Instructors as Orchestrators: A Qualitative Case Study that Explores the role of Instructors in an Adaptive Learning Classroom Environment

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Abstract

This qualitative case study highlights the vital role of the instructor and the importance of learning analytics (LA) in an adaptive learning (AL) classroom environment. Existing research does not consistently support a particular outcome for the use of the AL platform, ALEKS, as an instructional approach. An examination of the AL landscape has been characterized by inconsistent and inconclusive results. The persistent emphasis on students' attitudes and performance in relation to ALEKS, along with the comparative approach to traditionally taught classes, have prevented us from understanding the complex and multifaceted ALEKS classroom environment. This study is novel because it distinguishes itself from previous research by providing the AL landscape with a supplementary lens – that of the instructors. By exploring how the instructors in this study used the LA from ALEKS to enrich the students' learning experiences, we intended to gain a renewed understanding and a reconceptualization of the instructor's role from a parameter that can be overlooked to an orchestrator whose presence is vital.

This study draws on Laurillard's Conversational Framework (CF) as a theoretical foundation, which promotes an education-driven approach where technology serves pedagogy, not the other way around. This allows for an evaluation that challenges ALEKS to deliver on what education requires of it, and makes visible the vital role that educators play in the classroom. In sharp contrast with the quantitative orientation that has dominated previous research studies, this study espouses a qualitative stance to inquiry using open-ended research questions. Therefore, this dissertation employs semi-structured interviews, classroom observations, and documentary evidence as data collection methods to paint a vibrant image of the case study under investigation.

The findings demonstrate the multi-layered and intricate nature of an AL classroom environment. Evidence suggests that an AL approach to instruction depends on the active and engaged presence of instructors. Using the LA from the AL platform to cater to the individual needs of every student became an integral part of the instructor's role in the ALEKS classes studied. Further evidence indicates that the LA in ALEKS contributes towards a positive classroom dynamic and enhanced learner-instructor interaction. The CF adds another dimension to the findings and leads to an improved articulation of how

the different aspects of learning are enacted in an AL environment. The study concludes with an array of recommendations for implementers and decision-makers with regard to leading a successful AL experience.

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I am forever grateful to my wife, Sirine, and my children, Miriam, Lyanne, and Tarek, who I consider my guardian angels for their support and encouragement. I hope that I will inspire them to continue to achieve their full potential. I would like to thank my mother and father for all the sacrifices they have made, and I hope that they will always be proud of me.

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Chapter 1

Introduction

It is 9:50 a.m. on a sunny Monday morning. I am standing outside an introductory mathematics class eagerly waiting for the instructor's arrival to start the classroom observation. In this session, I will take an up-close and personal look at an AL classroom environment in action. At first glance, I notice that the class had started before the instructor is inside the room. I can see students with their laptops open through the neatly decorated glass walls as they start working in the AL platform, ALEKS. Upon the instructor's arrival, I immediately ask about what I saw. It's not out of the normal, he replies with a smile, the students know what to do because each is on a predefined learning path in ALEKS and they are developing their knowledge accordingly. I sit at the far end of the classroom, and it does not seem that these learners are bothered when the instructor tells them about the reason for my visit.

As the instructor logs into ALEKS, he immediately displays the 'Time and Topic Report,' which shows the amount of time spent by each learner and the topics attempted and mastered. A couple of minutes afterward, I see that two students have started working together, while the instructor is having a conversation with another about his progress based on the report from ALEKS. I can tell that the two students sitting in front of me are doing similar topics together, and are well ahead of the class. This relaxed classroom atmosphere is not interrupted when the instructor invites three students to the whiteboard to explain a common topic that they have struggled with. In this session, the instructor has answered questions based on individual requests and engaged in casual conversations with the majority of students about their progress. Later, during the interview, that instructor said:

> The students control the lesson. So, for me, I now see that my role has changed from more of the instructor to more a facilitator. That's how I would describe myself now, a facilitator. And the only reason I can say that is because of the use of adaptive learning. (P3)

Background

This study tells the story of a multinational group of mathematics instructors who use AL as a principal approach to instruction in their classes. It has been conducted in one of the federal higher education institutions in the United Arab Emirates (UAE). This relatively young nation that was often referred to as an oil-rich country has been taking giant steps to improve its educational system. The country's investment in education and technology, among other sectors, has yielded state-of-the-art educational institutions to cater for the ever-increasing number of students entering schools and universities. In the UAE, the rate of adult literacy was around 54% among men and 31% among women in 1975. Now, literacy rates are close to 95% for both genders, according to the UAE Ministry of Education (MOE, 2019).

The Ministry of Higher Education and Scientific Research reported an increase of 34.4% in the number of students in higher education institutions (HE) from 2009 to 2013 (MOHESR, 2014). Consequently, the country is reliant on a large expatriate workforce to provide quality education for its citizens, which, in 2014, constituted 94.6% of the total full-time teaching body in HE (MOHESR, 2014). This remarkable growth has been in response to the Government's efforts and emphasis on creating a knowledge-based economy that requires capable graduates who can meet the growing demands of the labour market (Ashour & Fatima, 2016). The country's Vision 2021 intends to equip Emirati students with the practical skills and knowledge for the modern world while preserving their national identity and culture:

> The UAE will successfully encourage Emiratis to maximise their potential by remaining in school and reaching higher levels of education. School drop-outs rates will fall, university enrolment will rise, and more Emiratis will climb higher up the ladder of learning into post-graduate education. (Vision 2021, p. 23)

The Science, Technology, and Innovation Policy (STI) supports the country's ambitious vision by advancing the use of digital technologies in education to amplify the effects of learning (STI, 2015). These two prominent government initiatives recognize the critical role of education and technology in fostering a new generation that is capable of

competing on the national and global levels. Despite ranking 27th in the global competitiveness report in 2017-2018, the UAE has to accelerate its progress "in terms of spreading the latest digital technologies and upgrading education" (Schwab, 2018, p. 32). According to the 2018 Global Competitiveness Report, the challenges are many for this young nation, and more work is needed to improve the quality of education in the country.

Evidence from related scholarly work indicated that the students' learning experiences during their school years were dominated by a teacher-centered and didactic environment where memorization and learning for the test were expected and accepted as a norm (Dahl, 2011; Faour, 2013; Hatherley-Green, 2012; Muysken & Nour, 2006; Raven, 2011; Roberts, Leung, & Lins, 2013). According to the Ministry of Higher Education and Scientific Research, 48% of high school leavers in 2014 lacked the necessary mathematical and English language skills (MOHESR, 2014). These numbers support the evidence from the literature that highlights the lack of basic mathematical and language proficiency (Dahl, 2011; Hatherley-Green, 2012), as well as the organizational and critical thinking skills needed for a successful transition to college (Dahl, 2011; Faour, 2013).

The need for the UAE to scale up education and support the transition of the Emirati students to college is evident. Therefore, the focus for the research presented here is on instructors that teach mathematics for the students enrolled in the general education program in an HEI using an AL platform called ALEKS. According to the classroom observation presented earlier in the introduction, it is believed that AL technologies have the potential to improve the teaching and learning experiences for instructors and students alike.

The students enrolled in this program of study have a weak background in mathematics and the English language and are those who were unable to achieve the necessary requirements that allow them to get direct admission into the bachelor's study track. The different courses under this program encourage a student-centered approach and foster independent and lifelong learners (*GARD Catalogue*, 2019).

This study is related to one of the mathematics courses within this program, which is a preparatory course that "focuses on developing proficiency in basic algebra and quantitative reasoning to equip students with the math skills to succeed in the BAS program of their choice" (*Course Syllabus*, 2019, p. 1). This course uses ALEKS to bring students to the level required in the bachelor's program. ALEKS is a web-based, artificially intelligent assessment and learning system (www.aleks.com). In this study, ALEKS has been used as an integral part of the course to cater to the needs of individual students. With the absence of studies in the region that inspect the use of AL and its impact on teaching and learning, this study sets a precedent.

Problem Statement

Existent research does not consistently support a particular outcome for the use of ALEKS as an instructional approach (D. Johnson & Samora, 2016; Murray & Pérez, 2015; Tesene, 2018). In fact, ill-defined implementation strategies, inconsistent, and sometimes contradicting results have been noted (see chapter 2). Previous studies focused on students' attitudes and performance with ALEKS, along with the comparative approach to traditional classes using a heavy quantitative slant.

Research on ALEKS tackled three different deployment scenarios. The first portrayed ALEKS as a drill and practice tool, the second treated ALEKS as a remediation tool, and the third considered ALEKS as a principal approach to classroom instruction. Underlying these studies is the assumption that the use of ALEKS is to cater to a diverse student population with varying mathematical abilities and educational backgrounds. It is not surprising, therefore, the focus on the learner and learning gains in ALEKS classes as opposed to students in traditionally taught classes.

However necessary, the persistent focus on the learner led to the unjust portrayal of instructors as bystanders in ALEKS classes and rendered the AL platform to a non-intelligent assemblage of exercises for students to solve. The implications of such an approach are detrimental to the role of the instructor as an active participant in knowledge creation, be it in AL classes or otherwise. A knock-on effect that is adjacent to the hidden instructor's role is the value of the LA in ALEKS as an integral part of the AL platform.

These outcomes have prevented us from understanding what it takes to learn and what it takes to teach in ALEKS classes. As such, this study aims to tell the story of a multinational group of instructors who used ALEKS as the primary approach to the delivery of a remedial mathematics course in a higher education institution. Specifically, the intricate and multifaceted relationship between these instructors, their learners, and the LA in the ALEKS platform. Understanding how these instructors view their roles in an AL classroom environment and orchestrate their instruction/ intervention using the LA in ALEKS will permit us to assess the student learning experience from a different angle – that is of the instructor's.

To move beyond the dominant positivist approach, inconclusive results and the variations in the use of ALEKS in the classroom, it is crucial to construct a deeper understanding of the instructor's role and recount how instructors use the LA from ALEKS to enable the learning cycle in the classrooms. As such, this study is underpinned by an interpretive philosophical assumption that warrants the use of a qualitative approach to inquiry. The focus, therefore, is on how these instructors interpret and make meaning of their experiences, and more importantly, on painting an image that directs our attention and extends our understanding of how these instructors orchestrate learning in ALEKS classes.

Statement of Purpose

This study delineates itself from previous research by approaching an AL classroom experience from the instructors' perspectives. It highlights an approach to instruction where the quantitative data from the platform's LA is translated by the instructor into insights. When coupled with qualitative data from the instructor's interaction with his students, it seems likely that these insights would enhance the students' learning experiences in the classroom and beyond.

As such, this study supplements the AL landscape with a much-needed lens – that of the instructors. Using the latter lens to research AL allows for a renewed understanding and a reconceptualization of the instructor's role from a parameter that can be overlooked to an orchestrator whose presence is vital. In parallel, this study will shed light on the

classroom learning experience and highlight ways where students benefitted from this approach to instruction.

Research Questions

Following on, the research questions in this study will investigate how AL can be used to enhance teaching and learning in the classroom. To reiterate, shortcomings in previous research (presented in chapter 2 of this thesis) prevented us from understanding what it takes to learn and what it takes to teach with the use of an AL platform like ALEKS. The focus on the learner, however necessary, should not deter us from acknowledging the vital role of the teacher enabling the learner to achieve their full learning potential. Therefore, this discussion points to the necessity to address a more significant issue, which is the role of the teacher in classes that use AL and its impact on students' learning. The latter gives rise to the following research questions.

RQ1: How is AL being used to assist students in their transition to college-level mathematics?

RQ2: In what ways does AL influence the practices of teachers and their approach to classroom instruction?

RQ3: How can AL most effectively be used to optimize the classroom learning experience?

Theoretical Framework

The theoretical framework that underpins this study makes the distinction between two diametrically opposite viewpoints on the use of digital technologies for teaching and learning. The first is technology-driven and the second is education-driven. In the former, digital technologies are viewed as tools to improve conventional learning. In the latter, however, "pedagogy exploits technology" and not the other way round (Laurillard, 2009, p.6). As such, this study capitalizes on the use of the CF (Laurillard, 2013) to offer an education-driven approach to the use of an AL platform named ALEKS.

In brief, the CF incorporates six basic types of learning that are common in education. These are learning through acquisition, inquiry, discussion, practice, collaboration, and

production. The best learning experiences, according to Laurillard (2013), combine all six learning types. Therefore, the CF can be viewed as both an evaluative tool that challenges any kind of technology to deliver on what education requires of it, and a tool that makes visible the vital role that educators play in the classroom.

Personal Motivation for the Study

I developed an interest in AL since it was first introduced at the college in 2013. As a mathematics educator for more than twenty years, I have always been looking for ways to incorporate technology into my classes. However, most of the available tools that I used improved the presentation of the content and concepts and were instructor directed.

The opportunity presented itself when the college administration agreed to explore the use of the ALEKS platform in one of its preparatory mathematics courses to facilitate the students' transition to college-level mathematics. My teaching experience using ALEKS was fulfilling as I felt that my students were able to achieve more than they did in regular classes. I invested enough time to train them on how to use ALEKS and tried to use the platform's LA to monitor their progress, which changed my classroom and my approach to instruction. I also had the opportunity to share my experience and work with other enthusiasts, and ended up conducting training workshops for mathematics instructors in different colleges and talked about ALEKS as a learning approach in regional conferences.

My interest in ALEKS as an AL platform has been driven by a firm belief that the one-size-fits-all approach to instruction has proven to be inadequate (Lai, 2011; Laurillard, 2008). For me, AL presents an opportunity that should be explored further from the lens of the implementers. Therefore, this study is a step in the right direction as I aim to highlight the role of the instructor in AL classes and explore different ways to translate the LA into insights as this will most likely enhance the students' learning experiences.

Rationale and Significance

The AL landscape is incomplete in the absence of studies that highlight the role of the instructor and the importance of the LA when translated into insights. The NMC Horizon Report, in collaboration with EDUCAUSE Learning Initiative, stressed that AL and LA

would have a massive influence on teaching and personalized learning (L. Johnson et al., 2016). Therefore, this study will fill a gap in the literature on the vital role of the instructor, who is responsible for transforming the LA into insights that enrich the students' learning experiences.

The study's main aim is to make visible the role of the instructor in ALEKS classes and highlight the importance of LA as an influencing factor that can contribute to a better learning environment. In doing that, the thesis will pave the way for further research on how instructors see their roles in AL classes and discover ways in which they support their students in such an environment. To that end, the use of the CF as a theoretical framework will provide an education-driven approach to the use of AL as an instructional approach.

Organization of the Thesis

This thesis comprises six chapters. Chapter two starts with a discussion of issues associated with AL and intelligent tutoring systems before reviewing existing research related to the ALEKS platform. The review of the literature is organized according to how ALEKS has been used as an approach to learning and identifies shortcomings pertinent to each mode of deployment. This structure reveals how Ill-defined implementation strategies, inconclusive and contradicting results, and the presentation of teachers as passive participants in knowledge construction have prevented us from understanding what it takes to learn and what it takes to teach using an AL platform like ALEKS. Next, the theoretical foundation of this study draws on Laurillard's CF to offer an education-driven approach towards AL and critique ALEKS as an approach to learning. Chapter two concludes with a short reflective account related to how the review of existing research has been conducted and lays out the study's research questions.

Following on, chapter three will then explain how the methodology was chosen appropriate to answer the research questions. It starts with the aim of the study and describes the epistemological basis for selecting a case study design. This chapter discusses in great detail the approach to sampling and data collection methods and provides a detailed description of the strategies and procedures used to analyze the data and addresses the limitations of the methods used.

Chapter four offers an account of the main findings which emerged from the data analysis process outlined in chapter three. Accordingly, this chapter delves into the essence to report the main themes and relates the findings from the interviews with instructors and the classroom observations to the three research questions in this study. In brief, the results supplement the existing research on the efficiency of the ALEKS platform from the instructors' viewpoints and highlight the crucial role they play in AL classes.

The discussion of the findings in chapter five examines the meaning and importance of the results from chapter four in relation to the review of the literature and research questions. As such, this chapter sends a strong message about the importance of the LA and the instructor's role in an AL environment. In addition, the CF, as an overarching theoretical framework, places the instructor at the heart of the event and yields a better articulation of how the different aspects of learning are enacted in an AL environment.

Lastly, chapter six presents a set of concluding statements and recommendations and integrates the analysis and interpretation of the findings to provide a synthesis that extends the AL landscape beyond the inconclusive and sometimes contradicting results found in previous studies. Therefore, this chapter concludes with a summary and a critical evaluation of the entire research study where recommendations and further research areas will be highlighted.

The next chapter will offer a review of the existing literature related to AL and ALEKS and lays out the study's research questions.

Chapter 2

Literature Review

Introduction

This chapter discusses key issues relating to AL and intelligent tutoring systems before turning to the ALEKS platform and reviewing existing research that has sought to evaluate its effectiveness in enhancing learning. The chapter is structured around the use of ALEKS in educational institutions – as ALEKS has been used as a drill and practice tool, as a remediation tool and as a principal approach to instruction. Next, the CF will be represented as the theoretical framework that will underpin this study. Lastly, a reflective account of the process and challenges faced when reviewing the literature will be offered.

Adaptive learning and Intelligent Tutoring Systems

Advances in artificial intelligence (AI) and machine learning, big data, and LA have led to the development and proliferation of high-quality learning technologies in recent years. In this field, the link with higher education is evident as the latter advances hold the promise of improving the quality of teaching and learning, personalizing students' pathways, and empowering all stakeholders in making well-informed decisions (Dziuban, Moskal, Johnson, & Evans, 2017; Liu, McKelroy, Corliss, & Carrigan, 2017; Mavroudi, Giannakos, & Krogstie, 2018). Some argue that advances in big data and LA will present new possibilities and challenges that will shape the future of teaching and learning, and "fundamentally change governance and the internal architecture of institutions of higher education" (Popenici & Kerr, 2017, p. 1).

AL, as a branch of learning technology that is inextricably connected with AI and LA (Mavroudi et al., 2018), promotes a learner-centered approach to education, decrease delivery costs, and improve the students' learning experience, according to Wilson, Watson, Thompson, Drew, and Doyle (2017). Tyton Partners, previously known as Education Growth Advisors, a leading strategy consultant in the education sector, describe AL as:

> a more personalized, technology-enabled, and data-driven approach to learning that has the potential to deepen student engagement with learning materials, customize students' pathways through curriculum, and permit instructors to use class time in more focused and productive ways. In this fashion, adaptive learning promises to make a significant contribution to improving retention, measuring student learning, aiding the achievement of better outcomes, and improving pedagogy. (Newman, 2013, p. 4)

Proponents of AL portray it as a promising technology that will have a profound and positive effect on learning and teaching, and some of the higher education's constraining factors like quality, cost and access (D. Johnson & Samora, 2016; Tesene, 2018). One of the advantages of AL, Premlatha, Dharani, and Geetha (2014) argue, is its capability to overcome the one-size-fits-all approach, to differentiate and personalize the learning according to the individual needs of each student.

In 2016, the NMC Horizon Higher Education Report, in collaboration with EDUCAUSE Learning Initiative, reported that colleges and universities have been showing greater awareness of such technologies and have been experimenting with the use of AL in many courses (L. Johnson et al., 2016). In fact, AL was identified by the same report as one of the technology trends that will drive educational change in the near future. Commercial education companies like Knewton, Smart Sparrow, and McGraw-Hill portray their AL products as transformative by creating a personalized learning experience for students and empowering teachers with tools that amplify the effects of teaching and learning in their classes. These proclamations were met by a profound enthusiasm from educational institutions and a growing body of research that has investigated the effectiveness of different AL systems.

In contrast, the collective evidence from the literature does not support these proclamations and has been unsuccessful in offering conclusive results that support AL as an approach to classroom instruction (D. Johnson & Samora, 2016; Murray & Pérez, 2015; Tesene, 2018). To understand and critically address the shortcomings of past and current research on AL we need to also examine results from research on Intelligent Tutoring Systems (ITSs) because some of the AL systems can be considered as adaptive

and intelligent (Brusilovsky & Peylo, 2003) and some consider ITSs as the founding father of AL (Craig et al., 2013; Desmarais & Baker, 2012; Hu, Luellen, Okwumabua, Xu, & Mo, 2007; D. Johnson & Samora, 2016; Murray & Pérez, 2015).

However diverse in their processes and types of support for instructors and students, commonly acceptable components of an ITS include the following:

(a) a "domain model" that represents the knowledge being taught

(b) a "learner model" that represents the knowledge progress of the learner from one topic to another

(c) the "instructional model" which is the output of the latter two models that represents the instructional strategies

(d) a "user interface" that communicates with the learner (Sottilare, Graesser, Hu, & Holden, 2013, p: ii).

Results from multiple scientific studies showed mixed results and different effect sizes were reported when the effectiveness of different ITSs was compared to traditional classroom instruction. One of the quantitative evaluations that examined the relative effectiveness of human tutoring (one-to-one tutoring), computer tutoring, and no tutoring, VanLehn (2011) reported effect sizes of $d = 0.79$ and $d = 0.76$ for human tutoring and computer tutoring when compared to no tutoring. VanLehn (2011) concluded that computer tutoring was almost as effective as human tutoring in STEM subjects.

Steenbergen-Hu and Cooper (2013) investigated the effectiveness of ITS as compared to regular classroom instruction on students' mathematical learning in K-12. Their meta-analysis of 34 studies between 1997 and 2010 showed that ITSs have a small to moderate effect size when compared to regular classroom teaching. For Ma, Adesope, Nesbit, and Liu (2014), the use of ITS was associated with higher performance and accounted for an improvement of 0.43 standard deviations across all levels of education. Their analysis showed that the results were not affected when ITSs were used as a primary or secondary mode of instruction apart from small group instruction and one-to-one tutoring, which yielded no significant difference in performance.

In a more recent meta-analysis, Kulik and Fletcher (2016) reported that ITSs were associated with an improvement of 0.66 standard deviations in test scores over traditional classroom instruction. There are many factors that might have contributed to the differences in effect sizes in the latter studies. Variances in defining ITSs led to differences in the inclusion/ exclusion criteria. VanLehn (2011), for example, included studies that focused on STEM subjects. Ma et al. (2014) and Kulik and Fletcher (2016) covered more domains, while Steenbergen-Hu and Cooper (2013) focused on middle-school mathematics only. These results should not be surprising since different ITSs have distinctive technological features and pedagogical approaches and are hard to classify. The plethora of AL (or ITSs) systems with diverse structures and approaches, added to the different implementation methods, might have been contributing factors that led to the inconclusive results.

Perhaps the most important distinction between AL systems and some ITSs is that the latter offer similar instruction for different students, while the former systems "attempt to be different for different students and groups of students by taking into account information accumulated in the individual or group student models" (Brusilovsky & Peylo, 2003, p. 157). What follows, then, is a study of a single AL platform that is algorithm-based and uses curriculum sequencing to analyze the performance of students and guides them through the material in a mastery learning environment.

Assessment and LEarning in Knowledge Spaces (ALEKS)

ALEKS is a web-based, artificially intelligent assessment and learning system (www.aleks.com). ALEKS is a practical application of the Knowledge Space Theory (KST) that was based on the seminal work of Jean-Paul Doignon and Jean-Claude Falmagne (Falmagne & Doignon, 2011; Falmagne, Koppen, Villano, Doignon, & Johannesen, 1990). KST "applies concepts from combinatorics and stochastic processes to the modeling and empirical description of particular fields of knowledge." (www.aleks.com). The original purpose of KST was to assess the knowledge state of the learner accurately, that is, a subcategory of all questions (domain) that the learner can answer correctly (Falmagne & Doignon, 2011). The initial focus on building a machine

to assess knowledge in the 1990s shifted from assessment to teaching according to Falmagne and Doignon (2011) who stated that

> It later turned out that the resulting instrument could form the core component of a teaching engine, for the sensible reason that ascertaining the exact knowledge state of a student in a scholarly subject is the essential step toward educating the student in that subject. (p. VIII)

The ALEKS system, therefore, can draw an accurate map of a student's knowledge state by asking a small number of questions, usually between 25 and 30 during the initial assessment. Since there exists a precedence relation between different knowledge states, ALEKS can draw a unique learning path that enables a student to move beyond his initial knowledge state (Fanusi, 2015; Nwaogu, 2012; Tempelaar et al., 2012). Questions in ALEKS are carefully selected to cover an entire domain and are algorithmically generated. In addition, ALEKS does not use multiple choice questions to prevent guessing, and students are required to produce an appropriate input using mathematical symbols and notations from the answer editor.

There are several resources available for students in ALEKS, such as the built-in calculator, dictionary, and e-book, depending on the initial set-up of the course. The ALEKS forum, in addition, is an area where students and instructors communicate by posting comments and questions, which is particularly helpful because the use of ALEKS is thereby extended beyond the classroom. Selecting the topics in ALEKS to match the course learning outcomes and choosing the right resources for students is a meticulous process with a lot of technicalities. Therefore, proper course set-up is an essential step because ALEKS is supposed to be a necessary part of the students' and instructors' experience throughout the duration of the course. Unlike the use of conventional digital technologies or homework management systems that are fully controlled by the instructor, the presentation of the topics in ALEKS and its continuous assessments are adaptive and regulated by the system.

