My Master' s research project (see Bahati, 2010) aimed at answering the question of whether ICT was being pedagogically integrated in teaching and learning at UR-CE. I concluded that, generally, UR-CE (formerly the Kigali Institute of Education) lecturers and students were sporadically using ICT as an add-on to their traditional "teaching and learning as usual", with no real impact in which lecturers would rethink ways of teaching that could lead to increased quality in student learning.

When I got an opportunity to pursue a PhD in 2014, I thought it was high time to put aside the rhetoric and get things done. I was excited and anxious at the same time. I was excited because I believed that my understanding of what "teaching in higher education entails" – with technology-enhanced learning as the focus – was going to be furthered as a result of my research endeavour culminating in new insights. My excitement, seemingly justifiable, was nonetheless offset by the awareness of the daunting task that was ahead of me: the production of anxiously expected "original", "authentic" and "new" research-based claims or knowledge. The question that was put to me by one fellow I met in the hotel corridor in Washington, DC, is still lingering in my mind. We were both attending an International Conference of the SITE. When I told him that I was in the final year of my PhD studies, he uttered: "well, what are you bringing to the table which was not part of the menu before?" I was not expecting such a question but, based on the various accounts of many people who took the PhD research journey, one should be prepared to this eventuality. Based on the research outputs I had produced so far, I wandered here and there and managed to concoct an answer to which my fellow did not react. I had no idea whether or not I satisfactorily answered the question.

Has the situation improved so far? To some extent yes. When I attended the SITE conference, my research findings were still scattered and dispersed across my publications and various notes and research diaries. The answer to the aforementioned question is attempted with increased confidence in this thesis, which coherently presents the answers to the following questions:

- What? (What was this research study about?)
- Why? (Why was it worth it?)
- How? (What methodology was applied?)
- So What? (What was found out?)
- Then What? (What is the value added based on what was found?)

Was the aim of this PhD research project achieved?

Throughout this study, three technology-enhanced instructional interventions were formatively designed and implemented to scaffold the students' development of SRL skills. The design guidelines for these instructional interventions were also proposed. It is assumed that the students who were involved in this study by doing the TEFAA could develop their SRL skills. Could the students really develop their SRL as a result of completing these TEFAA? If yes, to what extent? If no, why? Are knowledge survey, online student-generated questions

and peer-responses, and electronic reflective journals recommended for use across all the learning subjects? Are there any flaws and problems associated with the SRL strategies that were used?

Although these questions are beyond the scope of the present study, they are relevant and deserve research-based answers. This led me to realise that the quest for further understanding of technology-enhanced teaching and learning in higher education is far from complete. These unanswered questions imply that this study has some obvious limitations, some of which are discussed in the next section.

7.2 Limitations

Some of the key characteristics of scientific research are impartiality and openness to criticism. This study's findings and results are presented and the practical and scientific research contributions are advanced. However, this dissertation is open to some criticisms and limitations, which are discussed in this section.

The first limitation is related to the nature of EDR where the researcher plays the role of designer, implementer, and evaluator simultaneously. Although the entire research process was open to professional scrutiny and criticism (by co-lecturers and supervisors), the researcher had always an upper-hand in conceptualising, designing, developing, implementing, and researching the pedagogical strategies that were used in study. The involvement of other stakeholders was certain but not to the extent that a smooth and complete partnership with them (which is key to EDR) was achieved. This can – to some extent – undermine the credibility of the present research study's claims.

The second limitation is related to the research time frame and research setting. Conceiving, designing, building, iteratively testing an educational intervention and eventually proposing the resulting design guidelines require a substantial amount of time and a variety of experimental cases (Anderson, 2005). The limited scope of this study in terms of the reduced number of experimental cases (one educational intervention per one course, per one class) during only one semester cannot warrant conclusive research claims regarding educational interventions and the suggested design guidelines.

The third limitation points to the non-conducive research environment. TEL research is conducted in a learning environment where ICT tools are used to support and facilitate learning in a seamless integration of learning objectives, tasks, learning materials, tutors, teachers, other students and technology (Cartelli & Palma, 2009). Although, TEL researchers should avoid "letting the technological tail wag the pedagogical dog" (Callister & Dunne, 1992), access to computers, tablets, or smart phones and reliable as well as stable Internet connections were indispensable enabling factors for this study. The students were accessing the TEFAA through an online learning platform. However, due to unstable Internet connections and an ON-and-OFF UR e-learning platform, the students were sometimes frustrated and disappointed. I presumably believe that if the research

environment were more conducive, this study's results would have led to more insights and conclusions.

7.3 Future research

Metaphorically, this PhD thesis is just a drop in the ocean as far as technology-enhanced instructional assessment is concerned. Based on this study, a few research areas that can be further explored are proposed.

The first research direction would build on this study's limitations. Future research where a maximised research time frame and maximised collaboration between researchers and stakeholders working in a conducive research environment could consolidate and expand on the present study's results and conclusions.

The second research direction points to the fact that both formative and summative assessment are important in teaching and learning. Although their purposes are different, they are not mutually exclusive. Thus, future research can explore how formative e-assessment and summative e-assessment can inform each other to advance student learning. For instance, the question of how the effectiveness or ineffectiveness of formative e-assessment would impact summative e-assessment outcomes can be explored.

The third research direction would try to find answers to the aforementioned questions that could not be answered in this study. The aim of this study was to use technology-enhanced instructional interventions to scaffold the students' development of SRL skills. Could the students really develop their SRL as a result of completing these TEFAA? If yes, to what extent? If no, why? Are knowledge surveys, online student-generated questions and peer-responses, and electronic reflective journals recommended for use across all the teaching subjects? Are there any flaws and problems associated with the SRL strategies that were used? Although these questions are considered beyond the scope of the present study, they are relevant and deserve answers.

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