For students, ALEKS starts with an initial assessment to establish a baseline of what they know. Once concluded, the student is presented with a detailed report on the form of a pie chart that indicates what they already know and what they are ready to learn. Each slice

on the pie chart represents a learning outcome or an area in the curriculum. The solid color on each slice represents the portion that a student knows, and the remaining part shows what needs to be learned. In the learning mode, each student is presented with a set of topics that they are ready to learn. This dynamic set is adapted according to how well, or not, students perform. When students attempt a new question within the set of allowed topics, they have the option to press the 'explain' button where they are presented with a step-by-step solution. When students return to practice, a similar question is presented with different numbers. If they are successful on a number of occasions, the topic is then added to their pie. Upon finishing several problems or hours working in the learning mode, ALEKS initiates an assessment to make sure that the topics learned are retained. Students work in ALEKS to complete the required number of topics for the duration of the course.

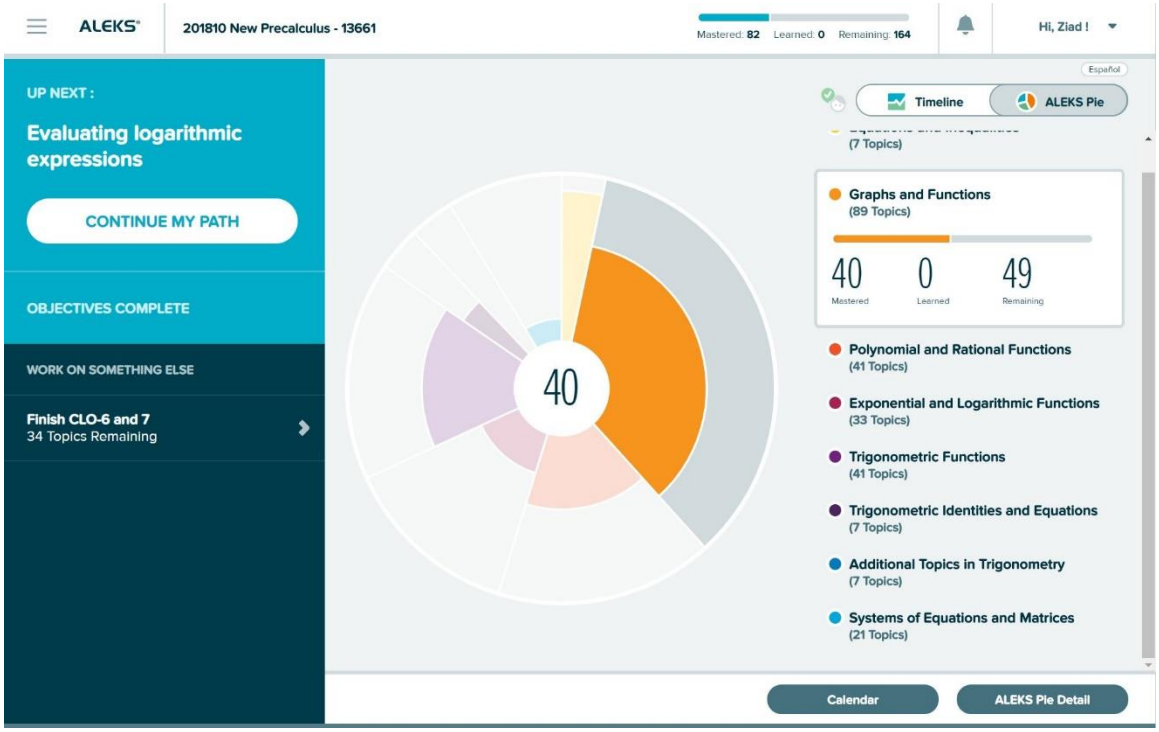

Figure 1. The student module in an ALEKS course

For instructors, ALEKS presents a similar pie chart that indicates the overall performance of their class. The instructor's main dashboard offers a range of tools that can be used to monitor the performance of individuals, a group of students, or the entire classroom.

Indeed, the LA provided through ALEKS on the form of various types of reports is considered as an integral part of the platform.

In 2011, the first International Conference on LA and Knowledge defined LA as the "measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Siemens & Long, 2011, p. 34). Many AL solutions use LA to either direct the student on what to do next or help the student decide on what to do next by offering a range of different activities (Chatti, Dyckhoff, Schroeder, & Thüs, 2012). On a course-level, the main stakeholders for the system-generated LA are the students and teachers (Siemens & Baker, 2012). The former group might be interested in how LA might improve their learning, while the latter group focus on how to use LA to enrich and gauge the learning experience inside their classes (Chatti et al., 2012; Holmes, Nguyen, Zhang, Mavrikis, & Rienties, 2019).

In ALEKS, instructors can use the LA to generate a variety of real-time, data-driven reports to help them optimize the learning experience of their students. For instance, instructors can identify whether students are logged-in to ALEKS or not and monitor the amount of time they spend working in the system, and the number of topics attempted and mastered. The *time and topic* report, for example, displays the time spent in ALEKS, the number of topics learned, and the number of topics attempted per day or week. Ineffective learning states can be detected when students try many topics and master a few over some time. The ratio of topics mastered to topics practiced '*mtop'* has been identified as a predictor for the students' ability to learn independently and final exam scores (Dani & Nasser, 2016; Mills, 2018).

For small groups and direct classroom instruction, the *ALEKS Pie* report identifies common topics that the students are ready to learn and enables the detection of challenging topics. This report gives the percentage and the names of students who are prepared to learn a specific topic and displays the number of students who have attempted to learn this topic but did not yet master. Lastly, the most detailed and comprehensive is the *Progress* report, which shows the total time spent in ALEKS, the progress made, and the topics learned per hour for the individual student, among other variables. More

importantly, taking action is the primary aim of LA (Chatti et al., 2012; Holstein, McLaren, & Aleven, 2017), and informed decisions can be made by instructors who can transform the system-generated reports into insights to gauge the students' learning inside and outside the classroom. The wealth of LA that ALEKS produces for teachers to orchestrate learning in their classes necessitates a further discussion on the role of LA as orchestration tools, which is presented in the next section.

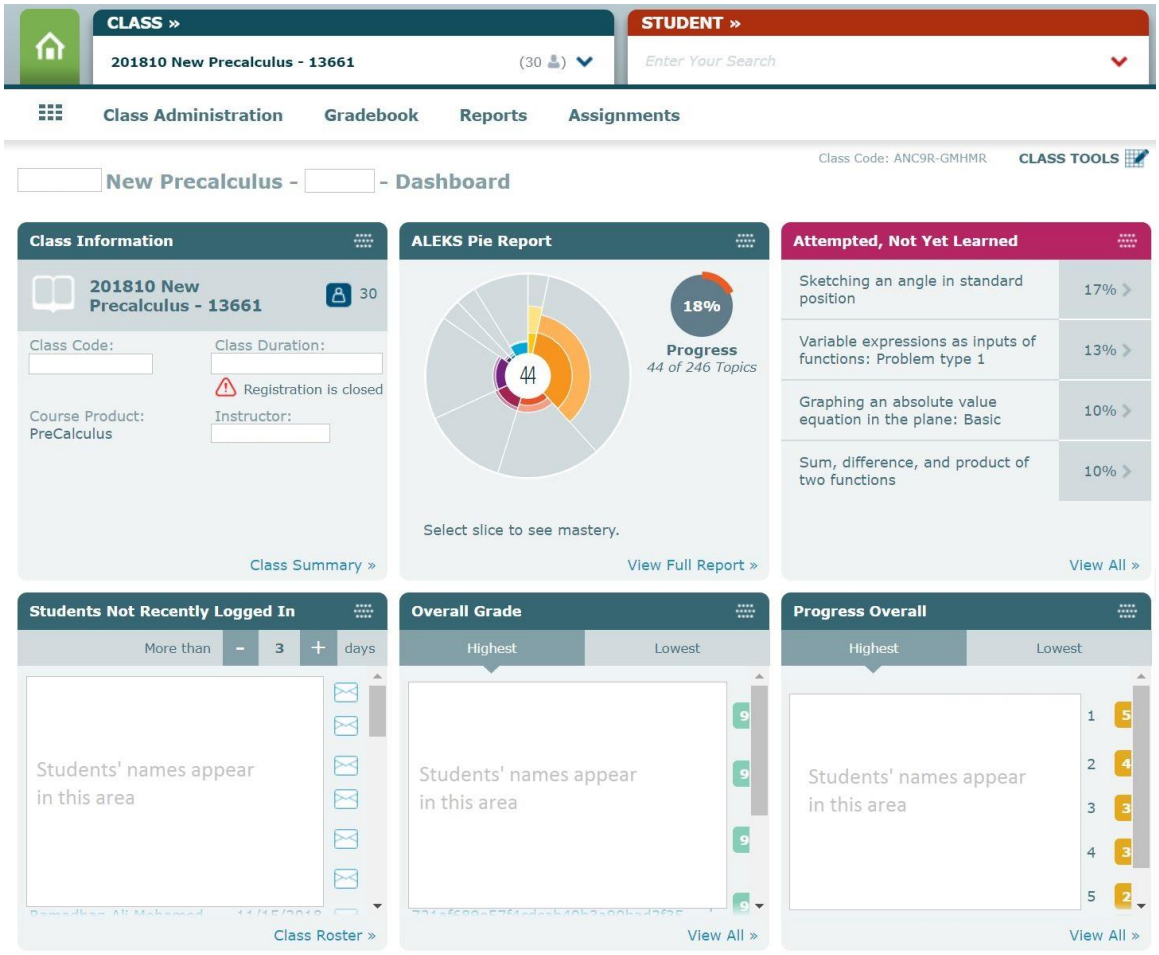

Figure 2. Instructor's dashboard in an ALEKS course

Orchestration and the role of LA as orchestration tools

The term 'orchestration' is an attractive and a helpful metaphor because it creates a "flavour that local design principles do not convey" (Dillenbourg & Jermann, 2010, p. 3). From an educational viewpoint, orchestration "refers to how a teacher manages, in real time, multi-layered activities in a multi-constraints context" (Dillenbourg, Nussbaum, Dimitriadis, & Roschelle, 2013, p. 485). The latter positioning of the teacher's role does

not advocate a teacher-centric learning environment as Dillenbourg, and his colleagues maintain that teachers are viewed as the drivers of multi-layered activities who are empowered to take instant decisions as to incorporate (or change) different learning scenarios in their classes within a set of constraints like curriculum, assessment, time, etc. (Dillenbourg & Jermann, 2010; Dillenbourg et al., 2013).

Orchestration technologies can be viewed as tools that reinforce the orchestration model as long as they support the various classroom activities, and are easy to use/ manipulate by the teacher (Dillenbourg et al., 2013). Examples of orchestration tools include Intelligent Tutoring Systems (ITSs) and intelligent learning environments (ILEs), according to du Boulay (2019), due to their ability to support the teacher in managing individual students' needs as well as an entire classroom. du Boulay's (2019) extensive review showed that the effectiveness of some ITSs and ILEs is not limited to individual students, and these orchestration tools can be considered as effective as a classroom assistant (c.f. Holstein, McLaren, & Aleven, 2019). The latter, du Boulay (2019) adds, is achievable by providing meaningful teacher training opportunities on the pedagogy stemming from the way ITSs and ILEs are orchestrated in a classroom setting.

The importance of linking pedagogy with the application of AI in du Boulay's (2019) study represents an immense opportunity because it shifts our attention to how LA tools can support the role of the teachers as orchestrators of learning in their classes (Mavrikis, Geraniou, Gutierrez Santos, & Poulovassilis, 2019; Mavrikis & Holmes, 2019). Also, Martinez-Maldonado et al. (2016) demonstrated that LA, as orchestration tools, can be used to support a wide range of orchestration activities in the classroom (e.g., semi-automated interventions). Taking an approach to LA from an orchestration viewpoint has led to a series of studies that highlighted the dynamic role of teachers in such an environment. For example, Prieto, Dimitriadis, Villagrá-Sobrino, Jorrín-Abellán, and Martínez-Monés (2011), Martinez-Maldonado et al. (2016), and Mavrikis et al. (2019) presented influential case studies from different educational settings by working directly with teachers, providing a wealth of information about classroom orchestration. In a rural Spanish school, Prieto, Dimitriadis, Asensio-Perez, and Looi (2015) worked with primary teachers to understand the complex practice of classroom orchestration in a Computer

Supported Collaborative Learning (CSCL) environment. The findings from their study showed how the alignment of design, technology, and teacher actions were crucial factors for successful orchestration. In addition, Martinez-Maldonado et al. (2016) explored how teachers support various students' face-to-face activities with the help of LA generated from surface devices (interactive tabletops). Their investigation involved a series of case studies on how the LA from interactive surfaces supported teacher awareness, planning, and actions within and across multiple classroom sessions.

Similarly, Mavrikis et al. (2019) worked with mathematics teachers on a set of LA tools in an Exploratory Learning Environment (ELE) to support classroom orchestration. The teacher assistance tools included Student Tracking (SD), Classroom Dynamics (CD), Goal Achievements (GA) and a grouping tool (Mavrikis et al., 2019). The results from classroom observations and teachers' reflections showed that the LA were perceived as useful tools that aided the teachers to attend to the needs of individual students as well as the entire classroom. In this study, Mavrikis and his colleagues demonstrated how carefully designed LA can inform teachers' decisions as well as student learning in a complex learning environment like ELE.

The notion of classroom orchestration, which, in this research study, involves LA as orchestration tools adds another dimension to the teacher's role in subsequent chapters. Thus, empowering teachers and recognizing their important role as the drivers of the various activities in their classes. What follows is a review of the literature around the implementation of ALEKS in K-12, colleges, and universities.

The use of ALEKS in educational institutions – why and how

The vast majority of the literature around ALEKS originates from the USA with a heavy quantitative slant. Studies have focused on the performance and perceptions of students using ALEKS and inspected the effectiveness of the platform and its impact on students' learning. Others have compared the performance of students in ALEKS classes as opposed to a more traditional classroom setting. Underlying these studies is the assumption that the use of ALEKS is to cater to a diverse student population with varying mathematical abilities and educational backgrounds. For these students, the tell-practice-test model and the one-size-fits-all approach have consistently proven inadequate (Lai,

2011; Laurillard, 2008). Using AL technologies as a tool to move beyond these models in mathematics classes, and generally, might give us the advantage we need to cross the latter thresholds.

Some of the research on ALEKS showed positive learning gains, while other studies showed no significant difference in learning outcomes. Despite the promises made, research on AL is embryonic with mixed results (D. Johnson & Samora, 2016). However, a closer inspection of the use of AL in different educational institutions reveals much more.

ALEKS as a drill and practice tool

To understand the context of existing research, it is essential to know how ALEKS has been used to help students learn mathematics. For instance, ALEKS has been used as a drill and practice tool where it is the responsibility of the students to practice and improve their skills by completing the required topics outside the classroom without any intervention from the instructor. As such, only the practice component of ALEKS was used, much like a homework management system, while in the classroom and the same material was covered for all students. Examples of studies undertaken in such contexts include Stillson and Alsup (2003) who examined the attitudes and performance of students using ALEKS in a basic algebra class, while Hagerty and Smith (2005), Strayer (2012), and Xu et al. (2008) compared the performance of students using ALEKS to those who were taught in traditional classes.

The misalignment of the textbook used in the classroom with the topics presented in ALEKS, the lack of knowledge of how ALEKS operated, and the excessive time it took to complete the required ALEKS assignments outside the classroom were recurrent themes in all these studies. Stillson and Alsup (2003), for example, had a small dataset comprising 59 students from three basic algebra classes. Initially, students liked the repetition of exercises and the immediate feedback given by ALEKS. However, the topics in ALEKS were not in sequence with the topics presented in the textbook, and some students felt they were studying for two different courses (Stillson & Alsup, 2003). Learning how ALEKS operated and the excessive time required to finish the system-generated assignments were among the challenges described. Consequently, Stillson and

Alsup (2003) reported that the course under study suffered high failure and dropout rates from the addition of the ALEKS component.

For Hagerty and Smith (2005) whose study comprised 251 participants, ALEKS was identified as a factor that made a significant difference in students' growth and retention over the semester. Unlike the previous study, Hagerty and Smith (2005) reported that the students spent enough time getting to know the ALEKS platform and how it operated. In this study, the students who used ALEKS outperformed those in traditional classes. However, out of the four groups that used the platform, one was made up of students who worked full time with family commitments. This group did not cope well with the time that ALEKS needed to complete the required topics. Eventually, 40% of the students in this group dropped out, withdrew, or failed the course. The drop-withdrawal-failure rate in ALEKS classes was at 27.8% as compared to 25.5% for traditional classes.

Xu et al. (2008) used a mixed-method approach to collect data from 86 participants in a statistics course. In terms of performance, the authors did not find any statistically significant differences between students who used ALEKS and those in traditional classes. However, they reported that the general perception of ALEKS was positive despite the challenges mentioned earlier. Strayer (2012) compared the students' perceptions of their learning environment in a traditional setting and a flipped classroom environment in an introductory statistics course. Students in the flipped setting where ALEKS was used outside the classroom to reinforce the content taught felt they were lost and overwhelmed with the unstructured nature of the flipped classroom. According to Strayer (2012), "students seemed always to be on edge, never feeling completely comfortable with how to engage with the material or use the class time" (p. 184). His results showed that students in the flipped class struggled with the assignments in ALEKS and failed to make the connection with the material that was taught in the classroom.

That being said, Strayer (2012) also reported that students from the flipped classroom were more open to collaboration and valued group work – an aspect that might partially be attributed to the use of ALEKS and the setup of the course, according to the author. Being the instructor and researcher, Strayer (2012) mentioned that his study "serves as a

warning against ill-connected online and face-to-face components in a blended learning environment" (p. 191).

For this category of studies that used one aspect of the ALEKS platform outside the classroom, the results were unpromising. If an AL platform like ALEKS is used without the proper set-up and knowledge of its capabilities and limitations to supplement an already demanding course without any intervention from the teachers, poor results should not be surprising. After the initial assessment, ALEKS places each student on a different learning curve. In the cases cited here, the differentiated practice outside of class was not supported by equivalent differentiation inside the classroom. These two disjointed components did not allow for a proper evaluation of ALEKS. Would the results be different had ALEKS been used as an integral part of a course or program? The next section allows an investigation of those studies which used ALEKS inside the classroom.

ALEKS as a remediation tool

Further evidence from the implementation of ALEKS as a remediation tool, mainly in K-12, found similar mixed results. In these studies, Platko (2011), Craig et al. (2013), Fanusi (2015) and Karner (2016), investigated the effectiveness of ALEKS as a remediation tool and compared the performance of ALEKS users to non-ALEKS users. These studies shared at least one feature in common, that is, ALEKS being an essential part of a course/ program that was used to bring at-risk students on par with regular students.

Platko's (2011) study comprised 1,269 eighth-grade, at-risk students, who were enrolled in mathematics remedial classes. Of those, 338 students used ALEKS in the classroom and 931 students in traditionally taught remedial classes that did not use ALEKS. In ALEKS double-block classes, 45 minutes were allocated for traditional instruction and another 45 minutes for working on ALEKS, where teachers assisted students when needed. Platko's (2011) quantitative results showed that ALEKS had a positive impact on the traditional class only for those students with very low scores. Thus, only 13.9% of the students who used ALEKS experienced growth against a standardized district assessment. Interestingly, and as a limitation of his study, Platko (2011) warned us that

these results might have been affected by the lack of teachers' knowledge and use of the ALEKS platform.

In a similar study, Craig et al. (2013) could not establish any statistically significant differences in the performance of sixth-grade students in an after-school remediation program. Their study used data from 253 participants that were assigned randomly to classes that used ALEKS as an instructional method and classes that were traditionally taught. Students' achievements on the Tennessee Comprehensive Assessment Program (TCAP) were used to compare the two groups. Students' behavior and class management issues between the two groups were also examined. The after-school remediation program recruited certified sixth-grade teachers who were offered a three-hour general training session that provided an overview of the program and the use of ALEKS. The teachers in ALEKS classes took on the role of a 'supervisor' and provided help only when students couldn't proceed without it. The upshot of this study was that students in ALEKS classes required a lesser amount of support from teachers – an added value for AL, according to Craig et al. (2013).

Along the same lines, Fanusi's (2015) study compared the performance of students in an ALEKS mathematics support class to the performance of students in a traditionally taught mathematics support class against the Criterion Referenced Competency Test (CRCT). The CRCT is a multiple-choice test that assesses the students' knowledge in mathematics at the conclusion of a school year. Fanusi's sample comprised 181 students from ALEKS classes and 113 students from traditional classes. In ALEKS classes, students worked at their own pace to complete their pie, while teachers offered help when needed and monitored the students' daily progress to make sure that they stayed on task using the ALEKS generated reports. Fanusi's (2015) analysis did not reveal any statistical significance in performance between the ALEKS taught group and the traditionally taught group with respect to the CRCT scores. There was a positive correlation, however, between the percentage of topics completed in ALEKS and the students' progress on the CRCT test.

Lastly, Karner's (2016) investigation involved ninth-grade, at-risk students who were enrolled in a Math Academy remediation class that used ALEKS, which ran in parallel to

their regular algebra class. In Math Academy classes, students work on ALEKS, finish their assignments, retake assessments, and receive extra instruction from a certified mathematics teacher as needed. Karner's (2016) results showed that students in the Math Academy classes were able to partially close the gap and perform on par with regular students against a standardized mathematics assessment. Unfortunately, the students from the Math Academy classes failed to achieve similar outcomes in their regular algebra course, with more than 60% of these students receiving D's and F's.

Despite this, evidence drawn from K-12 is encouraging given that students were left working on ALEKS with minimal intervention from their teachers. In the traditionally taught classes, however, the teachers were on familiar ground and were confident in their approach. These studies showed that students who used ALEKS were partially able to perform on par with regular students on standardized mathematics assessments.

The difficulties that students face in mathematics in K-12 are amplified by the time they reach the college level. These students will be required to cross another threshold to be able to obtain a college degree – developmental or remedial mathematics courses. In the United States where most of the studies on ALEKS have occurred, the latter type of courses acts as gatekeepers, where students cannot proceed to their majors without passing these courses. Higher educational institutions, therefore, have been considering AL technologies as a possible approach to help struggling students in mathematics cross the latter thresholds. Unfortunately, evidence from the implementation of ALEKS as a remediation tool in tertiary education reveals similar inconsistencies to the implementation in K-12.

Of the studies that have compared the performance of students in ALEKS classes to the performance of students in traditionally taught classes, J. M. Taylor (2008) recruited 93 participants from three colleges and two universities in Texas, USA. Out of these, 54 students were enrolled in courses using ALEKS, and 39 students in traditional classes. J. M. Taylor (2008) used the results from the National Achievement Test, First Year Algebra Test (NATFYAT), the Mathematics Anxiety Rating Scale (MARS), and the Fennema and Sherman Mathematical Attitude Scale (F-S Scale) to guide her study. Statistical analysis of the data obtained from the students in ALEKS classes showed a

significant increase in the means between the pretest and posttest scores (16.56 to 20.56), which indicated that ALEKS was helpful in improving students' achievements. Although the scores of both groups improved on NATFYAT, the students in traditional classes performed better than those in ALEKS classes. The results from MARS and F-S Scales, however, indicated that the students from the ALEKS group showed better attitudes and less anxiety towards mathematics by the end of the semester. The latter, according to J. M. Taylor (2008), represented an argument that can be made in favor of this approach to learning.

Hrubik-Vulanovic (2013) investigated the effect that ALEKS had on students' success in subsequent mathematics courses. In this study, traditional lectures were replaced with an emporium-style course delivery where students worked on ALEKS at their own pace in a lab with instructors helping when needed. The quantitative part of the study compared the performance of former ALEKS students to the performance of students who did not take ALEKS in subsequent mathematics courses that were taught traditionally. The results did not show any statistically significant differences in students' performance, which was encouraging, according to Hrubik-Vulanovic (2013). In the qualitative part, the students in the ALEKS emporium-style courses commented on their learning experience and study habits. The results indicated that many students did not value the learning experience in the emporium-style courses. Although some liked the self-paced aspect and detailed explanation of problems in ALEKS, many reported that they "were not able to sufficiently establish a student-teacher relationship" (Hrubik-Vulanovic, 2013, p. 100). Instructors thought of ALEKS as a useful drill-and-practice tool, but ineffective as a primary instruction tool.

In contrast with the above study, Aberle (2015) studied the performance of students enrolled in developmental math classes at Ozarks Technical Community College (OTC). To address low success rates, OTC redesigned these courses in the fall of 2011 to include computer-enhanced instruction. To cope with the transition, ALEKS training seminars were provided to the teachers involved in these classes. A stratified random sample of 500 students was chosen, which consisted of 250 students from lecture-based instruction, and another 250 from the computer-enhanced instruction classes and inferential statistics

were used to analyze the data. The difference in retention rates between the two groups was not significant enough to support Aberle's hypothesis. However, the success rate of students who received computer-enhanced instruction was significantly higher than those who received lecture-based instruction. After an initial drop in the scores for the first unit test, students in computer-enhanced classes performed better on the second- and third-unit tests when compared to the scores of students in traditional classes. Aberle (2015) attributed the students' drop in the first unit test "not [as] a result of their learning in ALEKS but rather a reflection of a "learning curve in adapting to a new way of doing math" (p. 92). As for the final exam scores, Aberle (2015) did not find enough evidence to support her hypothesis as the difference between the two means was not statistically significant.

The instructional model in Aberle's (2015) study used half of the class time for students to work on ALEKS and the other half for traditional lectures and assessment. It is not clear, however, whether the conventional lectures took into consideration the different learning paths for students working on ALEKS. Yet the fact that students in ALEKS classes performed as well as students in traditional classes represents a case in favor of AL as an alternative approach to mathematics instruction, Aberle (2015) argued. Perhaps one of the valuable recommendations made by the author is that teachers should continuously monitor the students' progress using the analytics provided by ALEKS to come up with early intervention plans and create support systems for students.

The research on ALEKS as a remediation tool portrayed teachers as passive participants waiting for students to ask for help. The nature of the studies cited here focused on students and repeatedly overlooked the role of the instructors. It remains unclear whether the instructors in ALEKS classes used the accompanying reports to monitor the performance of their students. The instructor dashboard in ALEKS helps in managing classes and tracking the performance of students. The LA and the various reports generated by ALEKS are an integral part of the platform and a necessity for teachers so that they can offer just-in-time assistance and feedback, not only for struggling students but for all the students in their classes.

To give an example of what happens when the instructor's module is not used or when teachers assume a less active role, Wang, Tang, Li, and Hu (2018) investigated the behavioral patterns of students and aimed to discover and predict how students learn in ALEKS. The authors examined 25,783 ALEKS log data entries of students' learning from six high schools in the USA from 2010 to 2014. They used a two-layer hidden Markov model (TL-HMM) to analyze their data. Students who mastered a topic were categorized as high-achievement and students who failed to learn a topic as low-achievement. For complex topics, the authors found that low-achievement students wanted more explanation and practice, while high-achievement students mastered the topic without much help from the explanation. For easier topics, however, lower-achievement students "were trapped in ineffective practice but fail to learn from explanations." (Wang et al., 2018, p. 377).

While it is impossible for us to know how the courses were taught and what kind of assistance was offered to students at that time, Wang et al. (2018) shed light on some of the limitations of AL technologies. The presence of a teacher, it seems, crucial to making sense of the LA provided by ALEKS and transforming these into insights to enrich the students' learning experiences in the classroom. One of the reports that we can generate from the instructor module in ALEKS relates the topics attempted to the topics mastered and tells us the amount of time each student took. Teachers can use this report to detect ineffective learning states and offer proper assistance for struggling students. Would we be able to see different results had ALEKS been used in a different format? The next section draws evidence from studies where ALEKS was used as a predominant approach to learning in regular mathematics classes.

ALEKS as a principal approach to learning

Unlike the two previous sections where ALEKS was used in a remediation program or as a drill-and-practice tool, this section draws evidence from the implementation of ALEKS as an integral part of the classroom/ course across K-12, colleges, and universities. The research conducted in this area did not deviate from the focus on students' perceptions and attitudes, and the comparative approach against traditionally taught classes. In these studies, Canfield (2001) and Serhan (2017) inspected the attitudes and perceptions of

students in ALEKS classes, while Mertes (2013), Kasha (2015) and Yilmaz (2017), investigated the effectiveness of ALEKS and compared the performance of students in ALEKS against traditionally taught classes.

The self-paced aspect of ALEKS, its detailed explanation, availability of resources, and the immediate feedback it offers were noted by students as advantages (Canfield, 2001; Serhan, 2017). The following themes were recurrent in other studies that focused on students' perceptions when ALEKS was used as a drill and practice tool despite the poor results. Canfield (2001) was one of the early researchers who mentioned the instructor's module in ALEKS and the useful information it provided, given the data generated by its various reports. Unfortunately, his study did not mention the instructor's role and classroom setting for ALEKS classes.

In Serhan's (2017) study, however, the instructor's role was described as a facilitator who was responsible for "guiding students through the learning process, offering assistance when needed, keeping track of students' progress and following up with them to ensure they remain on task and develop their learning throughout the course." (p. 3). The use of the instructor's module and ALEKS generated reports is essential for the latter to be achieved. However, a recurring theme from an open-ended question in Serhan's (2017) study asking students to list possible disadvantages of ALEKS was "lack of social interaction especially with peers and instructor" (p. 5). Many students reported that they were left alone in a self-taught classroom. The latter disadvantages highlighted by the author do not sit well with the description of the instructor's role given in his study. Perhaps this could explain why students were neutral in terms of how ALEKS impacted their learning. Interestingly, the lack of interaction between students and instructor echoed what Hrubik-Vulanovic's (2013) found in the emporium-style courses where the instructors assumed a less active role in the classroom.

The comparative approach and evidence from the implementation of ALEKS as a predominant approach to learning produced similar mixed results. However, a closer examination reveals weaknesses in the approach to using ALEKS in the classroom. For example, Mertes (2013) investigated a pilot study that aimed to replace traditional teaching with an alternative curricular approach that included ALEKS for students in

grades six, seven, and eight. One section of each grade was chosen at random for the pilot study (n=65), while the other sections were in traditional classes (n=283). This allowed the comparison between the performance of the two groups against the Minnesota Comprehensive Assessment (MCA-III) and the district-developed concept tests.

Statistical analysis showed that students in grades six and eight traditional classes outperformed those in ALEKS classes on the district-developed concept tests, but the results in grade seven did not yield any statistical differences between the two groups. In contrast, the results from MCA-III did not show any differences in performance for both groups in grades six and eight. For grade seven, students in traditional classes outperformed those in ALEKS classes. Mertes (2013) reported that the use of ALEKS was discontinued at the end of the pilot study. In her concluding remarks, and as a limitation of the study, Mertes (2013) reported that the teachers in the pilot study were not offered any training on ALEKS and its use in the classroom. In addition, the district-developed tests might have favored the book that was used for the traditional classes as these tests were not adequately validated. In this study, the ALEKS experience might have been predicted to fail as it is a sophisticated platform that needs proper training to know how to operate it efficiently. More importantly, exploring how to benefit from its LA to create a different learning experience in the classroom. Simply put, the AL platform was placed in unfavorable conditions, which prevented a proper evaluation of this approach to learning.

Similarly, Kasha's (2015) study demonstrated that the combination of ALEKS and an active instructor was able to produce good results. Her comparative approach investigated the performance and attitudes of two groups of students in a college algebra course – those who used ALEKS ($n = 27$) and those who were in traditional classes ($n = 29$). In the ALEKS class, the instructor used the generated reports and targeted his lecture time on topics that students struggled with and topics that students were ready to learn. Kasha (2015) could not establish any statistically significant differences in terms of performance and attitudes between the two groups. Unfortunately, the duration of the study was limited to one learning outcome of the college algebra course and not the entire semester, thus, too short. The upshot of this study was that the instructor used ALEKS reports to

regulate his approach in the classroom – an aspect that was missing in previous studies where instructors assumed a less active role in the classroom.

In sharp contrast with the above results, Yilmaz (2017) reported that students who used ALEKS in grades 6 to 9 were able to outperform their counterparts in traditionally taught classes across all levels. Also, there was a strong correlation between the percentage of concept mastery in ALEKS and the end of year exams. The sample size consisted of 1,110 students from two schools with similar profiles. Based on the researcher's description, we know that students worked on ALEKS for 45 minutes daily for the entire school year. Unfortunately, there was no indication of the classroom setting and the teacher's role.

The results from this illustrative review of the literature do not consistently support a particular outcome for the use of ALEKS in the classroom. The trend is, instead, towards inconsistent results. This conclusion is supported by the findings of a recent meta-analysis that examined the effectiveness of ALEKS on students' learning. Fang, Ren, Hu, and Graesser (2018) inspected 15 empirical studies between 2005 and 2015. Their analysis showed that the results from using ALEKS at different levels (K-12 or tertiary education) yielded no significant difference when compared to traditional instruction. These results remained unchanged when ALEKS was implemented in various formats (assistive or principal). However, shorter implementation periods showed more significant effect sizes over more extended implementation periods. It is possible that the degree of teacher-involvement might have affected the results of this study.

In conclusion, the focus on quantitative measures and the persistent emphasis on students' attitudes and performance along with the comparative approach to traditional classroom settings have prevented us from understanding what it takes to learn and what it takes to teach with the use of an AL platform like ALEKS. The process of teaching and learning is a highly complex activity, and the focus on the learner should not prevent us from acknowledging the critical role of the teacher enabling the learner to achieve their full learning potential. Therefore, this discussion points to the necessity to address a more significant issue, which is the role of the teacher in classes that use AL as an instructional approach and its impact on students' learning. Teachers are the key to technology

innovation and an essential element of the AL equation – an often forgotten component of research studies on ALEKS. Therefore, it is the goal of this dissertation to focus on the insights and perceptions of teachers that use ALEKS in their classes. Specifically, it is intended to explore how they use the LA as orchestration tools to cater to the different students' needs in their classroom.

The review of literature has demonstrated that ALEKS has primarily been used as a technology-driven approach, with the AL system being deployed and compared with a traditional classroom setting. Ill-defined implementation strategies, inconclusive and contradicting results, and the presentation of teachers as passive participants were consequences of this approach. An education-driven approach, however, would consider what it takes to learn and only then ask how AL as technology can help (Laurillard, 2013). The next section draws on the seminal work of Professor Diana Laurillard and her CF to evaluate ALEKS and highlight the teacher's role in an AL environment.

The Conversational Framework

In her book *Teaching as a Design Science*, Professor Diana Laurillard makes a strong case in favor of incorporating digital technologies in education and presents the CF as a means to evaluate these technologies according to the needs of the academic community. The author urges us to "go beyond mere awareness to full exploitation of these new opportunities" (Laurillard, 2013, p. 2). To do that, educationists should question and challenge these technologies from a vantage point, that is, "a continually renewed understanding of what education requires of them" (Laurillard, 2013, p. 3). Our vantage point, therefore, is the wealth of accumulated knowledge on what it takes to learn and teach. Diana Laurillard reminds us that our understanding of the fundamental principles of the learning process has not changed, despite the technological advances:

The primary account of formal learning as an iterative process, linking both knowledge and skills (theory and practice) and engaging the learner with teachers and their peers remains unchanged. What does change is how we motivate and enable formal learning. (Laurillard, 2013, p. 93)

The CF is a pedagogy-derived framework and a distillation of the central educational literature and learning theories developed over the last century, according to Laurillard (2013). The framework is intended to offer educators an education-driven approach to challenge the technology and help them think about teaching and learning from a student's perspective.

The aim of the CF is to represent, as simply as possible, the different kinds of roles played by teachers and learners in terms of the requirements derived from conceptual learning, experiential learning, social constructivism, constructionism, and collaborative learning, and the corresponding principles for designing teaching and learning activities in the instructional design literature. (Laurillard, 2013, p. 93)

In the teacher communication cycle (TCC), learners have access to the teacher's concept, which, in turn, helps them modulate their own concept. The teacher gives extrinsic feedback, which motivates each learner to ask questions and articulate their own understanding of the idea. In addition, the teacher monitors learners' conceptions and works with preconceptions by drawing on the learners' previous experiences, and uses formative assessment to foster conceptual knowledge, among many other functions.

The teacher practice and modeling cycle (TPME) provides an environment that motivates the learner to modulate their practice using extrinsic and intrinsic feedback provided by the teacher and the learning environment. Here, the teacher engineers the TPME within the learner's zone of proximal development (Chaiklin, 2003) and creates meaningful tasks that promote deep learning and gives the learners the means to articulate and share their knowledge with their peers.

The peer communication cycle (PCC) enables the learner to modulate their own concept by having access to their peer's concepts. Peers, for example, can provide comments, ideas, critique, and feedback, which motivates the learner to articulate their own understanding of the concept. Lastly, and as Laurillard (2013) explains, the peer modeling cycle (PMC) drives and enables each learner to generate actions, share, and modulate their practice by having access to their peer's output.

When we enable the teaching-learning cycle, we make visible the different ways the teacher-learner and learner-learner communicate. The integration of different learning theories like instructivism (teacher-focused), constructionism (practice-focused), social constructivism, and social constructionism/ collaborative learning is evident in the CF.

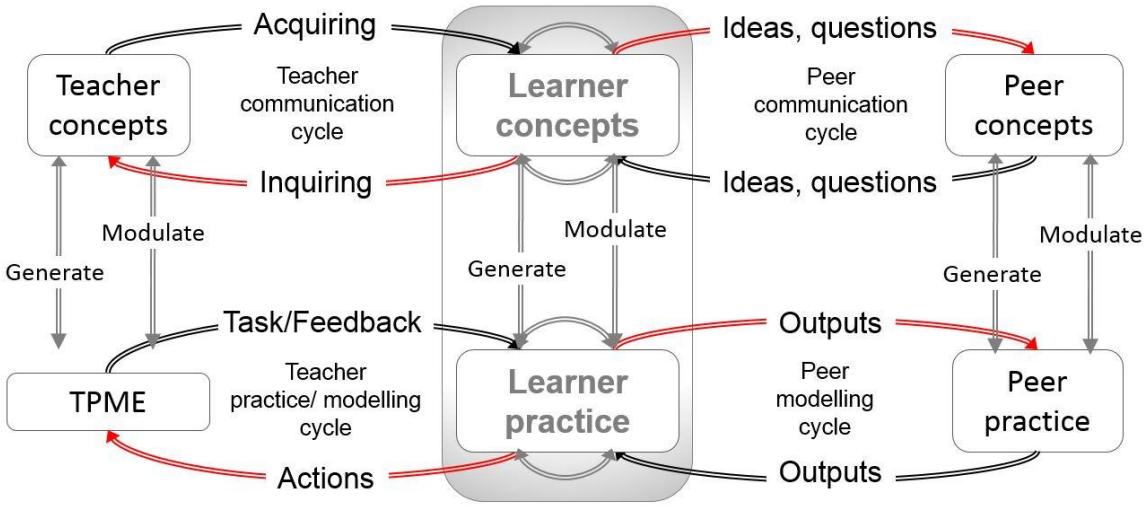

Figure 3. The Conversational Framework

By extension, the CF incorporates six basic types of learning that are common in education. These are learning through acquisition, inquiry, discussion, practice, collaboration, and production. The best learning experiences, according to Laurillard (2013), combine all six learning types. Laurillard (2013) argues that podcasts and web resources, however accessible, only provide access to the teacher's concepts. These require no action or articulation from students and therefore serve as good tools for learning through acquisition. Online forums, chat rooms, and wikis, for example, are considered useful tools for learning through collaboration. When digital technologies are viewed and evaluated from the lens of the CF, they represent an immense opportunity for educationists to improve the quality of teaching and learning and enable every learner to reach their full learning potential.

In critiquing ALEKS as an approach to classroom instruction, the CF is extremely useful as it sheds insight on the vital role that instructors could play. For example, how could teachers orchestrate the teacher and peer communication cycles to maximize the effectiveness of feedback to the learner and their response? The CF also provides an evaluation tool that could identify opportunities for innovation in AL. In that sense,

educators could be understood as facilitators, enablers, designers, and competent users of digital technologies in their classes. Such a conceptualization of the role of the educator requires a different approach when researching AL and this means the teacher must be considered as an orchestrator, not as a parameter that can be overlooked.

Reflections

Engaging with the literature on ALEKS was not an easy task. At first, I approached the research with the intention of replicating some of the existing studies that compared the performance of students in ALEKS to those in traditionally taught classes. A comparative study from a different context and culture, I thought, would be adequate. However, my initial attentiveness to the outcomes of these studies prevented me from looking for what was missing. Consequently, my concentration on the 'what' instead of investigating the 'how' and 'why' produced an initial review that could be interpreted as meaning that I was "assigning to the reader the task of sifting the evidence and assessing its relevance." (Lee, 2009, p. 57). Having been discontented with my initial approach and skeptical of my potential contribution to the existing body of knowledge, I attempted to critically engage with the literature from a different angle, which benefitted from some of the guiding questions posed by Lee (2009). These were:

How was the evidence generated?

What are the theoretical perspectives underpinning the evidence?

What kind of strategies were used to collect evidence?

What have I learned?

What do I need to do next and why?

Could things be done any differently? (p. 37)

The latter questions facilitated the discovery of five main categories pertinent to all the extracted studies. For each of the identified categories, I extracted relevant data from different studies in chronological order. I wanted to understand the interest in AL as an approach to instruction. As such, the first category targeted the reason why ALEKS was used, which allowed me to detect that institutions needed to cater to a diverse student

population with varying mathematical abilities and educational backgrounds. These institutions, it seemed, wanted to go beyond the one-size-fits-all approach, which has proven ineffective.

In the second category, I wanted to inspect the nature of the studies and the strategies used to collect evidence. I noticed that the majority of evidence was collected quantitatively using a comparative approach – ALEKS vs. traditionally-taught classes, along with studies that inspected the students' attitudes and perceptions. AL platforms/ systems do not usually come with a manual, and knowing 'what' ALEKS does is different from knowing 'how' it should be deployed. Thus, in the third category, I aimed to account for the different scenarios under which ALEKS was used. This permitted me to identify three main methods of deployment: the first as a homework management system independent of the work in the classroom; then the use of ALEKS as a remediation tool with minimal intervention from teachers; and lastly, ALEKS as a predominant approach to classroom instruction.

The insights I gained from inspecting the different implementation strategies led to the choice of organizing the review of the literature according to how ALEKS was deployed. In parallel, I wanted to go beyond the inconclusive results reported by the different research studies and identify the shortcomings in each of the deployment methods. Thus, the fourth category inspected the role of the instructor in each of these studies, which provided me with invaluable information that constituted the backbone of my research. The existing body of knowledge, it seemed, was less concerned with what I consider an essential part of the equation and the missing variable – the role of the instructor in ALEKS classes.

Lastly, in the fifth category, I noted how different researchers understood ALEKS and its various components. Coupled with the less visible role of instructors in ALEKS classes, I noticed that many researchers did not acknowledge the importance of the instructor module in ALEKS which contains the students' LA. Having organized the literature chronologically, I managed to paint an image that represented the evolution and applications of ALEKS under the five latter categories.

A researcher's background and position will affect what they choose to investigate, the angle of investigation, the methods judged most adequate for this purpose, the findings considered most appropriate, and the framing and communication of conclusions. (Malterud, 2001, p. 483).

Research Questions

The insights from the literature considered here led to the following research questions:

RQ1: How is AL being used to assist students in their transition to college-level mathematics?

RQ2: In what ways does AL influence the practices of teachers and their approach to classroom instruction?

RQ3: How can AL most effectively be used to optimize the classroom learning experience?

The approach I took to review the existing research informs this study's epistemological basis, underlying philosophy, and rationale. Therefore, the next chapter will consider the most appropriate methodology for answering these questions.

Chapter 3

Methodology

Introduction

There are four main sections in this chapter. The aim and design of the study explain the epistemological basis and underlying philosophy and rationale for choosing a case study design. Within this section, I present reflections on the methodological approach from my perspective as a practitioner-researcher. Following this, the approach to sampling is discussed. The next section provides an explanation of the data collection methods that will be used in this study. The data analysis section presents a detailed description of the strategies and procedures used to analyze the data and addresses the limitations of the methods used. Lastly, the strategies that will be put in place to ensure the reliability and validity of the study are discussed in detail.

Research Aim

The results from the review of the literature do not consistently support a particular outcome for the use of the AL system, ALEKS, as an instructional approach. Here, three distinctive features should be highlighted. The first is the focus on quantitative measures and the persistent emphasis on students' attitudes and performance along with the comparative approach to traditional classroom settings. The second is the absence of a discussion on the crucial role that the LA provided by ALEKS can play in personalizing instruction, while the third is the arguably partial and limited portrayal of teachers as bystanders – although common sense dictates that they are the ones responsible for translating the LA into insights to enrich the students' learning experiences. These essential factors which have been absent in previous research prevented us from understanding what it takes to learn and what it takes to teach with the use of an AL platform like ALEKS. The focus on the learner, however necessary, should not deter us from acknowledging the vital role of the teacher enabling the learner to achieve their full learning potential. Therefore, this discussion points to the necessity to address a more significant issue, which is the role of the teacher in classes that use AL and its impact on students' learning.

Contrary to the prevalent technology-driven approach found in the literature, the aim of this study is to offer an education-driven alternative by taking advantage of the CF to shed insight on the vital role that teachers could play in AL classes. This approach allows for a re-conceptualization of the teacher's role from an overlooked parameter as depicted in previous studies, to an orchestrator that translates the LA into insights to inform, enable, and motivate the learning cycle in their classes. Consequently, and in sharp contrast with the current quantitative slant, which produced inconclusive results, my open-ended research questions lend themselves to adopting a qualitative stance to inquiry by using exploratory verbs like 'how' and 'what' (Creswell & Poth, 2018). These research questions are drafted as:

1. How is AL being used to assist students in their transition to college-level mathematics?
2. In what ways does AL influence the practices of teachers and their approach to classroom instruction?
3. How can AL most effectively be used to optimize the classroom learning experience?

In the context of AL and its various applications inside the classroom, we need studies that examine its effectiveness from a different angle. That is, "a renewed understanding of what education requires" (Laurillard, 2013, p. 69) of this approach to learning. The section below explains how this study is designed, its epistemological basis, underlying philosophy, and rationale.

Epistemological Considerations

Contrary to the dominant positivist approach that we find in the literature around AL, the instructor's role deserves to be acknowledged and explored in subtle details. Having used ALEKS over many semesters in different classes, I felt compelled to tell the story of the instructors who use this approach in their classes and the challenges they encounter, and moreover, to recount how instructors use the LA provided by ALEKS to enable the learning cycle in their classes. To move beyond inconclusive results, the latter lens is crucial as it allows us to construct a deeper understanding of the instructor's role and this approach to learning. As such, this study is underpinned by an interpretive philosophical

assumption that warrants the use of a qualitative approach to inquiry. In doing that, I embrace the notion that "reality is socially constructed" (Mertens, 2014, p. 17) and aim to understand the "world of human experience" (Cohen, Manion, & Morrison, 2011, p. 17) through the viewpoints and perceptions of instructors involved in AL classes.

> [Qualitative research] is an effort to understand situations in their uniqueness as part of a particular context and the interactions there. This understanding is an end in itself, so that it is not attempting to predict what may happen in the future necessarily, but to understand the nature of that setting, what their lives are like, what's going on for them, what their meanings are, what the world looks like in that particular setting – and in the analysis to be able to communicate that faithfully to others who are interested in that setting…The analysis strives for depth and understanding (Patton, 1985, p. 1 as cited in Merriam & Tisdell, 2015, p. 29).

As such, the focus is on how these instructors interpret and make meaning of their experiences, and more importantly, on painting an image that directs our attention and extends our understanding of how these instructors use ALEKS in their classes – an aspect that has been vague in previous studies. Ultimately, these decisions will inform my choice of methodology and design in the following paragraphs.

To justify the choice of methodology and its fitness for purpose, the following should be considered. First, the majority of research originated in the USA, from a different context and culture. Second, ALEKS has been deployed and used in various ways, which depended on how institutions and implementors perceived this approach to instruction. For instance, ALEKS was used as a homework management system in some studies. Other methods of the deployment included ALEKS as an assistive or as a principal component of the course with varying degrees of instructor involvement. Added to that is the lack of evidence on how instructors use ALEKS and its LA to differentiate instruction in their classes. Given the variety of implementation strategies and taking into account the objectives of my research, a qualitative case study will be my choice of methodology.

Case Study Design

A case study has been defined as "an empirical inquiry that investigates a contemporary phenomenon (the "case") in depth and within its real-world context, especially when the boundaries between the phenomenon and context may not be clearly evident" (Yin, 2014, p. 16). The form of my exploratory research questions (how and why) and the focus on contemporary events over which I have no control (Yin, 2014) justify my approach to inquiry. The emphasis on current events and the ability to deal with multiple data sources like direct observations and interviews (to name a few) are unique strengths for a case study, as Yin (2014) confirms.

> The case is one among others. In any given study, we will concentrate on the one. The time we spend concentrating on the one may be a day or a year, but while we so concentrate, we are engaged in case study (Stake, 1995, p. 2)

In the above quote, Stake (1995) adds to our general understanding of the nature of this approach to inquiry through his emphasis on the 'one.' This is echoed by Merriam and Tisdell (2015) as well as Creswell and Poth (2018), who emphasize that the unit of analysis is the defining characteristic of a case study, not the topic under examination. What follows, then, is the importance of defining the 'case' and the unit of analysis as it will help bound my study (Creswell & Poth, 2018; Stake, 1995; Yin, 2014). Stake (1995) used the Greek symbol Θ (theta) to signify the 'case' denoting its importance and stressing that "Θ is likely to be purposive, even having a "self." (p. 2). My unit of analysis – Θ, therefore, will include a multi-national group of instructors who teach the only course at the college that uses ALEKS as a principal approach to classroom instruction. In teaching this semester-long foundation course, these instructors are responsible for equipping students with the fundamental mathematics knowledge they need to pursue their programs of choice. This unique group of instructors who teach the same course and use a similar approach are spread across many campuses and geographical locations within the parent institution.

Bounding the case in this manner will allow me to differentiate between internal data about the direct topic of investigation (the phenomenon) and external data that is related

to the context (Yin, 2014), and prevents my case study from going astray (Creswell & Poth, 2018). To qualify as a case study, the phenomenon under investigation should be "intrinsically bounded" as Merriam and Tisdell (2015, p. 47) assert. The finiteness of the number of people, interviews, and observations were examples given by the authors to directly assess whether the case is bounded enough: otherwise, an alternative approach should be chosen. These principles will be visible and emphasized throughout the research design, sample selection, and data collection instruments.

Following on, and having identified the focus and the intent of the study (Creswell & Poth, 2018), lies the importance of choosing the case study research design. Adopting a specific design, according to Yin (2014), is not a necessity, but advisable to strengthen the case and make it manageable. There are several approaches and procedures for designing a case study (Creswell & Poth, 2018; Merriam & Tisdell, 2015; Stake, 1995; Yin, 2014). Merriam and Tisdell (2015), for example, identify three domains: (i) historical case study (such as the history of an organization); (ii) biographical (studying one individual); and (iii) comparative or multicase (collecting data from multiple cases or sites). In a 2x2 matrix, Yin (2014) makes the distinction between two primary case study designs, the single case, and the multiple cases. Each of the two models will then branch to holistic (single-unit) or embedded (multiple units).

Echoed by Creswell and Poth (2018), Stake (1995) distinguishes between three main types or designs: (i) an intrinsic case study where the attention is given to the uniqueness of the case itself; (ii) an instrumental case study where we might have "a research question, a puzzlement, a need for general understanding, and feel that we may get insight into the question by studying a particular case" (p. 3); and (iii) a collective or multiple case study. The researcher's approach to design, Stake (1995) suggests, should be governed by the intention to "maximize what we can learn" (p. 4), as well as being attentive to issues related to access and resources. Stake (1995) also noted that "often we cannot decide" (p. 4) but emphasizes that the distinction among the three kinds of case studies will affect the methods used. Because of my genuine interest in how instructors use ALEKS and since my research questions seek out an understanding of how these

instructors use ALEKS to enable the learning cycle in the classroom (the bounded unit of analysis), my approach is better categorized as instrumental.

It is often said that the findings from a single case study may not often be generalizable (Cohen et al., 2011; Merriam, 2014). The same can be said about a single experiment, Yin (2014) asserts, as generalizations "are usually based on multiple sets of experiments that have replicated the same phenomenon under different conditions" (p. 20). However, findings from a single case can constitute, with other case studies, a vessel of data that can contribute to greater generalizability, according to Cohen et al. (2011). That being said, my case study will shed empirical light on the critical role of instructors in ALEKS classes and will provide an alternative angle that merits more attention in future investigations within the AL landscape.

Having discussed the aim of the research study and chosen the appropriate design, it is now pertinent that I describe the methods used for collecting data and consider the selection of the sample.

Data collection

> The design of a research study is "*a logical plan for getting from here to there*, where *here* may be defined as the initial set of questions to be answered, and *there* is some set of conclusions (answers) about these questions. Between *here* and *there* may be found a number of major steps, including the collection and analysis of relevant data" (Yin, 2014, p. 28, emphasis in original).

Building an in-depth understanding and painting a vibrant image of the case under investigation requires an array of qualitative data collection methods. Yin (2014) distinguishes between six forms of data collection methods: documentation, archival records, interviews, direct observations, participant-observations, and physical artifacts. When choosing the appropriate techniques, Stake (1995) reminds us that Θ (the bounded unit of analysis) should always be the focus. With that in mind, and in order to attend to the case study at hand in the best way possible, I decided to rely on interviews, direct observations, and documentary information, with the main emphasis on the first two, to

paint an image of how this specific group of instructors uses ALEKS at a HEIME. In case studies, the aforementioned methods are considered significant sources of evidence (Stake, 1995; Yin, 2014). Together, these data collection methods will be used to triangulate and substantiate the findings and eventually converge to convey a comprehensive understanding of the case being studied (Baxter & Jack, 2008; Merriam & Tisdell, 2015). As such, the three sub-sections below will tackle each method separately.

Interviews

In line with the exploratory nature of this qualitative case study, its research questions, and design, the aim is to construct an in-depth understanding of the role of instructors that use ALEKS in their classes. Being one of the widely used methods of data collection that allows the construction of meaning between the interviewer and interviewee, an interview "attempts to understand the world from the subjects' point of view, to unfold the meaning of their experience, to uncover their lived world" (Brinkmann & Kvale, 2015, p. 3). Along the same lines, Cohen et al. emphasize that an interview is a "social encounter, not simply a site for information exchange" (2011, p. 410).

There are many types of interviews that can be identified from different texts and sources, and each fits a specific purpose. These can be described along a continuum of "relatively structured" to "relatively unstructured" interviews (Brinkmann, 2013, p. 19). In qualitative case studies, however, Stake (1995) and Yin (2014) speak of interviews as guided conversations rather than rigid queries due to the unique viewpoint and experience of each interviewee. Taking these recommendations on board, I intend to use a less structured format that is situated somewhere in the middle of the structured – unstructured continuum (Appendix 1). Semi-structured interviews followed by probes, I believe, will enable me to focus and tackle different angles deemed central to my case study. Furthermore, the flexibility inherent in the semi-structured format permits the interviewees to elaborate on their experiences dealing with ALEKS and shed insight on the challenges they encounter in the classroom. These interviews will be audio recorded using two devices, a smartphone application, and a laptop to ensure that no data will be lost in case of malfunction. Transcribing the data obtained can be time-consuming and thus considered as a significant challenge for the interviewer. Using online specialized

professional translation services to transcribe the data can be efficient in mitigating the latter challenge. As such, I used the expert services of a commercial company (Transcribe*Me!*) to transcribe my interviews.

Like other data collection methods, lies the risk of subjectivity or bias, and the flexibility in semi-structured interviews can also be viewed as a lack of reliability (Cohen et al., 2011). These challenges, Yin (2014) suggests, can be moderated by corroborating the data obtained by interviews with information from other sources. Direct observations, therefore, will be used to supplement the evidence obtained from interviews.

Direct Observations

Direct observations, as an approach for data collection, presents itself whenever we investigate a contemporary phenomenon in a real-world context (Yin, 2014). Obtaining additional information about how instructors use ALEKS in their classes through direct observations provides an opportunity to better understand the case study. Given that the use of multiple sources of evidence is one of the principles of data collection in case studies (Yin, 2014), direct observations will most likely improve the quality and the interpretation of data collected through interviews (Musante & DeWalt, 2010). In fact, one of the main advantages of using multiple sources of evidence is the "development of *converging lines of inquiry*" (Yin, 2014, p. 120, emphasis in original).

Creswell and Poth (2018) distinguish between four observation types, the complete participant, the participant as an observer, the nonparticipant observer, and the complete observer. The latter types vary according to the degree of engagement of the observer with the people and activities being observed. Along that continuum, and being an outsider of the group under study, I will assume the role of a nonparticipant observer. Taking field notes without any direct involvement in an ALEKS class will allow me to complement the data obtained from my interviews and will enable the construction of an in-depth understanding of the phenomena under investigation.

The observation sheet that I developed was informed by the six learning domains that Laurillard (2013) identified as a basis for the CF (Appendix 2). When in class, I organized what I observed in two categories. The first tackled the actions enacted by the

instructor and the second, according to the six learning domains. In doing that, I was able to direct my observations towards having an excellent idea of how an ALEKS session runs. Furthermore, the collection of observations allows the formulation of innovative approaches to optimize the classroom learning experience. Observational data will complement the data obtained from interviews and will enable the construction of a vibrant image of the case study. Of course, this approach to data collection is not challenge free as I observed only one session of ALEKS for every participant, which depended on their approval. In this single session, instructors and students might not act the same in my presence, and this might affect the observation outcomes despite the steps that I took to explain that I was only interested in how an ALEKS session ran. However, direct observations, along with interviews, will help in obtaining a more accurate image of the case study at hand.

Documentation

Augmenting the evidence obtained through interviews and observations by collecting documentary information is highly advisable, especially in a case study (Yin, 2014). As such, a limited number of organizational documents will be collected and analyzed. Familiarity and selectivity for Bell (2005) are essential criteria for the researcher's approach to documentary data collection. Being a faculty member in the institution is advantageous as I will be able to select documents that are directly related to the topic under investigation. The materials that I will extract using the institution's course inventory management web page explain how ALEKS is being set up to be used as an integral part of the classroom instruction. These are the course syllabus and outline, and the Foundations Program catalog. These two prominent documents contain the rationale behind the use of ALEKS, the teaching and learning strategy, delivery framework, assessment strategy, and the program learning outcomes. One of the significant advantages of collecting documents, according to Merriam and Tisdell (2015), is that these are stable and not affected by the presence of the researcher. However few, together with the data obtained from interviews and observations will enable the construction of an in-depth description of the case study.

Now that I have justified the choice and rationale for the data collection methods, I turn to the selection of the sample for the case study. I will present and discuss this in the following section.

Sample selection

Informed by the established design of the case study, its type, and unit of analysis, this section will identify the criteria and techniques that I will use to select my sample. One of the sampling techniques in qualitative research is purposive sampling, where the researcher chooses a sample for a "specific purpose" (Cohen et al., 2011, p. 156). The latter, according to Merriam and Tisdell (2015), will enable the investigator to "select a sample from which the most can be learned." (p. 91).

As explained in previous sections, my study lends itself to explore how a specific group of instructors in a higher educational institution in the Middle East (HEIME) deal with ALEKS as the primary approach to instruction. For the purpose of obtaining in-depth information on the role of instructors and the classroom experience, my sample will include those who teach the only mathematics course that uses ALEKS and have been in the system for a minimum of one semester – the bounded unit of analysis. Having been at my workplace for the past ten years, I know that the first semester represents a steep learning curve for new instructors. Being acquainted with the demands of the system and our students is not an easy task, let alone the use of a challenging AL platform like ALEKS for the first time. Allowing one semester for a new instructor to get to know the institutional culture and 'what' ALEKS does, I believe, will improve the likelihood to "acquire in-depth information from those who are in a position to give it." (Cohen et al., 2011, p. 157). In making that distinction, I aim to "fence in" (Merriam & Tisdell, 2015, p. 45) my study around knowledgeable people who constitute the group that can shed insight on the topic under investigation.

This case study will be conducted at a HEIME, across its seventeen different campuses, and outside the department where I currently serve. These campuses are spread across six major geographical locations in the country. The nearest location is 15 kilometers from my campus, and the farthest is 300 kilometers away. The targeted multinational group of instructors who teach the only course that uses ALEKS are part of another department

with whom I share nothing other than being a colleague at the same parent institution. Access to this unique group, I believe, will be challenging, given the different geographical locations, their busy schedules, and workload. Central to my thinking at this point is the question of how I can have access to this group, being the outsider who is planning to interview them and observe how they use ALEKS in their classes. Thus, my choice of the snowball sampling technique as one of the most common typologies of purposive sampling (Cohen et al., 2011; Merriam & Tisdell, 2015). Snowball sampling allows the researcher to rely on a small number of individuals that satisfy the criteria of their research, which are, in turn, able to identify other respondents that qualify as well (Cohen et al., 2011).

With that in mind, I developed a plan to approach three instructors who work on the same campus as I am to be my potential candidates and informants. These instructors have a longstanding history within the institution and have been using ALEKS for many semesters, thus are qualified as possible candidates and informants for the study. Given that our campus has the largest population of students and instructors, it will be an appropriate starting point for my research.

Through my research, I aim to make visible the critical role of the instructor in ALEKS classes, and it is of great importance that my potential candidates be aware of this fact. Having the luxury of discussing the aim and scope of my research in person with the three instructors who work on the same campus as me will increase the chances of endorsing my study to other instructors. Therefore, I explained in great detail the aim and scope of my research to each of the three instructors separately and allowed them one week to decide whether they would like to be part of the study or not. In doing that, each potential respondent and informant had the privacy and the time to discuss the research study with me and ask questions freely.

Regardless, I also asked each of them if they can identify potential candidates that meet the requirements of the study from other locations within the parent institution. The names, email addresses, and geographical locations of these instructors can be easily retrieved from the institution's web page, which permitted the compilation of a list of

potential candidates. Fortunately, the three instructors that I had approached fully supported my research and agreed to be my candidates and informants.

Initially, I was hoping to interview and observe the maximum number of instructors that qualify from a pool of twenty that are teaching across different campuses. Since it was mid-semester by the time I received approval to conduct my research, some instructors preferred not to participate due to their busy schedules. Also, the time constraints and logistics involved in traveling and negotiating the interview and observation schedules with different instructors, while maintaining a regular teaching load of four courses proved challenging. The latter required a considerable amount of time to drive between campuses and overnight stay in hotels. That being said, I managed to interview ten candidates and observe seven ALEKS sessions. Next, I turn to the data analysis section that explains how my data will be approached and analyzed.

Data Analysis

One of the most important steps before the data analysis phase is the proper management of the data (Creswell & Poth, 2018; Merriam & Tisdell, 2015; Yin, 2014). Creating a database to organize data is crucial for easy access and retrieval of audio recordings, transcribed interview files, and observations. These will be stored electronically using my personal laptop and a secure cloud storage service (Dropbox). This way, I ensure that my files are password protected and have multiple layers of security. I also used a computer-assisted qualitative data analysis software (NVivo), which, according to Creswell and Poth (2018), is a method that has become popular in qualitative data analysis. Because I have multiple sources of evidence, I wanted a software that has the ability to combine all my sources in one place for easy retrieval. NVivo visually represents the relationships among codes and themes via its concept mapping feature, which is an aspect that appealed to my learning style.

> The page does not write itself, but by finding, for analysis, the right ambiance, the right moment, by reading and rereading the accounts, then understanding creeps forward and your page is printed (Stake, 1995, p. 73).

In writing about the art of data analysis and the search of meaning, Robert Stake lays it out beautifully in the quote above. This is a process through which we find answers to our research questions, and that "involves moving back and forth between concrete bits of data and abstract concepts, between inductive and deductive reasoning, between description and interpretation." (Merriam & Tisdell, 2015, p. 172). To achieve rigor within the analysis, I will follow the six-phase process for reflexive thematic analysis (TA) put forth by Braun and Clarke (2006).

Reflexive TA for Braun, Clarke, Hayfield, and Terry (2019) is a school of thought that emphasizes contextual meaning, multiple realities, and celebrates the active role of the researcher in knowledge construction. The flexibility inherent in reflexive TA and its ability to address different research questions (Braun et al., 2019) are reasons that contributed to the popularity of this analytic method. The fact that reflexive TA has been used for case study research (Cedervall & Åberg, 2010; Manago, 2013) and the latter reasoning show that this approach to analysis sits comfortably within the boundaries that I have set for my research study.

Interviews

In the six-phase process (Braun & Clarke, 2006; Braun et al., 2019), patterns are identified through a rigorous procedure of data familiarization, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and reporting. The semi-structured interviews were analyzed inductively (bottom-up) using a qualitative data analysis software (NVivo) so that the codes and themes were guided by the content of the data. As a first-time user, I had to familiarize myself with the software, its capabilities, and its limitations. I used UOL's repository and YouTube to learn how to import, analyze, and store the data from my interviews and classroom observations.

The first phase of the thematic analysis process involved reading and rereading the accounts, establishing a personal connection, and making casual notes on the sides as advised by Braun et al. (2019). In this phase, I went through every single document, read and reread as if it was my first time being exposed to these documents. This allowed me to get to know my data again, note interesting features that are pertinent to my interviews, and make connections between participants.

The second phase was more systematic and represented the subtle shift from casual note-taking to a more formal and rigorous meaning identification throughout the dataset. In this phase, and according to Braun and Clarke's (2006) advice, I coded for as many themes and patterns that I observed, one interview at a time. There were many instances where I felt slightly intimidated by the volume of the data I had. I coded, recoded, and altered my approach while I always reminded myself to trust the analysis method that I was using. These doubtful moments did not take long to disappear, and after coding the first three interviews, I felt more conversant with my data.

Following on, I continued to the construction of themes, keeping in mind that "Good themes are those that tell a coherent, insightful story about the data in relation to the research question." (Braun et al., 2019, p. 854). In phase three, I was able to see emerging patterns and started collating similar codes together in search of potential themes. I trailed Braun and Clarke's recommendations for every single phase as I plowed through my dataset. Next, I started refining my themes as phase four specified. Some themes collapsed in favor of other themes, and this is where I began marking the distinctive features of my themes. This phase comprised two levels, reviewing and refining themes. In the former, I reread the data under each theme to ensure it formed a coherent pattern. In the latter, I considered the validity of my themes in relation to the whole dataset. These two levels allowed the refinement of my thematic map, which will be presented in the next chapter.

The 'define and refine' in phase five is an additional step to ensure consistency and coherence and determine the defining characteristics of the data within each theme. This allowed me to capture the story that each theme told and put things into perspective for the overall story in relation to the research questions in this study. Phase five was concluded when it became confident that I was able to describe the content of each of my themes in a couple of sentences, as Braun and Clarke (2006) suggested. With this phase concluded, I started producing my findings.

Direct observations

The same approach to TA was used to analyze classroom observations. Unlike interviews where I wanted the data to guide my codes and theme production, my observations were analyzed deductively, allowing the theory behind the CF to guide the coding process. In that, the six learning types from the CF acted as initial codes that were ready to be tagged to the observational data. For example, I marked instances where I felt learning through acquisition was happening or when learning through practice was initiated by instructors. Also, the different learning cycles in the CF were used for instances where I felt instructors, students, and peers were engaged in certain activities in the classroom.

Classroom observations will play an assistive role to the data extracted from interviews with instructors. I will be asking about the classroom experience and the differences between an AL approach and a traditional approach. Instructors will be asked about their roles and the importance of the LA from ALEKS. Thus, coding for the six learning types will complement the insights gained from the instructors. Because the CF offers an education-driven approach to evaluate any form of technology according to what education requires of it, it is only logical to categorize what I observed in the classroom under its six learning types. Using the CF as a theoretical framework and a base for generating my initial codes allowed me to shed insight on the critical role that teachers could play in AL classes.

Documents

The two documents that I extracted from the institution's course inventory management web page explained how ALEKS was being set up to be used as an integral part of the classroom instruction. These two prominent documents contained the rationale behind the use of ALEKS, the teaching and learning strategy, delivery framework, and mapping to the program learning outcomes. These two documents were used to provide the necessary background information about the immediate context.

Ethical Considerations

"Ethics has to do with the application of moral principles to prevent harming or wronging others, to promote the good, to be respectful and to be fair" (Sieber, 1993, p. 14 as cited

in Sikes, 2004, p. 16). I have a firm belief that research is a noble act that should be approached under the above guidelines. Prior to conducting the study, I examined Federal and institutional policies relevant to conducting research studies at my workplace. This helped me in drafting my proposal in a way that explains in fine detail the work I plan on doing with the instructors and the impact of my research. I've also talked with my immediate supervisors about my project and future plans for improving the quality of instruction using AL at the institution and elsewhere – these are gatekeepers, according to Creswell and Poth (2018). Having been at the institution for more than ten years, I knew that the process of obtaining approval for research was lengthy, and I prepared myself for it. Eventually, and after four months, I received ethical approval from my institution to go forward with my research study. A couple of weeks after, I was able to obtain consent from Liverpool University Virtual Program Research Ethics Committee (Appendix 1).

In preparation to conduct the study, I made sure that my participant information sheet contained enough information about the type and aim of the study so that my participants were well aware of the different aspects of the research. For example, I explained that instructors could opt for an interview only and it is not obligatory to have a classroom observation before the interview if their time does not permit, or for any other reason they might have.

This case study was conducted at a HEIME, across its different campuses, and outside the department where I currently serve. Faculty members who wish to participate were part of a separate department with whom I shared nothing other than being a faculty in the same institution. Although access to the contact information of all instructors was available from the institution's online repository, I was worried about the logistics of setting the interviews and observations at different research sites. These ranged from 15 kilometers to 300 kilometers of traveling at times. Also, whether instructors will allow enough time for the research, given their busy schedules and workload. Strategically, I decided to use the snowball sampling technique and relied on a small network of instructors that I know professionally and are able to identify other candidates in different research sites.

The three primary informants and participants in the study work on the same campus as me. These are instructors with whom I have a professional relationship and a similar interest in AL platforms and their potential. I approached each separately and confidentially through an email containing the participant information sheet (Appendix 2), consent form (Appendix 3), and the authorization letters from HCT and UOL. In my email, I briefly explained why I am contacting them and referred to the attached documents for more information about the study and emphasized that these emails and attachments were to be treated confidentially. Upon their initial approval, I asked each of them for a brief meeting to decide on the logistics and referral of other potential candidates.

In speaking of the power relationship between the researcher and researched, Merriam et al. (2001) bring to our attention that awareness and negotiation are essential. Thus, I left it to each participant to allocate the preferred date, time, and venue of the observation and interview. This was the start of the first round of data collection.

The second layer of data collection comprised of the referred individuals from the primary informants. The exact same procedure was followed by sending individual emails to the potential participants and asked them for their participation. To encourage instructors to step up and participate in the study, I mentioned the name of the person who referred the potential participant throughout the different phases of data collection. With this in mind, it was anticipated that some of the referred names from the 1st layer would be repeated in the 2nd layer. Therefore, a third layer was needed to reach the maximum number of participants. This point marked the start of the second round of data collection.

Although the same procedure was followed, and despite sending a couple of reminder emails, I received approval to conduct an interview only from two instructors as their time did not permit a classroom observation. It was towards the end of the semester, and they were not comfortable with classroom observation. At this point, I started the third round and concluded the data collection phase of my study.

During the time for the interviews, I re-emphasized for each candidate that I will strictly adhere to the requirements of HCT and UOL, and I will consider the ethical and moral

implications at the various stages of the research. Among these, gaining informed consent, protecting the participants from any harm or deception, protecting their privacy, anonymity, and confidentiality. As for the classroom observations, each instructor explained to their students that a researcher would be attending the session to observe how the classroom ran using ALEKS, then invited me to attend the session. That being said, I cannot entirely prevent some aspects of social desirability (Lavrakas, 2008) from intervening in how my participants responded to my interview questions and during class observations. Social desirability, according to Lavrakas (2008), "is the tendency of some respondents to report an answer in a way they deem to be more socially acceptable that would be their "true" answer" (p.2).

Summary

The aim of this study is to provide an educational-driven approach to researching AL by capitalizing on the CF as an evaluation tool. This study will make visible the crucial role that instructors play in ALEKS classes. As such, this exploratory study undertakes an interpretive philosophical assumption that warrants the use of a qualitative approach to inquiry. This stems from my epistemological belief that "reality is socially constructed" (Mertens, 2014, p. 17). The focus, therefore, is on how these instructors interpret and make meaning of their experiences, and more importantly, painting an image that directs our attention and extends our understanding of how these instructors use ALEKS in their classes.

The rationale behind the adoption of a qualitative case study approach was highlighted and explained in detail. Semi-structured interviews, classroom observations, and documents, as data collection methods, sit comfortably within the boundaries that I have set for this study. The inductive-deductive approach to thematic analysis followed Braun and Clarke's (2006) guidelines to the minute details. Lastly, the steps for recruiting the participants in this study were described with emphasis on the ethical and moral implications at the various stages of the research.

The next chapter will offer an account of the main findings which emerged from the data analysis process.

Chapter 4

Findings

Introduction

In an attempt to address the significant role that a teacher can play in classes that use AL as a principal approach to teaching and learning, this chapter offers an account of the main findings which emerged from the data analysis process outlined in the previous chapter. This qualitative case study provides an education-driven approach by taking advantage of Diana Laurillard's CF to shed insight on the vital role that teachers could play in AL classes – an aspect that has been overlooked in previous studies. Reiterating, the research questions that guided this study are drafted as:

1. How is AL being used to assist students in their transition to college-level mathematics?
2. In what ways does AL influence the practices of teachers and their approach to classroom instruction?
3. How can AL most effectively be used to optimize the classroom learning experience?

To that end, the six phases in Braun and Clarke's (2006) thematic analysis approach allowed the formulation of overarching themes and sub-themes that assisted in answering the research questions for this study. Phase five in Braun and Clarke's (2006) guide for thematic analysis aims to identify the essence of each theme, determine what aspect of the data it captures, and write a description that tells a story of each theme. In following this phase, five different themes and fifteen sub-themes were identified. Together, they will be used to deliver an account that tells the story of a group of instructors that use ALEKS as a principal approach to learning.

To set the scene, it is vital to provide an introductory account of the course that uses ALEKS as an approach to learning, the instructors involved in teaching this course, and their students' profiles. As such, the chapter starts with some background information to assist the reader in understanding the immediate context of the study. Following that, the emergent themes and sub-themes will be discussed in detail. The chapter concludes with

a section that relates the findings to the research questions, and a summary of the key findings.

Background

Specific to the multiple research sites, the campuses are part of a large Federal higher education institution in the UAE. The instructors and students are part of the General Education program at the colleges, which aims to enhance academic and personal development and facilitates the transition of the students to their programs of choice. The different courses under this program are expected to promote a student-centered approach and foster independent and lifelong learners (*GARD Catalogue*, 2019). The students enrolled in this program are those who were unable to achieve the mathematics and English language requirements that allow them to get direct admission into the bachelor's study track.

Course overview

This research study is related to one of the mathematics courses within this program, which is a preparatory course that "focuses on developing proficiency in basic algebra and quantitative reasoning to equip students with the math skills to succeed in the BAS program of their choice" (*Course Syllabus*, 2019). The course's five learning outcomes should provide the students with a strong conceptual understanding of mathematical concepts, procedural fluency, and applied skills. Instructors in this course are expected to encourage active learning and provide individualized feedback for their students on a regular basis, as indicated in the course's teaching and learning methodologies section. The students enrolled in this course should have a personal laptop and are required to work independently outside the classroom for a minimum of 5 hours/week.

The AL platform, *ALEKS 360*, which includes a fully integrated eBook, is used to cover the course's requirements. As such, the pie chart in ALEKS is divided into five different sectors, which consist of a total of 231 topics that are categorized according to the course's learning outcomes. ALEKS is set up as a master course across all campuses for a period of 16 weeks with two 2-hour sessions per week. The use of a shared teaching and learning model and assessment is expected across different campuses.

Instructors' profiles

The use of the snowball technique yielded ten interviews and seven classroom observations. The participants involved in this study are considered highly experienced instructors who have a longstanding history in the colleges and have been teaching the same preparatory course before the inception of ALEKS in 2016. This means that they have been using ALEKS as a primary approach to learning in their classes for the past four years.

To establish rapport between the interviewer and interviewee and allow an in-depth conversation during the interview, the first question was designed to reveal important background information pertinent to the profiles of the instructors involved in this research study. This information acts as a springboard that allows the reader to obtain an initial idea about the instructors' past learning experiences and delve into the main findings. Adjacent to that is the researcher's intention to link the past and the present in order to provide an answer for the third research question.

Involved in this study were seasoned mathematics instructors who have been in the teaching profession long before the inception of ALEKS at the colleges in 2016. The vast majority hold a master's degree in mathematics or education and have been teaching for over a decade. These instructors had a similar learning experience that was dominated by a common traditional, teacher-centered approach during their school and college years. One of the instructors smiled and said that "on a larger scale…most of our classes were instructional-based" (P7). It was "very traditional and conventional type of studying, learning, and teaching takes place" (P5), where "Math teachers tend to stand at the board and write the solutions to the homework that we did" (P2), "but I think back when I was that age, I think that was kind of the common approach" (P3).

Although from different countries and cultures, this multinational group of instructors shares a passion for teaching, as many indicated. Despite their traditional learning experiences, one of the instructors mentioned, "I like education, and I like teaching. I decided to be a doctor, but I changed and decided to go for something very interesting for me" (P9). When she was doing her master's degree, one of the instructors did some tutoring to help finance her studies. She noticed that her students were happy with her

approach and decided to become a teacher (P8). One of the male instructors who was influenced by his math teacher's attitude in school said:

> So like my poor father because I was good at math, and I like math and all of that, wanted me to go into engineering. And, no, I had no interest in being an engineer. I just wanted to be a teacher. (P3)

For a couple of instructors, however, it was the convenience of the short working hours that drew them into teaching. For these instructors, the common denominator is making a difference through their contribution to their students' learning.

> what motivated me is…you are responsible to the students. You don't look into whatever nonsense…whatever happens so many things. And when you look at the students, you feel so happy that you've done something. (P8)

Another said, "I teach my students how to learn. Not only this is the solution, but how to discover." (P6). One of the most important things is:

> To be able to break things down and explain things, and make it easy for students to understand, which I think is a big skill that good teachers have. They can teach to the level of the students in front of them" (P3)

Being passionate about teaching and trying to make a difference, for another, is "to try innovative ways of teaching…to inculcate in my classroom so that the students get interested all of the time" (P1).

Because of their extensive experience in teaching mathematics under the General Education program and their knowledge of the students' previous learning experiences over the years, these instructors seem to have formed a preliminary idea about their students' profiles. Their perceptions will be highlighted in the section below.

Instructors' perceptions of students' profiles

During their time at the college, many instructors indicated that the majority of students lack the basic English and mathematics knowledge, and study skills. Evidently, these students were placed in this program of study because of their weak educational

backgrounds. One instructor explained that teaching becomes more challenging when students come with “a low-level English and maths skills. Or if they have behavioral problems” (P7). Another mentioned that “language would be my first concern because that's the greatest barrier for the students” (P10). Unfortunately, the language barrier will affect the students’ performance in mathematics because the course is taught in English as one instructor indicated:

> When my student sees numbers, they're okay. But when they see words, they're totally lost, like, "What happened, Miss?" Because they are second language learners; they don't come up with very good English skills. (P5)

Other instructors mentioned the students’ weak study skills and shortcomings in their past learning experiences. One instructor claimed that “their learning culture wasn't so good. So, they were not hard workers, I would say. Okay. They wanted everything on a plate, like spoon-feeding” (P1). Another instructor said, “even with the ones who got the language, they still have the barrier maybe of reading” (P4). These beliefs concur with the literature related to the English language, mathematical skills, and past learning experiences (Dahl, 2011; Hatherley-Green, 2012), as well as the students’ reading (Daleure, 2017; Shannon, 2003). With other courses in the program, this mathematics course will be expected to work towards addressing the learning challenges mentioned earlier.

Now that the immediate context has been exposed, it is now necessary to delve into the essence and report the main themes and sub-themes that emerged from the interviews with instructors and the classroom observations. Figure 4 provides a summary of the thematic map that will guide the rest of this study. Following that is an explanation of each of the themes and sub-themes in the next section.

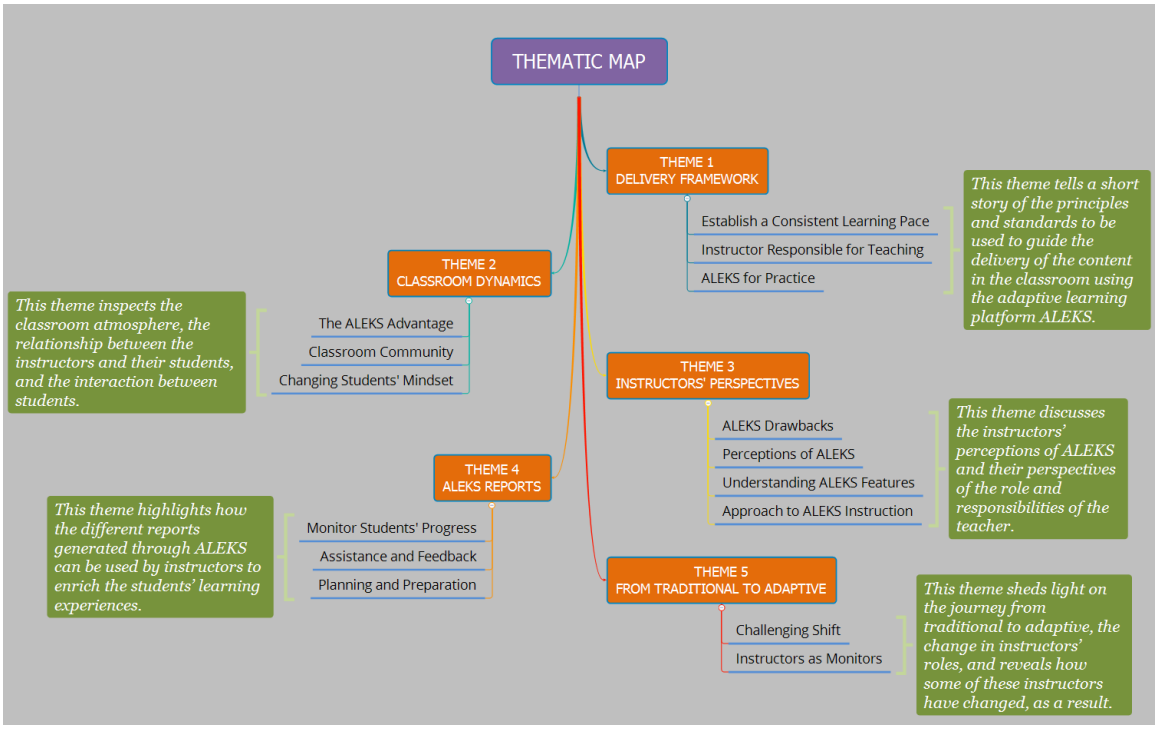

Figure 4. A summary of the thematic map

Theme 1: Delivery Framework

> What we found is the best thing was, like I just said, we designed worksheets for each LO, which has a couple of examples of each topic. And in a particular class, we would take PowerPoints may be up to 10 topics. And where the teacher will explain one, and then there's examples for the students to solve. And they write their notes, they highlight key vocabulary and then, when we finished the presentation, the students work ideally on those topics. (P10)

The delivery framework theme tells a short story of the principles and standards to be used to guide the delivery of the content in the classroom using the AL platform ALEKS. This theme emerged when it became apparent that the ‘unspoken rule’ among instructors is to allocate a certain amount of time for learning through acquisition and use the remaining time to learn through practice in a given ALEKS session. These two learning types were identified by Diana Laurillard’s CF. Important to say that the course syllabus does not specify an approach to instruction using ALEKS, and it is left to the discretion of the instructor to choose whatever style they see fit.

Thus, the apparent consensus among instructors was to not use ALEKS as a standalone due to the students' weak educational background. As one of the instructors indicated:

> the delivery framework should be like that, "otherwise, it wouldn't work. Because it hasn't worked before like when we started, they said only ALEKS classroom. So, it didn't work that way. But when we started like this, it started" (P1)

Another added, "So if you just go and depend only solidly on ALEKS, you wouldn't have a good outcome of that" (P4). There were attempts before to run the classroom using ALEKS for instruction and practice without the intervention of the instructor, but this approach was not successful. The delivery framework, however, reveals three distinctive features of the findings. First, establish a consistent learning pace to manage the content. Second, the instructor is the one responsible for teaching the material. Third, ALEKS is used only for drilling and practising.

Establish a consistent learning pace

> We keep a short-term goal in the beginning of the lesson, for them to cover, the objective of the classroom, to cover these many topics. When all the students achieve that, I feel that this is really great, and I see with my own eyes. (P1)

To achieve mastery of 231 topics throughout the semester and have enough room for assessment, eight out of 10 instructors believed in breaking the content into manageable chunks. This was done by setting a daily or weekly target for students to achieve. P1 felt that consistency is convenient for both the instructor and the students since the results can be seen directly. Mastery learning is an approach that focuses on the vital role of continuous assessment and feedback in education. According to Slavin (1987), the essential characteristic of mastery learning demands a certain level of performance in a particular concept before moving to the next idea. In ALEKS, students are required to solve 5 different variations of a specific topic before moving on to the next. In between, ALEKS assigns knowledge checks to ensure that mastery has been achieved.

One instructor observed, “I was helping one teacher, okay? The students were solving 23 topics. It's like you put them in the ocean. No. In this class, I'm going to cover only 10. So, this is the 10.” (P6). This instructor was offering advice to her colleague that assigning 23 topics for a given session will be too much for students to handle. The students will be overwhelmed and discouraged when they cannot achieve the target. She added, “So like yesterday we covered eleven, today we cover three, tomorrow eight. That's it.” (P6).

Another instructor gave a different reason in favor of establishing a consistent learning pace. He mentioned, “I always emphasize to my students that it does not matter that you finish your pie quickly because the knowledge check will decrease your score” (P9). This instructor claimed that when students worked quickly to cover a large portion of their pie, they won’t be able to retain the information for long. Consequently, the student’s pie score will decrease because ALEKS assigns a knowledge check on a regular basis to make sure that the concepts learned are retained.

That being said, the remaining two instructors, P2 and P3, had a different approach to instruction and content management using ALEKS. Although P2 seemed to have a weekly target in mind, she knew that her students have varying abilities, and are on different learning curves. She asserted:

> I open up the pie. They can go where they want. It's circular learning, so they should meet the easiest topics for each subject topic as they go. And I think that's good for them for their freedom, initially. (P2)

P3 took a similar approach and stressed, “let the students interact with the program. That's the whole idea…It designs the learning to the needs of the student, not to your needs to try and get or have to cover all of these questions.” The views of the latter two instructors will be made visible in subsequent themes when the direct instructor’s role is discussed in more detail. For the majority, however, establishing a consistent learning pace during class gives rise to another sub-theme. That is, the instructor is the one responsible for the delivery of the content.

Instructor responsible for teaching

> So, if we have two different types, okay? Some of the teachers they said what? independent learning, read the explanation, if you have any questions, come to me. And they were not learning. Okay, for me I do not believe with explanation. That's why I want to explain my way. (P6)

There is a common belief that P6 shared with many other instructors. That is, the delivery of the content is the sacred responsibility of the instructor. Although ALEKS has embedded videos and explanations to help students understand whatever concept they attempt, P6 maintained that the students of those instructors who relied only on ALEKS and used it as independent learning in their classes did not learn. Interestingly, this argument revealed two diametrically opposite approaches to instruction using ALEKS. The responsibility falls back on the instructor to deliver the content for the first approach, while the second is describing the instructor as a spectator that allows ALEKS control over the delivery of the material. Does it have to be one way or the other? Subsequent themes will cast light upon these opposing views.

Likewise, P5 feels that "We all share; it's a common role. So, the goal is common for the student to get the knowledge that the teacher wants to give them." There are few students who have the ability to progress on their own and, "most of the time, like 80% of the students fall back on the teacher with a little bit of traditional" One of the instructors adds, "I am the base. I lead them through the process." (P7). In a classroom where students are on different learning curves from the beginning of the term, this seems like a traditional approach to instruction. A possible explanation for that outdated approach in a course that uses AL is related to the involved students' profiles, as another instructor explained:

> It's not very easy to be done without the role of the teachers because I told you there is always an explanation there, but most of the time they are not able to follow the explanation. Okay? So, then the teachers are explaining. (P8)

Learning through acquisition, according to the classroom observations, lasted between 20 to 40 minutes, depending on the content and instructor. There was no uniformity in the time allocated for direct instruction in ALEKS classes. For the majority, however, the instructor is responsible for the delivery during that time. What happens in the remaining time gives rise to the last sub-theme in this category.

ALEKS for practice

> For our lesson today. Okay, they started with building up their pie. Okay? And different topics and I will help all of them. Then stop everything. Get that concept. Now open your Aleks. Apply whatever you have learned now. Okay. Show me the full mark now spread. Go back to your pie again. That's my strategy in teaching. (P6)

This quote summarizes the three distinctive features of the delivery framework theme. During the classroom observation, P6 maintained a tight grip by assigning a target of 10 topics that the students must achieve before the end of the session (100 minutes). When P6 announced the start of the explanation, her students knew that they had to close their laptops and listen. Twenty minutes later, the students fell back on ALEKS to practice the concepts taught. While they practised, P6 offered help for those who needed it and encouraged others to keep up the pace and finish building their pie scores for the day.

P5 argued, "it's basically drill and practice. So, it drills the students and then it makes, with explanation and all, and then it makes you practice" To that end, ALEKS assigns five different questions that must be answered to master a particular topic. These algorithmic questions change from one student to another to prevent cheating. Important to say that there are no multiple-choice questions in ALEKS exercises to minimize guessing. Therefore, ALEKS is suitable for these instructors to check whether their students understood the concepts taught or not. In short, most of the classroom time "is used for practice purposes. Sometimes we allow ALEKS; sometimes we allow pencil and paper" (P7).

Taken at face value, these instructors have subscribed to a top-down approach/ transmission model during the first part of the session. The use of ALEKS for practice

might have been an indication that the majority thought of the platform as a way to boost their teaching efficacy without having to change their pedagogy (Lai, 2011). Given that the students in ALEKS classes are on different learning curves, teaching to the common denominator seems counterintuitive. For example, what happens with those that do not fall within the norm? The high achievers and those with relatively lower abilities are likely to suffer the most. It is essential, therefore, to shed light on the intricacies of the classroom dynamics. This will be the highlight of theme number two.

Theme 2: The Classroom Dynamics

> Some of them (students) like to work individually and if they do, fine. Some students prefer to work in groups. Set them up in groups and it also then allows you to spend more time with those students, who are a little bit behind or who are struggling that small bit because you don't have to worry about maybe 60% of the class. They're happy enough working by themselves or working in groups. They can figure it out between them, and if they don't, they still come and ask you, and you give them that little bit of help by you. (P3)

The findings from theme 1 showed aspects that were similar to a traditional learning experience despite the use of the AL platform, ALEKS. Most of the instructors in this setting explained essential topics at the beginning of the session and let the students practise for the remaining time. However, the above quote serves as an example of the dynamics involved when students began their work on ALEKS. P3 gave an overview of how he catered for the different students' needs in his ALEKS class. To begin to understand what happened beyond direct instruction, practising and drilling, we need to take a closer look at the classroom dynamics. Therefore, this theme inspects the classroom atmosphere, the relationship between the instructors and their students, and the interaction between students. The findings suggest distinctive features pertinent to the collected evidence related to classroom dynamics. These are categorized into three sub-themes.

The 'ALEKS' advantage

> This is different because you know the diversity, the background of our students. Some students are very good. Some students, even though they're very good, they don't want to work. Some students are not that up to the mark. So, this is a real challenge for you. Everybody will not be working on the same topic. (P8)

Running a class using ALEKS is far different from a traditional classroom setting, according to P8. This instructor acknowledges the diverse abilities of her students, but not because she spent a lot of time with them to get to know them well. On the contrary, the students' mathematical background is revealed from day 1 when students take the initial assessment in ALEKS. In doing that, ALEKS draws a baseline of students' knowledge so that learning is based on the individual needs of every student. The majority of instructors agreed and gave more reasons to differentiate the ALEKS experience from the traditional setting. P1 insisted:

> It's more than in the traditional classroom. Because here we get to relate to the student more because we know them quite well. We've seen their reports with our own eyes. (P1)

Here, P1 was able to relate to her students because she saw their progress on a daily basis through the information that ALEKS provided. P9 explained:

> If we go for something other than ALEKS, we have to build the knowledge of the students. We need to assume a bigger role, not leave the students on their own. (P9)

As an instructor, P9 seemed to appreciate stepping back during 'practice time' because ALEKS gives immediate feedback to students when attempting a particular topic. In a traditional classroom setting, "it's much more difficult to identify students that are struggling early on and maybe identify the students who are being really successful" (P10). Differentiated instruction is also an advantage since the instructors were able to see that their students are on different learning curves. All agreed that ALEKS as a

standalone worked well for good students, which permitted these instructors to cater for the less able students in their classes. P2 explained:

> You can identify the weaker students, and you have the time to work with them that you wouldn't have in a class where you're standing in front of the 30 teaching all the same thing at the same time. (P2)

> It does free up more time in a two-hour lesson or an hour lesson to focus with the five, the six, or the seven, whatever it might be. Students who do need more help and more guidance. (P3)

There is enough evidence to suggest that instructors are more able to cater to the different needs of their students because of the information provided by ALEKS. Consequently, the interaction between the students and their instructors is enhanced. What about the interaction with the students and their peers in ALEKS classes? This will be highlighted in the below sub-theme.

The classroom community

> So, it's a lot more engaged. It's a lot more active. The students seem happier. They seem to enjoy themselves a little bit more. Yeah. So, it's positive. It's more positive, and there's a better interaction. There's a two-way interaction now. (P3)

During the class observation, I immediately noticed the settled atmosphere in P3's class. The students seemed to know what they were doing, and all were working towards building their pie scores. There were two high achievers at the back working together on ALEKS. During the little time P3 spent in front of the class, it was to help a group of students who were experiencing difficulties with a specific ALEKS topic. In an ALEKS class, another instructor added, "it is a collective effort, like the teacher, the friends, then that student input" (P1). To be successful, the instructor is not the only provider, instead, "a triangle" with three vertices (instructor, peers, and student), as P1 concluded.

In a classroom with varying students' abilities where each is on a different learning path, many instructors talked about students helping each other; "in many classes, I've seen it.

Some students, three, four of them join together, and then they work collaboratively. Okay? That's happening everywhere" (P8). There were many instances during the classroom observations that I conducted where I noticed that aspect when students reached the practical part of the session. P9 insisted that students don't solve the work for others, they show them how to work and "sometimes the girls prefer their peers to explain to them, and they like it" Not only you find students helping each other, but "sometimes they (the peers) can better identify what the problem is" (P10). Based on the theoretical framework that underpins this study, the peer communication cycle (PCC) in the CF enables the learner to modulate their own concept by having access to their peer's concepts (Laurillard, 2013). Peers, for example, can provide comments, ideas, critique, and feedback, which motivates the learner to articulate their own understanding of the concept. Also, the peer modeling cycle (PMC) drives and enables each learner to generate actions, share, and modulate their practice by having access to their peer's output. As such, the latter two aspects were visible in ALEKS classes.

Another exciting feature of students helping each other was highlighted by half of the instructors. Apparently, the highfliers in an ALEKS class were identified early during the semester. There are students who possess the knowledge and skills to work through the material in ALEKS with minimal help from their instructors. These students assumed a role that was similar to the instructor's role during the practice part of the session, many claimed.

> If I go back to what I said when they do the initial Knowledge Check-in students, some are high-fliers you can see already, and some have problems. The students will tend to ask those higher fliers sometimes if they're comfortable with them, and there's a good classroom dynamic, "Okay. I'm busy with somebody else; they'll work with him." Also, sometimes I'll say, for instance, "Mohammad, I can't get to Ali. Can you check what his problem is?" (P2)

Throughout the course of the semester, Mohammad became a reference for other students because he was able to finish the assigned topics in a relatively short amount of time. As a result, he used to help P2 with weaker students. Likewise, P1 labeled those students

who helped other students regularly as "shadow teachers" Despite finishing the material early, these students were stuck in this course for the rest of the semester with no option to register for another math course due to college regulations. P5 ended up dividing the work between the two of them: "I told her that today I will deal with these students and you will deal with those" Similarly, P10's student "used to help in the first hour by doing peer teaching." However, to reward these students for their help, P5 and P10 offered extra sessions that would further help them in the next mathematics course. In an AL environment like this, students can become teachers and lifelong learners, according to Pavlik (2015).

One of the advantages of ALEKS lies in its ability to rapidly diagnose what a student knows and assigns individual students on different learning paths. This was one of the rationales given by the instructors as to why the ALEKS experience was different from a traditional classroom setting, as indicated in the first sub-theme. We have also seen evidence that suggested elements of collaboration and peer tutoring during the practice part of the sessions from the second sub-theme. The third and last sub-theme in this category talks about the change in the students' mindset.

Changing students' mindset

> It's not about A's, B's, C's, D's. It's about that mindset change of not enjoying math, to go into the position of where, okay, now I enjoy it. And it might not necessarily be the program (ALEKS) itself, but it's what the program (ALEKS) allowed to happen that, obviously, changed the viewpoint of students on math. (P3)

Initially, and during the first week of the semester, many students in P3's class expressed feelings of fear and dislike when talking about mathematics. This is not surprising, given the students' past learning experiences. According to P3, it is not ALEKS as a learning platform; it's what ALEKS allowed to happen. In making this comment, P3 believed that ALEKS facilitated the change of conceptions from anxiety and fear to independent and responsible students, and impacted the classroom learning environment positively.

Throughout the different themes, we will be looking at “what ALEKS allowed to happen” (P3). Along similar lines, P5 stated:

> The real success story for me, I suppose, would be those students who come in and say, "I hate math." And at the end they say, "Oh, I like it. It's good. This was good. I like ALEKS" (P5)

These beliefs concur with research studies that inspected the feelings of fear and anxiety associated with learning mathematics. Other instructors also highlighted what ALEKS allowed to happen. Many noticed that their students changed their perceptions about mathematics, and the classroom learning experience in general for various reasons. For example, P5 mentioned that his students believed that it is the role of the teacher to help the students and did not expect to be the ones who were helping each other, P5 added, “they said that not only did they learn math, but they learned a lot of skills like helping the friends.”

Others talked about the student’s pie chart in ALEKS and how it acted as a motivator for some. Recall that the pie chart in ALEKS displays the progress of students on an individual basis. It indicates the students’ scores and suggests what topics they can do next. These features, according to many, allowed students to monitor their own progress and take ownership of their learning. When students see their pie increasing as they navigate from one topic to another, they get motivated to work outside the classroom to improve their pie scores. Likewise, when their pie scores decreased, they were able to see what they did wrong and fix it:

> I mean, mainly, it's a student's success. That's where I've seen some students who've gone from basically unable to very able in terms of language and their ability to solve questions, and their motivation level because they see that they're progressing in that environment. (P7)

> It's like, okay, she gets the concept, and she has to practice. Once, twice, three then complete. Congratulations. She will get feedback. And her pie is increasing. You know, it's like something here. You can see it. (P6)

Being able to see their progress every time they attempted a topic, the individualized aspect of the pie chart, and feedback from ALEKS were contributing factors that allowed that change in students' perceptions. These were not the only factors, and the following themes will have much to uncover. So far, we have seen evidence that suggested an improved classroom atmosphere, communication, and collaboration between instructors, students, and peers.

One of the aims of this research study is to investigate and make visible the instructors' roles in classes that use AL as an approach to instruction. Therefore, the subsequent theme will turn our attention to the perceptions of the instructors involved in this study.

Theme 3: Instructors' Perspectives

> So, if you talk about ALEKS and you have explained the concept, and so when you've done your traditional part of teaching, and then the system takes on to evaluate, reevaluate, assign, reassign, suggest. The system will suggest, "Okay. You're having difficulty with this level question, please check page five and six in the textbook," or "Here is an extra resource that you can go and tap on and look into these ideas." So adaptive learning is like a car but with wings. (P7)

This theme discusses the instructors' perceptions of ALEKS and their perspectives on the role and responsibilities of the teacher. The insights gained from the first theme indicated that the instructors assumed the responsibility of content delivery, while ALEKS took care of practice. The above quote by P7 emphasized the latter assumption when the instructor talked about the two parts of his session. However, one cannot but notice in P7's description that most of the action took place in the second part of the session when students worked in ALEKS. Similarly, the practice part of the ALEKS session, according to the previous theme, had a significant impact on the classroom environment and students' perceptions of their learning experience. Further evidence will lead us deeper to deliver an account that is directly related to the teachers' thoughts.

ALEKS drawbacks

> The examples in ALEKS are pre-prepared, and they are fixed. You cannot change them unless you add something more. Not only ALEKS itself, but you have to add, say, your input so you can that you can make sure that ALEKS would work not only for the exams. (P4)

During the interviews, it became apparent that the majority of instructors have some reservations about the AL platform, ALEKS. One of the downsides, according to P2, is the inability to manipulate the content in ALEKS. She added, "if I was designing a system, I would make sure that the teacher in the classroom had authority and access to changing anything within that particular program." Recall that the questions in ALEKS are pre-set according to a specific format and are algorithmic. This means that each item has the same form with an infinite number of variations. As such, complex guidelines govern this process, and it is not permitted to alter the content. That being said, P4 said that instructors could add their own content as a Word file, for example, and attach it to a specific topic in ALEKS. Why would these instructors want to change questions or explanations given that ALEKS offers five different variations for a single problem?

> But a lot of the students struggle with the language in ALEKS. I mean, if they're second language learners, particularly when you're doing LO1, which is percentages and ratios and there are 23 topics there but within each topic, there could be 10 different word problems. And the differences in the language is quite subtle for second language students. (P9)

A possible answer to the question, according to P9, could be linked to the students' profiles and the linguistic challenges they face, especially when the content in ALEKS was not designed for second language learners. P7 added, "ALEKS is, I mean, it's an American based system that basically uses or was created for native speakers."

However, the wording of the questions in ALEKS is not the only reason, but also the explanation that ALEKS provides when students press the "help" button.

> Some questions I know that ALEKS's explanation is okay. They can understand it. You follow that. Some questions ALEKS put different

> words, and students have problem with the language. They do it very indirectly, so I said, "No, this is very easy thing. You do it this way. This is the way." (P8)

There are two aspects to what P8 had mentioned. The first is about the language barriers which were referred to before. The second, however, is that some instructors believe that they can offer a better and shorter explanation to many topics as an alternative. According to P9, videos were developed by some of the instructors to help students with "their language level. Because some of the explanations, the reading explanations, again, they're really, really, really wordy."

Some talked about another challenge they faced when students worked in ALEKS. According to P6, "they don't have partial credit. Either zero or hundred. Okay, they solve correctly, but by the end something rounding, that's only the issue of ALEKS." Had the question been written on a paper during a quiz or a test, instructors would have given partial credit for an incorrect answer. So, it is the working out of the question as P4 indicated:

> You don't see really what the students do. You just see the final answer, if the final answer is correct. So, it doesn't really show you. Again, this is another thing lacking in ALEKS is the format working out. (P4)

These were the challenges cited by instructors as drawbacks of ALEKS. The implications of these shortcomings on the instructors' approaches to using ALEKS will be revealed soon after we discuss some of the perceived ALEKS advantages.

ALEKS strengths

> ALEKS is one of the programs that allows you basically to that extension part, extending the teacher and the students, and in their work and ability. And you have somebody who's monitoring your work. It's the teacher, plus ALEKS itself is doing the job. That's adaptive learning basically. (P7)

Despite the drawbacks cited previously, the majority believed that ALEKS is an efficient platform that extended the abilities of students and instructors, as P7 mentioned. P8

added, “ALEKS is only help your teaching, to help your teaching, enhance your teaching.” Apparently, it is seen as a shared task between the instructor and ALEKS to cater to the students’ learning. According to P10, “ALEKS builds on the individual needs of the student. More personal. Ok? ALEKS takes into consideration the different needs of learning for students.”

The whole idea about an AL platform is to incorporate that individual aspect to learning due to the belief that not all students learn the same way or proceed at the same pace through content mastery. It is not surprising, therefore, that instructors considered ALEKS an advantage because of the personalized characteristic that it brought to their classes. P9 claimed, “it's a remarkable tool. I like the reports that it generates. It can motivate the student. And also, it can make the student responsible for their learning.”

Instructors gave specific reasons for what they thought contributed to the efficiency of this platform. Access to learning was one of the advantages cited because knowledge is not confined within the walls of the classroom.

> Because sometimes we don't get in there, in a building or classrooms, that much time to be with students to complete all the topics that we have dealt with. But it is an open classroom. It's like a split classroom nowadays. We call it a split because they can use it anywhere they want after the lessons, at home, in a coffee shop, anywhere where there is an internet connection. (P1)

In this course, students are supposed to show that work has been done outside the classroom. Students can progress through the topics, and build their pie scores in any location, provided an internet connection is present. Instructors consider this an advantage because they don’t have to go through every single topic in class and they leave it to their students to show responsibility for their own learning. P6 added, “They can enjoy studying by using text. They can be in the coffee shop, for example. Both mobile or laptop and enjoy. I always advise them, enjoy studying. Enjoy.”

Another advantage that contributed to the instructors' positive perceptions is that ALEKS can save a lot of time. Thus, allowing these instructors to concentrate on what mattered the most – their students' learning.

> You got a review. You can generate a test. A lot of PowerPoints, videos. Everything is requested on the ALEKS page. You don't need to do anything extra. Everything is there. Technology is actually easy for you. But if you do the conventional way of teaching, it's significantly more difficult for you. (P8)

> The Knowledge Check is an individual test for everybody. It's built for them, which is no one teacher could prepare that kind of an exam themselves. It would take days and days and days of work and programming and everything else. (P2)

Other than the resources that are available for everybody like the PowerPoint presentations and embedded videos, instructors can generate reviews, homework assignments, quizzes, and tests with a click of a button. When one's students are on different learning curves, instructors are required to produce material for individual students – a task that is virtually impossible to achieve in a short amount of time. Thus, the time saved from these daunting tasks can be geared towards students' learning.

In sharp contrast with the positive perceptions that the majority talked about, one gave an interesting analogy to how he sees ALEKS.

> ALEKS is like fast food rather than getting the people a proper cooked meal. Yeah. It's just ready, and you eat rather than sitting down, and they cook it themselves. Just give them something which doesn't go in-depth. It just goes to the surface, scratching the surface. It is quite restrictive. (P4)

Although P4 agreed with the majority that some of ALEKS features can save time, he added: "it makes you lazy." Interestingly, a 'properly cooked meal' for P4 does not include ALEKS as the main dish:

> Right. The thing is, I don't only depend on ALEKS. And I don't think any teacher should just depend on ALEKS because ALEKS itself - ALEKS is not a teacher. (P4)

The instructor's role is essential, and their perceptions of the learning platform will dictate the way they use technology in their classes and will affect the students' learning experience (Julie et al., 2010). The latter will be revealed in a later sub-theme. For now, knowledge of ALEKS features will be highlighted next as it became apparent from the interviews with instructors that it might hold the key for a successful teaching and learning experience.

Knowledge of ALEKS features

> With the platform ALEKS. So, you have to have a very sound knowledge of ALEKS yourself, and you have to help your students as well. So, it should be-- from the student's approach also; you should have the skills. And from a teacher's point of view also, you should have also those skills. Because if you're not going to use the software that is provided to you 100%, then what's the point of having a software? (P5)

Not only should instructors have a sound knowledge of how ALEKS works, but also the students, P5 claimed. Using ALEKS in the classroom without knowing its capabilities and limitations is a recipe for failure, according to P1. She added:

> Actually, it took almost a year to understand ALEKS because there are many features in ALEKS which are very, very useful for the students as well as for the teachers. (P1)

Apart from understanding what ALEKS does as a learning platform, instructors should be confident using the many embedded features to enhance the students' learning experience. How to set up a quiz or a test, for example, and how to use the reports that ALEKS provides to adapt one's teaching according to the varying needs of one's students. Otherwise, ALEKS becomes a disadvantage for the instructor and his students (P4). The turning point here is the emergence of a shared understanding that ALEKS can be used for more than practicing and drilling. What will become apparent throughout the

remaining part of this study is that we only scratched the surface in terms of the embedded features in ALEKS and how these instructors will use it to their advantage.

> I mean, you have to tune the learners to the particulars of the program, and it works well because it is adaptive. So, it works with the students' abilities as it sees. And so, it assigns homework based on student's knowledge and ability and completion level, and it comes back and checks. As a model, it's perfect. (P7)

When ALEKS is used as an integral part of a course, it is crucial that students also know what they will be dealing with day in and day out. For example, students should know that after the initial assessment, they will be placed on different learning curves, each according to their abilities. It is unlike the traditional learning experience and training students on ALEKS is a must.

> It gives them more of an idea of how ALEKS works, that, "Okay, I can jump from here to here. It's giving me questions in order of difficulty. One time I'm in the green part. One time in the blue part. I'm moving everywhere." So, they also see from that. It's not one particular section; it's made up of very many different parts. But eventually, in places, they do overlap, like I've done something with exponents. Now I'm seeing it when I'm doing area, and I have something square. (P2)

Once the initial assessment was finished, P2 explained to her students what would happen next. She related the course learning outcomes to the colored slices that appear in her students' pie charts. For example, the knowledge check that ALEKS deploys on a regular basis will make sure that the information learned is retained. It is made out of 30 questions, 15 of which are on topics the students have learned already. Any mistake in these 15 questions will decrease the pie scores, according to P10. The other 15 are made out of new topics that the students have not learned yet, and any mistake in these will not decrease their pie scores. On the contrary, getting these questions correct will increase the students' pie scores instantly without having to go through the practice part. Consequently, knowledge of these minute details is essential for instructors and students alike as it facilitates the teaching and learning experience in ALEKS classes.

The first theme showed that in an ALEKS session, the majority of instructors assumed the responsibility for content delivery. To shed light on the taught part of an ALEKS session, it becomes crucial to reveal how these instructors approached ALEKS instruction.

Approach to ALEKS instruction

> Some teachers may use ALEKS with their students but in a different way than I would tend to. I don't produce worksheets for the students and go through 20 questions in the class with them, or ten and ask them to listen to me. I'd prefer to let them go ahead, and when they're stuck or when I can see they're stuck, even though they're not telling me I can see the report, intervene at that stage. (P2)

P2 marked the distinction between two different approaches to instruction. She allowed her students the freedom to interact with the material presented in ALEKS first and used the generated reports to offer help as needed. P2 added:

> In a class of 27, I feel that if I'm at the board answering a question, I might have the attention of eight of them or a third of the class. The rest are pretty much doing what they want. (P2)

This instructor knows that her students have varying abilities and are on different learning curves. Therefore, teaching to the common denominator by asking all her students to pay attention while she explained seemed counterintuitive. While some might be interested in the explanation of a particular question, others will be working on different topics:

> For me, if we are trying to make students independent learners and we want them to take ownership of their learning, then this is the way they will learn. We can't keep spoon-feeding all the information. They need to realize that if they do the work, they'll be successful. (P3)

P3 followed the same approach and allowed his students to interact with the topics presented in ALEKS freely. He drew a line between ‘spoon-feeding’ the content by

offering whole class instruction and encouraging students to be responsible for their own learning. P3 added, ALEKS is designed to meet "the needs of the student, not to your needs to try and get or have to cover all of these questions."

I categorized these two instructors as progressive users of ALEKS because of their ability to exploit and integrate ALEKS fully in their classes. Their approach, according to Julie et al. (2010), is an example of a practical implementation of digital technologies. The rest, however, follow a diametrically opposite approach to ALEKS instruction.

> So, because I like Aleks, okay, as a question-and-answer, but not as explanation. I'm not going to tell her, "Read the explanation, and if you need any help come." No. Stop everything. Listen to my explanation…it's not independent learning course. So, they need instructor. (P6)

For P6, allowing her students to attempt questions in ALEKS on their own is not an option because she believes that her explanation is better. During the class observation, P6 asked her students to stop working on ALEKS to pay attention to her. The instructor is preparing her students to tackle the last learning outcome of the course. Despite the positive interaction with her students, she was in full control of the scene, addressing all her students from the front of the classroom. Displayed on the electronic board was a nicely laid out document with questions from ALEKS that represented that day's quota of 10 topics. A hard copy was provided for students to work with as soon as P6 finished her presentation. The whole process took 55 minutes; then, students started working in ALEKS. For the rest of the time, while students worked in ALEKS, everybody was working to reach the day's quota, and one could not but notice the positive energy in this classroom. Students were motivated to finish the work; some were helping others while P6 monitored their progress and gave real-time updates using the reports that ALEKS generated.

P10 agreed that this approach worked best because her students just moved from school, and they needed time to adjust. To emphasize, she added:

> From the start I know that we are doing LO2. I focused on the topics that we are supposed to learn in LO2, which are 52 topics. I saw those students who are under 60% or 70% and solved those topics. (P10)

Similarly, P7 provided a worksheet for his students to practice after he explained the concepts involved in his quota. These questions were taken from ALEKS for students to show that they can produce the steps involved in getting the mean, median, and mode for a set of numbers. According to P7, he needed to "check whether they can do it by hand or not. Because before they can do ALEKS, they have to understand the concept and be able to solve an equation and do many other things that we require them." His students started building their pie in ALEKS as soon as they finished the worksheet. In this part of the session, individual learning through practice was prevalent, and all students were working to reach a common end, despite the fact that they were on different learning curves. When I asked the instructor why he chose to have his students practise a worksheet, given that ALEKS produced the same questions with explanations, P7 replied, "it's there, I'm sure. But will the students be able to do it on their own at this level? Maybe once they have taken a course, they become more adaptive to learn using technology."

The fixation on the students' weak learning backgrounds has prevented the majority of instructors from allowing more independent learning in their classes. P5 claimed, "ALEKS wants the learner to be independent. But we are not actually making our students independent because, like I said, they don't come with those study skills." The instructors' perceptions of their students and the learning platform are contributing factors to how they approached instruction using ALEKS.

That being said, another feature of ALEKS emerged as instructors talked about monitoring their students' progress using the reports generated from the learning platform. What falls below is a theme that highlights how these instructors' used the LA from ALEKS to improve the students' learning experiences.

Theme 4: ALEKS Reports

> Here, you're happy to see that everybody's working every day. Every time, you know how many hours or how many minutes you spent on ALEKS. How many topics he has mastered? How many topics he is ready to learn? So, all those reports, you can see it. (P8)

So far, the delivery framework theme showed that an ALEKS session comprised a taught component and a practice component. In the former, instructors were the ones responsible for content delivery while in the latter, students practiced in ALEKS. We have seen evidence from the 'classroom dynamics' theme that showed improved communication and interaction between instructors, students, and their peers. In addition, despite the drawbacks mentioned by instructors, the majority believed that ALEKS is a valuable learning platform. Further evidence directed our attention that what happened during the practice part has significantly influenced and improved learning and teaching experience for students and instructors alike. Do instructors sit and watch students practice in ALEKS? What factors contributed to the improved communication in ALEKS classes? The present theme has a lot to uncover about the classroom learning experience. It highlights how the different reports generated through ALEKS can be used by instructors to enrich the students' learning experiences.

In the quote above, P8 gave an example to indicate the advantage of ALEKS classes over traditional classes. In ALEKS, all data pertinent to students' progress can be extracted from various reports. P1 asserted:

> If a student is enrolled in ALEKS, 24/7 they are with us. Because whatever they do in ALEKS, it will be seen in ALEKS. So, they are right with us. (P1)

The ability to monitor your students' progress in real-time using the generated reports from ALEKS was cited by all instructors as a critical aspect of the learning platform.

Using reports to monitor students' progress

> Yeah. It's a comprehensive package. It gives you all what you need in terms of particulars of students' behavior within learning environments.

> The average time spent per question. How many hours have they spent on a particular learning objective? (P7)

Here, P7 was talking about the time and topic report and how he was able to monitor students' progress inside and outside the classroom. Recall that this particular course required independent work outside the classroom. Like P7, the majority found it essential to monitor how many topics were mastered according to the time spent for each student during the week or on a daily basis. P6 added:

> I like it because you can track students. Okay, you have an assignment, and you work at home, okay. Even she is absent, okay, there's an assignment, she has to solve it, and I can track them. (P6)

When instructors used the progress report and click on a student's name, they can obtain an up-to-date record of the time spent, the topics mastered, completed or incomplete assignments, and learning rate for that individual student:

> You can say in week two to him, "Look. You did well. Your pie has gone up by 28 topics, but really did you do this yourself?" "Oh, my brother helped me." "Will he help you in the exam?" You know this isn't going to work. So again, that's something that you wouldn't be able to do without having seen what the student's building rate was prior to this. (P2)

Instructors like P2 can viewed, analyzed, and compared their students' learning trends and acted accordingly. This included talking with students, negotiating, and offering advice. In ALEKS classes, instructors felt that they were with their students 24/7, as P1 mentioned earlier. Interestingly, P3 provided a different perspective as he said, "things like time and topics, teachers would use, and they continue to use it as a stick to beat the students with." This instructor was talking about the kind of evidence that students cannot argue with – the time students spend in ALEKS and the number of topics they are able to finish.

> The student can't say, "I did it." The evidence is there. You can say, "Look, you spent 20 hours on this. Look at what the rest of the students

> have spent." Even kind of the more stubborn of students will then go, "Yes." And they know what they have to do. (P9)

> And he or she will say, "Miss, I was studying." One second. Okay, you have been only four hours, or you never touch Aleks. Okay, so four hours you are working, just in that class time, which was not enough to pass you. (P6)

P6 and P9 provided some of their students with hard evidence about their progress outside the classroom, which indicated that their work was insufficient. These instances are usually taken as an opportunity to guide students when they have problems. That opportunity presented itself when these instructors talked about using reports to help and provide meaningful feedback – an aspect that I found prevalent during the classroom observations.

Using reports for help and feedback

> And even from the reports, like Time and Topic, if they don't know this, we just go to them. We don't ask them whether they need help or not. They don't even have to ask us. The ALEKS is pointing them to the teacher that, "Okay, this student needs help. Go to him." (P1)

When students started practising in ALEKS during class time, instructors relied on the reports to offer help when students struggled with a particular topic. P1 mentioned that she doesn’t have to wait for her students to ask for help, as she can tell from one of the reports who are the ones that need assistance. So, the use of ALEKS reports is not only to track students’ progress but also for intervention when students struggle. Even P4, who mentioned that he does not depend on ALEKS, said: “I look at the pie or and see if there are any topics that they will struggle with.” These instances when instructors felt they needed to intervene were not directed to individuals only. ALEKS reports indicated those topics that were attempted, but not gained for some students.

> It's not just a case of the students do everything by themselves. There are times where I will, as I said, I will look at those reports and say, "Okay. There's maybe a group of six students who've tried this topic, or they've

> done their best, but they just don't get it." Then, yes. I would say to them, "Okay. Gentlemen, first, just for two minutes, I just need you to just listen to me. (P3)

When students work in ALEKS, these instructors will be busy monitoring, helping, and giving feedback. For P3, these reports are the backbone of his classes, and although he allows his students more freedom to attempt topics, they are never left alone.

> For me, after the midterm test, for example, I sit with every single girl. I open her report on ALEKS and check the wrong questions/ partial credit and solve with her. If there are common mistakes for all the class, I will put it on the board and explain it for everybody. (P10)

Just-in-time feedback is a direct result of translating the data from reports into insights. According to Hattie and Timperley (2007), timely feedback has a widespread impact on students' learning and success. When the students' pie scores decreased after a midterm or knowledge check, proper feedback from instructors helped these students get back on track. In ALEKS classes, reading and acting on the reports entailed constant monitoring, inside and outside the classroom.

Using reports for planning and preparation

> So, I see to it that at least 70 to 80 percent of my students have completed that work, which has been taught, and then I move on. So, it definitely helps going to the class every single time looking into where the students are standing or where the class is standing. It is very important. (P5)

Planning and preparation are essential aspects of teaching. Instructors usually plan their lesson based on what was previously done in the classroom, one lecture after the other. In ALEKS classes, however, you might prepare your lecture for part of a session and discover that your students have mastered that concept during their independent study time. Therefore, P5 referred to the importance of reading the reports before class to know how your students have progressed, where they struggled, and plan your session accordingly. According to P8, "We always see the report. And then accordingly based on the report, you can base your teaching on that."

The ‘ready to learn’ report will give instructors crucial information that they need to plan for their next lesson as it will specify the topics that their students are ready to learn. Also, it will give them the names of those who attempted a question, how many times they had tried, and whether they were successful or not. Therefore, P1 indicated, “so we don't have to waste time on things which they know, but what they are ready to learn. What they are ready to learn next. What is next?” The ‘ready to learn’ report, P3 used for grouping his students according to the topics they’ve mastered or attempted. P3 added, “You should see group work because it's set up. I mean, you can look at the reports. You can see which students need to complete which topics. You can put them together. Let them work together” Interestingly, P3 was the only instructor who mentioned the use of reports to group students according to their abilities.

So far, we have seen how instructors used ALEKS reports to enrich the learning experience in their classes and beyond. Clearly, these instructors assumed a role that was not visible before – using the LA from the AL platform to cater to the individual needs of each and every student they have in their classes. Evidence from the literature supports this role, according to Lai (2011), who stated that the use of digital technologies must promote communication and collaboration between teachers and their students. Next, we highlight how the mindset of some of these instructors has changed as a result.

Theme 5: From Traditional to Adaptive

> You have to be able to support every student. You have to have the ability to tackle different cases and to check the students that are on a different content or different learning outcomes. He has to be able to give the students enough room to produce. He has to purposefully plan before his session to have a general idea about the students. (P9)

In classes that use AL as a principal approach to instruction, P9 highlighted certain qualities that instructors should have. Encircling is the belief that students in these classes are on different learning curves, have varying abilities and needs. This view is supported by evidence from a continuous flow of students’ learning data embedded in the platform. From support to adaptability, these instructors should be able to cater to the individual needs of their students. Translating the LA into insights, as emphasized in the previous

theme, takes precedence. The last theme sheds light on the journey from traditional to adaptive, the changes in instructors' roles, and reveals how some of these instructors have changed as a result.

A challenging shift

> ALEKS let me transfer from a traditional teacher to a teacher who build and focus on the personal needs of the students. it made me feel like I am a facilitator inside the classroom. even with my current role as a trainer, I now tend to let my trainees work more, and I do less. (P10)

Because ALEKS concentrated on the individual needs of her students, it facilitated the transition from a traditional instructor for P10 as she felt that she did not have to teach collectively the whole time. More than half of the instructors involved in this study talked about the challenges they encountered. P1 asserted:

> So first when I started with ALEKS I had a bit of difficulty because I've also used the generic, traditional type of classroom, okay? So, when I started ALEKS, even I wasn't quite forward and open. (P1)

Her prior teaching experience for the past 18 years was all about lecturing where students took notes silently, while she solved some examples on the whiteboard. She acknowledged that learning in her classes "was very monotonous, and I prepare, I go, I teach, and I teach only with my ideas." P1 indicated that having ALEKS as an approach to teaching and learning affected her approach to instruction. She added:

> I don't feel dominant, nowadays. I have blended in with my students. And sometimes even, we have more ideas. As teachers, we get more ideas with ALEKS. (P1)

Likewise, P9 mentioned that ALEKS allowed more freedom for his students and indicated that he stepped back during practice. Similarly, P2 portrayed her prior approach to instruction as traditional and mentioned how difficult it was for her to monitor her students' progress and offer remedy in a timely manner. She acknowledged that having ALEKS in her classes "is a step forward" from what her classes used to be.

> I have to say that I really like ALEKS because of the reporting, because of the fact that right from the get-go you have some feedback on the actual ability of the student. Okay. I would wish that I have that in every other class where there isn't an ALEKS. It's made me stand back a bit that the students get on with the stuff themselves. (P2)

For P2, ALEKS reports had a significant contribution to how her approach changed. As a result, she learned to step back and allowed her students more control over their learning. however, she still felt that she was "the master of ceremonies" because of the reporting functionality in ALEKS.

Having been influenced by his mathematics teacher's approach during his school years, P3 molded his own teaching accordingly.

> And I think my thing is, for me, it was a control thing, letting go because I've learned now that, for example, I love noise in my lesson. I encourage noise in my lesson. Whereas back when I first started out and I guess less experienced, the last thing I wanted was noise because noise equated to you don't have control. And if you don't have control, the students are not learning. If the students are not learning, then you're a bad teacher. So, it was always about that control. (P3)

Prior to using ALEKS, P3 taught from the front of the classroom, lecturing and assigning work while his students listened quietly. The shift to ALEKS was challenging because of his "fear" of losing control. P3 added, "you still have control. It's just a different-- it's in a different form, shall we say."

> The students control the lesson. So, for me, I now see that my role has changed from more of the instructor to more a facilitator, and that's how I would describe myself now, a facilitator. And the only reason I can say that is because of the use of adaptive learning. (P3)

The shift in control allowed his students to take the initiative and be responsible for their own learning. Interestingly, P3 follows a 'rule of thumb' when dealing with his students in ALEKS classes:

> Okay. "Try it yourself. If you can't do it by yourself, ask your friend. If your friend can't help you, ask your group, and if your group can't help you, then you ask me." So, it's like I'm now the fourth port of call. Whereas, at the beginning, I would have been the first. (P3)

Being the fourth port of call for P3 did not prevent him from relating to his students and offering help when needed, as his classroom observation indicated. Note that P3 was the only instructor who mentioned using ALEKS reports to group students. As such, instructors have to expect and accept a different form of control in their classes.

> So, I had this old fashioned, at the same time I find something that is new, which is you give freedom to the students. You move around, cooperative learning, all of this. So, it was a bit of difficult to put yourself in this form, but with the time, I felt at ease. (P4)

Although P4 displayed a perception of ALEKS, which was not so positive, he had to adapt to this new approach and allow more freedom for students in his classes. Much has been said about the 'control' factor in relation to the use of digital technologies. For a successful implementation, it is claimed that instructors must be willing to step back and get rid of some of that control (Lai, 2011; Pavlik, 2015).

There are varying degrees of adaptation to this approach to learning that some of these instructors displayed. P5 mentioned that AL is the way forward as she learned a lot of new things in ALEKS classes. When P5 was asked whether a traditional approach is an option for her, she replied: "To traditional? Impossible. I don't think I can even sit in a traditional class anymore. I will probably doze off." In conclusion, having the right tool with the proper features facilitated the shift from traditional to adaptive for some of these instructors.

For others, however, it was the thrust to use technology as P8 indicated: "But here, they want to promote more technology in everything, so we have to follow the system. You don't have any option." Despite thinking that ALEKS contributed positively to his students' learning, P8 maintained that teaching mathematics is more efficient using a

more traditional approach. He added, “I'll always go back to the conventional way of teaching.”

Instructors involved in AL classes need continuous support and training to be able to integrate these new approaches to learning in their classes (Julie et al., 2010; Laurillard, 2008). That being said, many agreed that dealing with AL classes required a particular skill that is not present in traditional courses and highlighted the changing role of the instructor, as a result.

Instructors as monitors

> It's like you're a monitor. As well as being a teacher, you're a monitor. That's the way I see it. You're monitoring what's happening. You're looking at the reports, analyzing them, seeing what indications they're really giving you about the student. (P2)

A direct implication of having the embedded LA in ALEKS is when the instructors take on the monitoring role. Without the students’ learning data, ALEKS would have been reduced to an exercise drilling platform. Equally important are the instructors who used the ALEKS generated reports to offer guidance and feedback for their students as theme four indicated.

For P2, being the monitor is a necessity in ALEKS classes if instructors want to improve their students’ learning experiences. P8 added, “So everybody has a different requirement. And you should know who needs what. It's that kind of customized learning.” The only constant in ALEKS classes is that students are on different learning curves. Most of the instructors acknowledged that fact despite teaching to the common denominator for the first part of the session. However, it was the second part of the session that revealed what an AL class should look like. As such, the ability to read and analyze various reports in ALEKS is crucial for these instructors in order to offer individual assistance and feedback, according to P10.

Another aspect that is directly linked to the data generated from ALEKS is the ability to motivate. Some instructors argued that motivation was an essential element and was data directed:

> [I] encourage students now when I look at their pie, and I look at what they're building... "Go home tonight, and all I want to do is 10, 15 minutes. If you can do three topics, if you can go in and you can work on three topics, and you can figure out those three topics, and you can master those three topics, then that's good enough for me." (P3)

P1 and P7 also mentioned the kind of motivation that is based on reading the reports and is directed to the individual needs of every student. Recall that some instructors felt that they knew their students better due to reading these reports. Thus, encouraging their students to increase their pie scores by studying regularly is based on real-time data for every individual student.

A great deal of teaching and learning in ALEKS classes depended on reading the reports and transforming those reports into insights, as many instructors mentioned. Keeping "an open mind" and adapting to the changing needs of their students is essential, according to P5. In conclusion, "you have to look at your students, you have to look at ALEKS (reports), and you have to adapt accordingly. There's no one size fits all." (P9). Finally, P9 concluded her interview with a smile and said, "I'm adaptive."

With this last note, it seems appropriate that I conclude the presentation of the findings. The next step is to introduce a section that relates these findings to the research questions in this study.

Thematic Map and Research Questions

This section relates the findings from the interviews with instructors and the classroom observations to the three research questions in this study. It is a step that I find necessary to highlight before the introduction of the discussion chapter. Therefore, the thematic map will be restructured in figure 5 to accommodate the research questions in relation to the previously identified themes.

The successful transition to college-level mathematics at HEIME requires the completion of a bridging course where students learn mathematics using an AL platform called ALEKS. These students with a weak background in English and mathematics (Dahl,

2011; Hatherley-Green, 2012) cannot proceed to choose a major before obtaining the required skills in the latter two subjects.

To understand how ALEKS has been used to assist these students in their transition to college-level mathematics, we draw evidence from three themes. The compounded findings from themes 1, 2, and 4 will provide the necessary foundation for that. The delivery framework theme allowed the discovery of the principles and standards that were used to guide the delivery of the content using ALEKS. When compounded with the evidence obtained from the classroom dynamics theme and how ALEKS reports were used to improve learning from theme number four, we can understand how ALEKS has been used to assist the students in their transition to college-level mathematics. As such, the insights gained from the delivery framework, classroom dynamics, and ALEKS reports will contribute to answering the first research question.

The review of the literature enabled the formation of an understanding of the students' learning experiences during their school years. This will be contrasted with the findings from this study to highlight the changes in the learning experience as a result of using ALEKS. Here, the changing classroom dynamic when students began their work in ALEKS, the instances where changes in students' attitudes were reported by instructors, and how ALEKS reports have contributed to a better classroom learning experience will have the most weight.

To understand how ALEKS influenced the practices of the instructors involved in this study and their approach to instruction, we draw upon the instructors' past teaching and learning experiences, and the collected evidence from themes 3, 4, and 5. The instructors' perspectives, ALEKS reports, and the journey from traditional to adaptive will cast light on the second research question. In this study, the instructors benefited from the LA embedded in ALEKS, which proved to be an invaluable tool that enriched the students' learning experiences. These insights will be contrasted with previous research studies that portrayed instructors as bystanders. Therefore, the discussion of the findings will emphasize the crucial role of instructors in ALEKS classes and will make visible how some of these instructors changed their approach to learning, as a result.

Lastly, the CF (Laurillard, 2013) that serves as a theoretical framework for this study and the findings from themes 1, 2, 3, and 4 will provide a roadmap to optimize the classroom learning experience using an AL approach. Utilizing the CF as a theoretical framework in this study will provide further insights into the kind of learning that took place in ALEKS classes. Thus, the findings from the above themes will be translated in terms of the different learning types and learning cycles in the CF. Recall that learning through acquisition and learning through practice were two highly visible learning types in ALEKS classes. The last research question will build on these findings and will try to discover ways to advocate more learning types using the LA from ALEKS. More importantly, these findings will offer an education-driven (Laurillard, 2008) viewpoint to using ALEKS as a primary approach to learning.

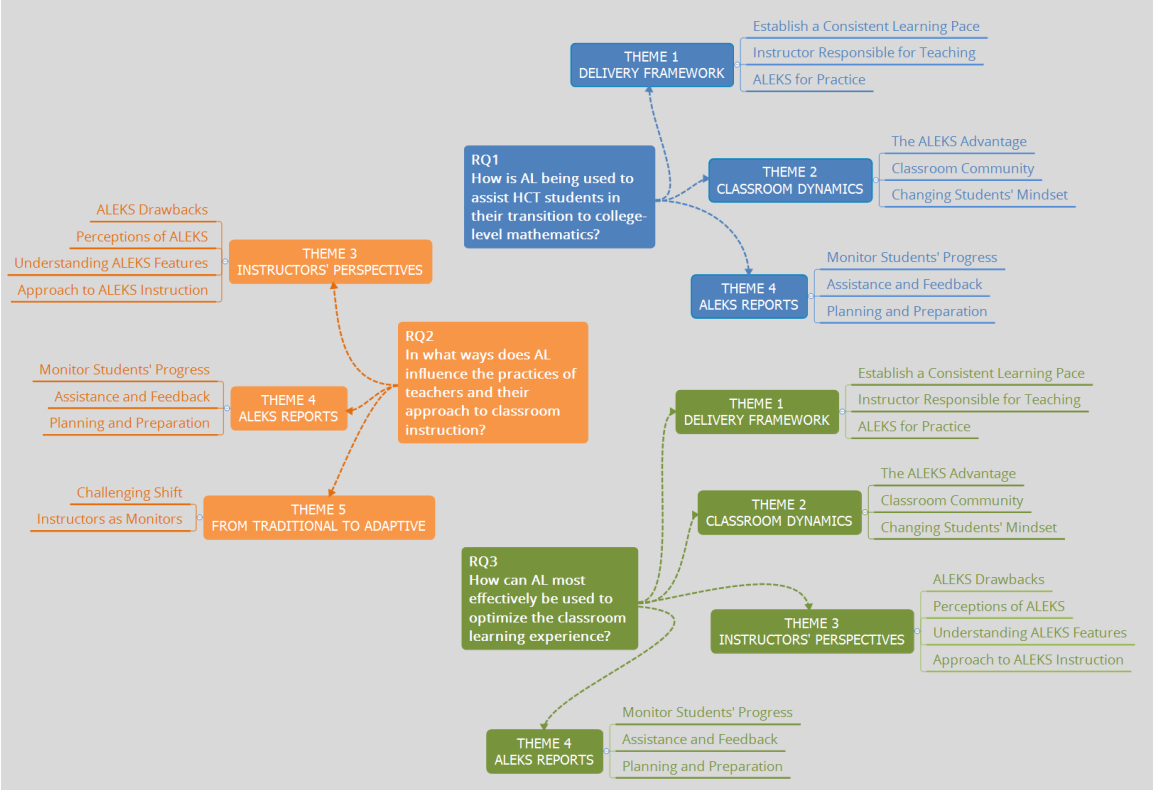

Figure 5. Research questions in relation to the findings

Summary

This study started in the classroom and will end in the classroom, while in between, the thesis highlighted the critical role that instructors play in ALEKS classes. The presentation of the findings started with an overview of the delivery framework that was

used to guide the delivery of the content in ALEKS classes. The results suggested that most of the instructors assumed the responsibility to deliver the material in the first part of the session, while ALEKS was used for practice in the second part. However, two instructors stood out because of their ability to exploit and integrate ALEKS fully in their classes. Direct instruction for P2 and P3 was directed by the LA generated from ALEKS instead of teaching to the common denominator.

Changes in the interaction between instructors, students, and their peers contributed to an improved classroom atmosphere, especially in the second part of the session, where students worked in ALEKS. Following that, the instructors' perceptions of ALEKS and approach to classroom instruction were recorded. These have set the scene to the discovery of two fundamental aspects in ALEKS classes – the students' LA and the role of instructors in ALEKS classes. Unfortunately, these two aspects were not adequately addressed in previous research studies, and therefore, prevented us from understanding what it takes to learn and what it takes to teach with the use of an AL platform like ALEKS.

The discussion in the next chapter delves into the meaning and importance of these results in relation to the review of the literature, research questions, and overall conclusion and impact.

Chapter 5

Discussion

Introduction

One of the distinctive features of previous research on ALEKS is the partial and limited portrayal of teachers as bystanders. The cumulative evidence from the literature is incomplete when the role of those who are required to interpret the LA provided by the platform into insights is not adequately recognized and understood. As such, this study aims to tell the story of a group of instructors who used ALEKS as the primary approach to the delivery of a remedial mathematics course in a HEIME. Using the CF as an overarching theoretical framework, this study also intends to provide a supplementary lens to the research on AL by introducing an education-driven approach to the use of ALEKS in mathematics classes.

This chapter starts with a summary of the main findings from chapter four. Next, attention will be directed to the interpretation of the finding in light of the review of the literature. The chapter concludes with a section that reflects on the research questions in light of the findings and the overarching theoretical framework.

Summary of Findings

This qualitative case study comprised ten interviews with instructors and seven classroom observations of ALEKS classes. Unlike previous research on AL, the findings in this study exemplified the multi-layered and complicated nature of these classes from the instructors' perspectives. This chapter offers a close and personal encounter with an approach to instruction that necessitates a different skillset from instructors and is dominated by the use of the students' LA to improve learning. It begins with a summary of the findings from the emergent themes that were identified using Braun and Clarke's (2006) thematic analysis in chapter four.

The five emergent themes painted an image of an AL journey that started and ended in the classroom. The 'Delivery Framework' theme revealed the principles and standards that guided the delivery of the content in ALEKS classes. The majority of instructors

discussed in this theme assumed the responsibility for the delivery of the material during the first part of the session and allowed students to practice using ALEKS in the second part. The apparent consensus that ALEKS does not work well on its own in the classroom was reinforced by the instructors' knowledge of their students' lack of mathematics skills and a *laissez-faire* approach from the course syllabus. To manage the delivery of the content and establish a consistent learning pace, these instructors divided ALEKS topics into manageable chunks to be covered in every session. Consequently, learning through acquisition and practice were two highly visible learning types from the CF.

The second theme gathered evidence of what happened beyond direct instruction and practice, by delving deeper into the classroom experience and inspecting the classroom atmosphere, the instructor-student relationship, and the interaction between students and their peers. This theme highlighted how instructors viewed AL classrooms differently from traditionally taught classes. One of the distinctive features of ALEKS is that it draws a baseline of knowledge to what a student knows and engineers a unique learning path for every learner. Being able to see where what you students achieved, and where they struggled on a daily basis was a crucial factor that instructors relied on to cater for the different needs in their classes. Consequently, the instructors were able to allocate more time for those who struggled with the content and give timely feedback to those who needed it. Further evidence suggested an improved classroom environment where students benefitted from their peers' help.

In particular, highfliers in ALEKS classes assisted these instructors and helped students during the practice part of the session. In the terms of the CF, the instructors were able to put in place the peer communication cycle (PCC), which enables the learner to modulate their own concept by having access to their peer's concept (Laurillard, 2013). Peers, for example, can provide comments, ideas, critique, and feedback, which motivates the learner to articulate their own understanding of the concept. In addition, the peer modeling cycle (PMC) drives and enables each learner to generate actions, share, and modulate their practice by having access to their peer's output. As a result of this personalized experience and positive classroom atmosphere, instructors reported that

many students displayed a better attitude and changed their perceptions of mathematics classes.

The third theme delivered an account of the instructors' perceptions of ALEKS and their perspectives on the role and responsibilities of the instructor. Here, instructors mentioned some of the disadvantages of ALEKS like the inability to manipulate the content and questions. Also, the complicated language and lengthy explanations in ALEKS were highlighted by many instructors and might have contributed to their approach to instruction. Despite these shortcomings, the majority maintained a positive perception of ALEKS as an approach to learning. The individualized aspect that ALEKS carried to the classroom, the availability of teaching resources and access to learning that extended beyond the classroom outweighed the disadvantages cited earlier. Knowledge of ALEKS features was crucial for a successful teaching and learning experience for instructors and students alike. Otherwise, it is a recipe for failure; the majority agreed.

The last two themes focused on the practice part of the session, which suggested that it significantly influenced and improved the learning and teaching experiences of students and instructors alike. The fourth theme, using ALEKS reports, highlighted potential reasons that contributed to the positive ALEKS experience. In that regard, the students' LA that ALEKS provided had the most impact. The instructors highlighted three different utilizations:

- Using the reports to monitor students' progress. Instructors used the progress report to obtain an up-to-date record of the time spent, the topics mastered, completed or incomplete assignments, and the learning rate for any student. These instances were usually taken as an opportunity to guide students when they encountered difficulties with the content and with time management.
- Using reports for help and feedback. The use of ALEKS reports, it seemed, did not only target students' progress but also for intervention when students struggled with the content. When students worked in ALEKS, the instructors were busy looking at the reports, helping, and giving just-in-time feedback for those who needed it.

- Using reports for planning and preparation. Unlike a traditional learning experience where instructors proceed with the content based on what was done before, in ALEKS classes, you might plan your lecture part of a session and discover that your students have mastered that concept during their independent study time. Therefore, using the reports to plan took precedence in ALEKS classes.

Clearly, these instructors assumed a role that was not visible in earlier themes. Using the LA as orchestration tools to cater to the individual needs of every student became an integral part of the instructor's role in ALEKS classes. In the last theme, many instructors discussed the challenging shift from traditional to adaptive and highlighted how ALEKS helped in changing their perspectives on teaching and learning. Instructors used terms like '*less dominant*', '*stepping back'*, '*more freedom*', and '*less control*' to indicate how ALEKS affected their approach to instruction. In ALEKS classes, continuous guidance, help, feedback, and motivation were data-driven and were aimed towards an individual student or a group of learners. As such, a different skill was highlighted as instructors became monitors that read, analyzed, and acted based on the various reports from ALEKS.

Next, attention will be diverted to the interpretation of the finding in light of the review of the literature.

Contribution to Existing Research

Existing research can be understood as focusing on the different approaches taken to incorporating ALEKS in mathematics courses. Chapter 2 considered three different ALEKS implementation strategies. The first of these was when ALEKS was used as a drill and practice tool outside the classroom. In the second approach, ALEKS was used as a remediation tool to bring at-risk students on par with regular students. The last highlighted the use of ALEKS as a principal approach to instruction. These categories will be revisited in light of the findings in this study.

ALEKS as a Drill and Practice Tool

Recurrent observations from the first implementation approach indicated essential factors that should have been present as *a priori* to ALEKS deployment. For example, the misalignment of the textbook used with the topics presented in ALEKS, lack of knowledge of how ALEKS operated, and the excessive time it took to complete the required ALEKS assignments outside the classroom were highlighted in different research studies (Hagerty & Smith, 2005; Stillson & Alsup, 2003; Strayer, 2012; Xu, Meyer, & Morgan, 2008). In this category, ALEKS was used in a blended learning environment to reinforce the concepts taught in the classroom. The shortcomings indicate how vital the ALEKS set-up is. Despite the positive feedback from students about ALEKS in the research studies mentioned above, the classroom component was not aligned with the topics presented in ALEKS, and the generated reports were not used to guide instruction. As such, the differentiated aspect of ALEKS outside the classroom was not met with differentiated instruction and feedback inside the classroom.

The instructors involved in these studies had an open door policy and were ready to help their students whenever needed (Stillson & Alsup, 2003; Strayer, 2012; Xu et al., 2008). However important, these instructors could have assumed a proactive role and used the reports to offer help and assistance without waiting on students to ask. It is essential to mention that one of the highlights of this study resided in the instructor's ability to act according to the data they observed from the students' LA. Shortcomings in this category revealed insufficient knowledge of ALEKS – an essential aspect that instructors in this study warned us about.

One of the most critical factors for a successful blended learning experience is the effective integration of the face-to-face component with the online component, according to Garrison and Kanuka (2004). The apparent disjunction compounded by insufficient knowledge of the learning platform in this category of studies placed ALEKS and the learning experience at a disadvantage. When compared to a structured traditional learning experience, these results were not surprising.

The results of this study, however, emphasized that ALEKS is much more than a platform that contained a set of exercises for students to practice. It represented an

approach to learning and instruction that engineered a unique learning path for each student based on their abilities and allowed instructors to monitor, analyze, and take actions based on the students' LA embedded in the AL platform. In fact, the student module and the instructor module are inextricably connected components of the platform, unless the learner is enrolled in a self-taught course. The latter positioning of the instructor's role is in line with Dillenbourg's (2013) notion of orchestration where the instructor is the driver of multiple activities in their classes.

> They should be trained at the beginning. Now, there are lots of functions in ALEKS. If you don't know them, you would be disadvantaged, and the students would be disadvantaged. You cannot just give the student ALEKS and say, "Okay then, just do this, and you pass." You have to guide them through ALEKS, and you have to show them how ALEKS works. (P4)

Evidence showed that understanding and knowledge of ALEKS features are vital for students and instructors alike. Otherwise, the learning experience is doomed to fail. The taught component, the practice part, and what students were able to achieve outside the classroom were interwoven and connected through ALEKS reports – an aspect that was far from being delivered in the first implementation category.

ALEKS as a Remediation Tool and as a Principal Approach

Evidence from the different implementation strategies was inconclusive, as noted earlier in Chapter 2. That being said, students in various studies enjoyed the repetition of exercises, the immediate feedback from ALEKS and were able to monitor their own progress (Canfield, 2001; Nwaogu, 2012; Serhan, 2017) – a recurrent characteristic that confirmed students' positive attitudes towards ALEKS as reported by the instructors involved in this study. To amplify the effects of the students' positive perceptions of the learning platform and show them that they are being watched over, the instructor on the other end of the platform must assume a different posture.

Unfortunately, when ALEKS was used as a remediation tool or as a principal approach to learning, the instructor's role was limited to assisting students only when needed (Craig

et al., 2013; Hrubik-Vulanovic, 2013; Karner, 2016; Nwaogu, 2012). It would not be surprising in some of the studies that students in ALEKS classes felt they were left alone in a self-taught environment which lacked the interaction between instructors, students, and their peers (Hrubik-Vulanovic, 2013; Serhan, 2017). In Serhan's (2017) study, the instructor was responsible for "guiding students through the learning process, offering assistance when needed, keeping track of students' progress and following up with them to ensure they remain on task and develop their learning throughout the course." (p. 3). However, a recurring theme from an open-ended question in Serhan's (2017) study asking students to list possible disadvantages of ALEKS was "lack of social interaction especially with peers and instructor" (p. 5). Thus, the description of the instructor's role does not sit well with the reported results. When little or no training was provided for instructors involved in AL classes (Aberle, 2015; Mertes, 2013; Platko, 2011; Serhan, 2017), inconclusive results were inevitable. Even with studies that showed positive learning gains in ALEKS classes (Aberle, 2015; Yilmaz, 2017), the instructor's role was not reported.

Ill-defined implementation strategies, inadequate and poor understanding of ALEKS as an approach to instruction, and insufficient knowledge of its features were factors that might have led to inconsistent results, as stated earlier. Added to that is the absence of a discussion on the crucial role that the LA provided by ALEKS can play in personalizing instruction and the limited portrayal of teachers as bystanders, although common sense dictates that they are responsible for interpreting the LA into insights to enrich the students' learning experiences. Equally crucial to the focus on the learner is recognizing the vital role of the instructor enabling the learner to achieve their full learning potential. The absence of these factors as a focus in previous research studies placed ALEKS as an approach to learning at a disadvantage.

In ALEKS classes observed in this study, differences in knowledge and performance among and between students were accepted and celebrated. In fact, the latter represented the backbone of this approach to learning and instruction. In the ALEKS classes, students helped each other, and some acted as shadow teachers, which resulted in an improved learning experience.

> The students will tend to ask those higher fliers sometimes if they're comfortable with them, and there's a good classroom dynamic, "Okay. I'm busy with somebody else; they'll work with him." Also, sometimes I'll say, for instance, "Mohammad, I can't get to Ali. Can you check what his problem is?" (P2)

Beyond the direct meaning that the above quote conveys, it also tells a story about trust and shows learning as a shared responsibility in ALEKS classes – "a triangle" (P1) with its vertices being the instructor, a student, and his peers. This study showed that the students' LA from the AL platform played a central role in improving the classroom dynamics and the interaction between instructors and their students. That being said, the unsung heroes were the instructors who translated these analytics into insights. The learners in this study benefitted the most from individualized instruction, guidance, and feedback from their instructors based on ALEKS reports. Whether a remediation tool or a primary instruction tool, no student should be denied the chance to benefit from the reports generated in ALEKS.

In ALEKS classes, the reports were used to offer help and feedback for students and as a planning and preparation tool for instructors. In consideration of the foregoing, another skill has been highlighted, being the monitor as well as being the instructor. An AL approach to instruction, therefore, depends on the active and engaged presence of instructors who are willing to ascribe to the latter orientation.

In conclusion, the findings in this study supplement the AL landscape with a much-needed lens, the instructors' viewpoints, challenges, and successes. It extends our understanding to cover an essential aspect of ALEKS classes that remained unexplored in previous studies – that is, how impactful and crucial the role of the instructor is. To that end, the next section will reflect on the research questions in light of the findings.

Findings in Relation to the Research Questions

This section is structured around the research questions in this study. The following subsections offer an interpretation of each of the research questions in relation to the findings and the broader literature.

Recall that the research was conducted on many campuses that were part of one of the largest federal institutions in the UAE. The instructors involved in this study taught an introductory mathematics course that aimed to equip students with the knowledge and skills to facilitate their transition to college-level mathematics. This multinational group of experienced educators used an AL platform named ALEKS to cater for the different students' needs in their classes. As such, the research questions tell the story of those instructors, their challenges and successes, and provide the AL landscape with a supplementary lens from the instructors' viewpoints.

Research question 1

The first research question was, "*How is AL being used to assist students in their transition to college-level mathematics*?"

Drawing from related scholarly work, it appeared that the students' past learning experiences were dominated by a teacher-centered and didactic environment where memorization and learning for the test were expected and accepted as a norm (Dahl, 2011; Faour, 2013; Hatherley-Green, 2012; Muysken & Nour, 2006; Raven, 2011; Roberts et al., 2013). The lack of critical thinking and study skills was compounded with deficiencies in English language and mathematics (Dahl, 2011; Hatherley-Green, 2012), which placed these students in the General Education Program.

To deal with a diverse population with varying abilities in mathematics and enhance the students' academic and personal development, the AL platform ALEKS was utilized as a principal approach to instruction. Informed by their students' weak background in mathematics, the apparent consensus was to split each session into a taught component where instructors delivered the content and a practice component using ALEKS. In a hundred minute session, the taught component lasted between 20 to 40 minutes, depending on the instructor's discretion, and the remaining time was dedicated to practice. Apparently, there were attempts before to run the classroom using ALEKS for instruction and practice without the intervention of the instructor, but this approach was not successful. A potential reason might be that the shift from a teacher-centered

environment to a student-centered environment can be troublesome for students with such learning profiles.

According to Hatherley-Greene (2014), who conducted a study at the same institution that inspected the students' transition from school to university, 39 out of 116 students remained in the program and were able to progress into their chosen majors. These students needed a transition period before applying a full-fledged student-centered approach to cross the "cultural borders into college life" (p. 17). In 2011, a similar study at the same institution recommended a step-by-step approach so that students get accustomed to a diametrically opposite orientation to their past learning experiences (Dahl, 2011). Given the aforementioned challenges and recommendations, the semi-structured approach to instruction that was taken by the instructors in this study seemed appropriate.

Evidence showed that the students in this study benefitted the most when they worked in ALEKS during the practice part of the session. Recall that ALEKS places every student on a different learning curve according to the results of the initial assessment. Thus, the differentiated aspect of instruction during the practice component. Instructors reported that students enjoyed the feedback from ALEKS and were content because they can track their own progress and see the results of their work directly from their pie charts – a recurrent aspect depicted from previous studies that inspected the effectiveness of ALEKS in different contexts (Canfield, 2001; Nwaogu, 2012; Serhan, 2017).

In ALEKS classes, students helped each other, and some acted as shadow teachers, which portrayed learning as a shared responsibility and led to a positive classroom dynamic.

According to P5, students often mentioned that they did not learn math only, "but they learned a lot of skills like helping friends." In addition, ALEKS reports were used to monitor students and track their progress. These instances were taken as an opportunity by the instructors to offer personalized guidance and feedback for individuals and small groups of students. According to Hattie and Timperley (2007), "feedback is one of the most powerful influences on learning and achievement, but this impact can be either positive or negative" (p. 81).

> If it's a student who's been stuck on the same question and I can see he's done it one, two, three, four, five times wrong, right, wrong, right, wrong, right, I would go to him, okay, I would look at the questions he got wrong and say, "What happened here? What happened here? Do you know your mistake?" And usually, the students would say, "Okay. I want to do it now myself. Okay. I understand." It's not so much that you have to go and teach the topic or that, you have to point out what it is that they're missing in the question. (P2)

In the quote shown above, the feedback was given straight after P2 noticed from her reports that one of the students was struggling in a specific concept. After a series of successes and failures, it was apparent that the student was not going to master the idea without the instructor's help. Therefore, P2 approached that student and guided him so that he discovered what was wrong. In this instance, a powerful aspect of feedback was recorded – one that tackled "faulty interpretations, not a lack of understanding." (Timperley & Hattie, 2007, p. 102). In addition, useful feedback, according to Nicol and Macfarlane-Dick (2006), is an essential factor that supports self-regulation.

> If they need the help, you are there but I even found the more students get used to using the program, and even I asked them when I see them - and they're looking at the explanation or what it might be, and I said, "Okay. Do you want my help? Do you need my help?" And a lot of time now, they would say, "No. We're okay, sir. We'll work it out." (P3)

In the above quote, P3 noticed how his students became self-reliant and responsible for their own learning. When students are presented with the opportunity to monitor their own progress and benefit from practical and timely feedback, they can become resilient and resourceful self-regulated learners (Nicol & Macfarlane-Dick, 2006; Zimmerman & Schunk, 2001). These positive aspects about learning were not attributed to ALEKS *per se*, instead, to "what ALEKS allowed to happen" (P3).

In conclusion, ALEKS classes provided the opportunity for students to assume a proactive role towards their own learning, monitor their own progress, and offer/receive help when needed. In ALEKS classes, these students were watched over by a group of

experienced instructors that supported their learning using the platform's embedded features. Unlike the students' previous learning experiences, the latter were attributes of an active and positive learning environment. Next, an interpretation of the second research question is offered in light of the findings.

Research Question 2

The second research question was, "*In what ways does AL influence the practices of teachers and their approach to classroom instruction?*"

Despite the fact that the majority of instructors ascribed to a transmission model (Laurillard, 2008), which conveyed a teacher-centric approach to instruction during the taught part of an ALEKS session, evidence showed that learning in ALEKS during the practice part impacted students learning the most. In addition, the students' LA embedded in ALEKS played a crucial role in changing how instructors perceived their roles in AL classes.

Here, there are two distinctive characteristics of the AL platform that should be highlighted. The first was when the initial assessment given in ALEKS drew a baseline for the students' knowledge states and represented a reference point for instructors, as explained in chapter four. The latter was reflected and updated in the students' pie charts as they continued to work in ALEKS. This feature, according to the instructors, marked the distinction between an AL environment and a traditional learning experience. In this study, evidence showed that the results from the initial assessment provided valuable information for instructors about individual students and many times regulated the taught part of the ALEKS session.

The second was when the instructors used the different reports generated from ALEKS to offer individualized instruction, feedback, and guidance for their students. This approach to learning analytics "shares a movement from data to analysis to action to learning." (Chatti, Dyckhoff, Schroeder, & Thüs, 2012, p. 18), with instructors and students being the main stakeholders (Siemens & Baker, 2012).

> If a student is enrolled in ALEKS, 24/7, they are with us. Because whatever they do in ALEKS, it will be seen in ALEKS. So, they are right with us. (P1)

The actionable nature (Chatti et al., 2012; Holmes et al., 2019; Siemens & Baker, 2012) of the students' LA permitted the instructors to monitor their students' interactions with the content in ALEKS and track their knowledge and provided ongoing opportunities for meaningful instructor-student and student-student communications that extended learning beyond the walls of the classroom. Consequently, the emphasis from the majority of instructors on being the monitor who analyzed and acted on the generated data from ALEKS reports. For these instructors, LA played a significant role and provided vital insights into the performance of the learners in their classes (Siemens & Long, 2011). Such a conceptualization of the role of the educator requires a different approach when researching AL, and this means the instructor must be considered as an orchestrator, not a parameter that can be overlooked. In considering the notion of LA as orchestration tools (Martinez-Maldonado, 2016; Mavrikis et al., 2019), evidence suggests that the instructors in this study showed great appreciation of these tools due to their ability to support individual students' needs as well as an entire classroom.

In assuming that active and engaged posture during the practice part of an ALEKS session, instructors had to relinquish much of the control that they assumed during the taught part. Recall that instructors used terms like '*less dominant*', '*stepping back'*, '*more freedom*', and '*less control*' to indicate how their perceptions changed when they used ALEKS.

> And I think my thing is, for me, it was a control thing, letting go because I've learned now that, for example, I love noise in my lesson. I encourage noise in my lesson. Whereas back when I first started out and I guess less experienced, the last thing I wanted was noise because noise equated to you don't have control. And if you don't have control, the students are not learning. If the students are not learning, then you're a bad teacher. So, it was always about that control. (P3)

Indeed, control must be relinquished as it is one of the essential factors that hinders a successful integration of technology in the classroom (Lai, 2011; Pavlik, 2015). In this study, many indicated that ALEKS was a significant improvement when compared to the way they approached instruction before. However challenging the shift from traditional to adaptive was for some of these instructors; it transformed in varying degrees how they viewed their roles in an AL environment.

Research Question 3

The third research question was, "*How can AL most effectively be used to optimize the classroom learning experience?*"

The theoretical framework that underpins this study represents a pedagogy-derived framework and a distillation of the central educational literature and learning theories developed over the last century (Laurillard, 2013). Laurillard's CF enables a critical evaluation of technology, digital or otherwise, according to its ability to enable the teaching-learning cycle.

> Adopting this approach, we could see technology as the means by which teaching professionals could discover how to use technology to achieve the ambitions inherent in our education policies. This means using technology to solve a specific problem, not finding the problem that technology is a solution for (Laurillard, 2008, p. 28).

In critiquing ALEKS as an approach to classroom instruction, the CF is beneficial because it exemplifies an education-driven approach and sheds light on the critical role of the instructor in such an environment. In contrast with previous studies on ALEKS, this approach places the instructor at the heart of the event and not on the side. Laurillard reminds us that in "terms of the actors in the teaching and learning process, it is important to represent the teacher, the learner, and the learner's peers" (2009, p. 8). The CF encompasses learning through acquisition, inquiry, discussion, practice, collaboration, and production, as illustrated in figure 3. An optimal learning environment combines all six learning types (Laurillard, 2013).

When the ALEKS experience was inspected using the CF in this study, it led to a comprehensive evaluation.

Learning through acquisition was dominant during the first part of the ALEKS session when instructors assumed the responsibility for the delivery of the content. This conventional approach in formal education meant that students played a relatively passive role in the construction of knowledge transmitted by the instructor (Julie et al., 2010; Lai, 2011). Important to mention that learning through acquisition was targeted towards completing the weekly quotas from the topics in ALEKS. Here, instructors did not take into consideration the fact that a portion of their students was either well ahead with the material (high achievers) or struggled with the content (low achievers). As this approach to instruction targeted the common denominator, the outliers might have been disadvantaged by that initial approach.

> I'd prefer to let them go ahead, and when they're stuck or when I can see they're stuck, even though they're not telling me I can see the report, intervene at that stage. In a class of 27, I feel that if I'm at the board answering a question, I might have the attention of eight of them or a third of the class. The rest are pretty much doing what they want. (P2)

> It's not just a case of the students do everything by themselves. There are times where I will-- as I said, I will look at those reports and say, "Okay. There's maybe a group of six students who've tried this topic, or they've done their best, but they just don't get it." Then, yes. I would say to them, "Okay. Gentlemen, first, just for two minutes, I just need you to just listen to me. (P3)

In this study, two instructors did not ascribe to the norm because they approached ALEKS differently. P2 and P3 utilized the reports to guide instruction in their classes and allowed more freedom for their students to interact with the content presented in ALEKS. Therefore, the teacher communication cycle for P2 and P3 was enacted by the LA from ALEKS while the same cycle was approached traditionally by the majority. For P2 and P3, the needs of the learners were prioritized, while for the majority, precedence was

given for the delivery of the content. Using an AL platform like ALEKS means letting go of the one-size-fits-all approach in favor of a more personalized aspect of learning.

> The principal contrast between conventional and digital learning designs should be that the technology facilitates the shift from teacher-focused to learner-focused activities that we see represented in the Conversational Framework: the continual iteration between theory and practice, learner and learner, and learner and teacher, on both levels. Making the best of the technology means exploiting these features, not simply using the digital to emulate the conventional. (Laurillard, 2009, p. 15)

Examining the AL environment from the lens of the CF allows us to explain in more significant details how learning was approached and delve deeper into the teaching and learning experience where one of the central questions turns out to be "How can the LA from ALEKS be further exploited to assist the enactment of the various learning types and learning cycles within the CF?"

LA from the Lens of the CF

Wedding the notion of LA as orchestration tools to the kind of learning that the CF advocates allows us to "shift away from a narrow data-centric view of analytics towards a consideration of the pedagogical and human factors in play" (Mavrikis, et al., 2019, p. 2922). Thus, positioning the LA from ALEKS in service of pedagogy requires a careful consideration of how these orchestration tools impacted the teacher-learner relationship from the lens of the CF. What falls below, then, is an adaptation of the of the CF with an emphasis on the various aspects of learning enacted from the incorporation of LA as orchestration tools.

In the teacher practice and modeling cycle (TPME), Laurillard (2013) emphasizes the importance of the different iterations necessary for the learner to make the internal connections and to generate and modulate their practice and concepts. With enough of the right internal cycles, learning begins to develop, Laurillard (2013) asserts. One of the notable adaptations in light of the findings is replacing ALEKS with the TPME in the CF as illustrated in figure 6. Beyond the initial course set-up, ALEKS uses the Knowledge

Space Theory to create a unique learning path for individual students based on the results of their initial assessment. The uniqueness of the learning path and continuous knowledge check that ALEKS uses to verify that the topics learned were retained are aspects of the AL platform that were not designed to be manipulated by the instructor. Therefore, another notable adaptation is where the ALEKS-Learner Communication Cycle replaces the Teacher Practice/ Modelling Cycle in the CF.

> …the system takes on to evaluate, reevaluate, assign, reassign, suggest. The system will suggest, "Okay. You're having difficulty with this level question, please check page five and six in the textbook," or "Here is an extra resource that you can go and tap on and look into these ideas." So adaptive learning is like a car but with wings. (P7)

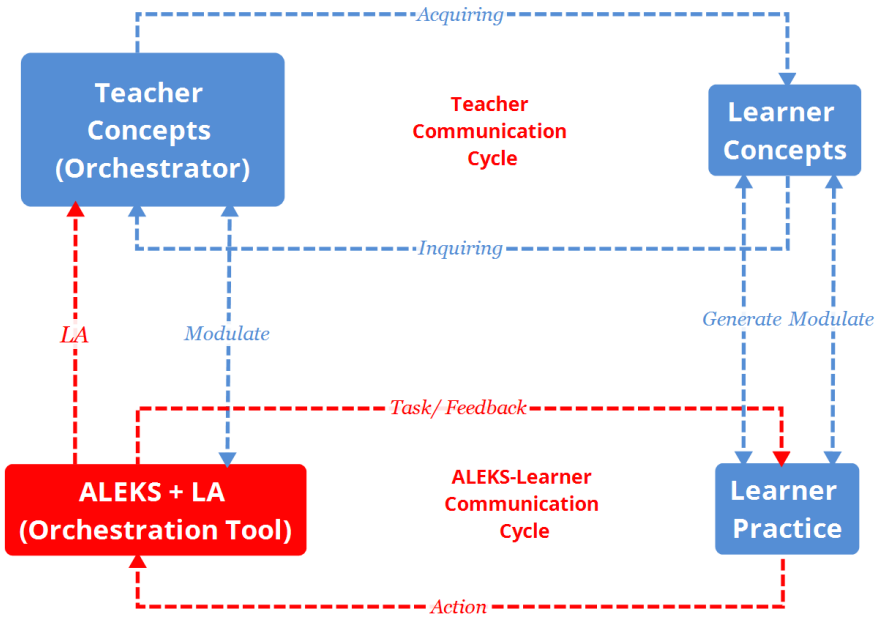

Figure 6. An Adaptation of the CF in Light of the Findings

In this cycle, ALEKS communicates a set of topics that the student is ready to learn and indicates relevant resources in each topic (explanation, e-book, and videos) for students to utilize (P7). Upon the successful completion of a set of exercises, ALEKS adds the learned topic to the student's pie chart, which represents the student's current learning state. If unsuccessful, ALEKS adjusts the student's learning path accordingly. This intelligent environment can reduce (to an extent) the instructor's load and enables the

learner to "learn without being taught" (Laurillard, 2013, p. 90). However, this does not mean that the instructor's role is limited to a spectator's waiting for learning to happen. On the contrary, the instructor is actively engaged in the process through the seamless feed of LA from ALEKS in the form of various reports (Teacher concepts ↔ ALEKS+LA). In this study, the learner-ALEKS dialog was amplified by the presence of an active instructor who monitored, analyzed, and intervened based on the continuous stream of LA from ALEKS, as shown in figure 6.

The '*Time & Topic*' report, for example, allowed the instructors to monitor their students' activities in ALEKS. This report shows the total time spent in ALEKS, the number of topics mastered, and the number of topics attempted but not mastered for any desired time frame. When the report shows that student X, for example, attempted five topics but mastered only 2, the instructor can identify the specific topics that were not mastered and look at the student's attempt for each question. In another scenario, student Y spent the last 15 minutes in the learning mode but was not able to master any topic yet. The latter scenario might indicate that the student needs help or he is trying to game the system, which triggers an immediate action from the instructor. In using this report, the instructors in this study were able to intervene and offer one-to-one instruction for individual students as well as leading small group discussions based on the LA from ALEKS. Hence improving the teacher communication cycle in the CF and harnessing the power of LA to orchestrate various learning activities that tackled different learning types (e.g., acquisition, discussion). The insights gained from the LA as a consequence of using this report made visible specific aspects of student learning and allowed the instructor to act accordingly (Martinez-Maldonado, 2016; Mavrikis & Holmes, 2019).

On a class level, the '*ALEKS Pie*' report provides an overview of student learning. It also presents a detailed count of the topics that students are ready to learn, and which students are ready to learn them arranged in descending order. This report aided the instructors in identifying the high achieving students who were ahead of the rest early on in the semester. Many instructors talked about how high achievers acted as shadow teachers and became a reference for their peers. By having access to their peer's concepts, learners are able to modulate their own ideas, their practice, and generate actions. These are portrayed

in the peer communication cycle and the peer modeling cycle in the CF. An increase in the learner's pie scores, as a result, could be interpreted as a reflection of learning within the last two cycles. In addition, the same report helped the instructors in this study to form different groups and targeted their instruction according to the topics that their students were ready to learn. The different interpretations of the LA from the 'ALEKS Pie' report impacted how students communicated together and portrayed learning as a dynamic activity. In sum, this synergy between the instructor and ALEKS produced a combined effect greater than the sum of their separate effects (Baker, 2016; Holmes, Mavrikis, Hansen, & Grawemeyer, 2015).

Offering this explanatory account from the lens of the CF leads to an improved articulation of how the different aspects of learning were enacted in an AL environment. With the seamless flow of LA, the instructor is the orchestrator who reads, analyzes, interprets, and acts. Being education-driven, the CF presents an immense opportunity for an interpretation of LA as orchestration tools with a focus on enacting the different learning types and enhancing the various learning cycles in the classroom.

Summary

Shortcomings in previous studies have prevented us from understanding what it takes to learn and what it takes to teach in an AL classroom setting. The lack of a proper discussion on the role of the LA and the instructor placed ALEKS as an approach to learning at a disadvantage when compared to a traditional classroom experience. The five emergent themes in this study painted an image of an AL journey that started and ended in the classroom. In contrast with earlier research, this study sends a powerful message about the importance of the LA and the instructor's role in an AL environment.

Using the AL technology to enable the learner to achieve their full potential should be underpinned by the notion that one size does not fit all. This discussion supported that belief by showing how impactful learning was when students worked in ALEKS. In addition, the instructors in this study assumed a posture that was not visible in earlier studies. Using the LA from the AL platform to cater to the individual needs of the learners in their classes was highlighted as a vital component of the instructor's role in ALEKS classes. Being the ones who interpreted the platform's LA into insights, the

instructors in this study were portrayed as orchestrators who acted as monitors and offered feedback and guidance for their students.

The discussion showed that AL could provide the ground for a transformative learning experience for students and instructors alike. The earlier explanatory account from the lens of the CF led to an improved articulation of how the different aspects of learning were enacted in an AL environment. It is essential, therefore, to supplement the latter explanatory account with an exploratory account that discovers ways in which we can translate the LA into the different types of learning that the CF advances. In that sense, educators could be understood as facilitators, enablers, designers, and competent users of digital technologies in their classes.

This study sheds light on two vital areas that were absent previously, the LA as orchestration tools in an AL approach to instruction, and the importance of the instructor's role. The use of the CF as a theoretical framework provided further insights into the kind of learning that took place in ALEKS classes. Next, the conclusion will provide a summary and a critical evaluation of the entire research study where recommendations and further research areas will be highlighted.

Chapter 6

Conclusion

Introduction

This chapter offers a set of concluding statements and recommendations. The analysis and interpretation of the findings will be integrated to provide a synthesis that extends the AL landscape beyond the inconclusive and sometimes contradictory results found in previous studies. The use of the CF as an overarching theoretical framework yielded a better articulation of how the different aspects of learning were enacted in an AL environment. This chapter, as a result, continues to explore ways in which instructors could get the most out of the LA to support the different learning types and cycles within the CF.

This chapter starts with a summary of the research study, its purpose, methods, and results. Following on, a critical evaluation of the study that highlights the added value of the CF. The limitations of the study will be discussed, followed by recommendations with regard to policy, practice, theory, and subsequent research. This study concludes with a reflexive account.

A Summary of the Research Study

This study complemented the existing body of research by highlighting the crucial role of the instructor in an AL classroom setting. It illustrated how instructors were able to use the LA from ALEKS to provide students with a better learning experience. The results showed how important it is for instructors to have a sufficient understanding of the various features of ALEKS and its limitations. In addition, the use of the CF as an overarching theoretical framework provides "a renewed understanding of what education requires" (Laurillard, 2013, p. 69) of this approach to learning by indicating the types of learning that were enacted in ALEKS classes.

As such, this qualitative case study conveyed a vibrant message in the instructors' own voices and explored in subtle detail how a specific group of instructors in a HEIME dealt with ALEKS as a primary approach to instruction. It comprised ten interviews with

instructors and seven classroom observations across many geographical locations within the parent institution. This unique group of multinational instructors used ALEKS as a principal approach to instruction to enhance the academic and personal development and facilitate the transition of their students to their programs of choice. To that end, the six phases in Braun and Clarke's (2006) thematic analysis approach allowed the formulation of overarching themes and sub-themes that assisted in answering the research questions for this study.

The discussion and interpretation of the findings in chapter five exemplified the multi-layered and intricate nature of an AL classroom environment. It underlined that the effectiveness of ALEKS would be diluted if used only drilling and practicing. It also indicated that the student module and the instructor module are interwoven together and showed how the students' LA in ALEKS has contributed towards a positive classroom dynamic and enhanced student-instructor and student-student interactions. More importantly, the anonymous heroes were the instructors who interpreted these analytics into insights that improved the students' learning experiences in ALEKS classes.

Critical Evaluation and the Added Value of the CF

The use of the CF as a theoretical framework added another dimension to this study and provided further insights into the kind of learning that took place in ALEKS classes. The discussion chapter showed that learning was more impactful when students worked in ALEKS. During that part of the session, the LA from ALEKS to the instructor and just-in-time feedback from ALEKS to the students improved the instructor communication and modeling cycles. In fact, control leaned towards ALEKS and the learner, which indicated that the task/ feedback from ALEKS was tailored to the needs of the individual since every learner was on a different learning curve.

Important to mention that these instructors reacted to the data generated from ALEKS to further support their students. Also important to note that the instructor could improve the peer communication and modeling cycles rather than just letting it happen. Creating computer-supported learning designs using the students' LA in ALEKS is the added value of the instructor, not only just imparting knowledge and standing by while students teach themselves.

> Technology works best when it has to meet a challenge; and worst when it is a solution looking for a problem…rather than start with what the technology has to offer, we start with what learners might need. (Laurillard, 2008, p. 6)

The added dimension, therefore, is to what extent can the instructors using ALEKS activities to support the different learning types and communication cycles that are advocated in the CF. Therefore, moving from ill-defined and technology-driven implementation strategies towards an education-driven approach to AL turns into the real challenge. For example, we can rely on the '*Ready to Learn*' report to create specific groups within ALEKS based on the topics that the students are ready to learn and design a collaborative learning activity for different groups in the classroom. ALEKS forum is a place where students can share ideas, which can be used to support various activities. The above report can also be used to promote learning through inquiry. By extension, students can show what they've learned by increasing their pie scores, which can be considered as a form of learning through production since it signifies the individual scores of every student.

Educators, therefore, can decide on how to use what they know about students to target different aspects of learning found in the CF. In addition, instructors can share individual progress reports and allow students to reflect on their progress and let them design their learning plan accordingly. There are a lot of possibilities when the LA from ALEKS is used to promote the kind of learning that the CF supports.

> Teaching is more like a design science because it used what is known about teaching to attain the goal of student learning, and uses the implementation of its designs to keep improving them. (Laurillard, 2013, p. 1)

When actively engaged in creating a model for learning in ALEKS classes, instructors could be portrayed as facilitators, enablers, designers, and competent users of AL technology in their classes. That being said, such a conceptualization of the role of the educator requires an approach to teaching as a design science (Laurillard, 2013).

Presenting the CF as a framework for instructors to translate the LA from an AL platform into insights requires continuous training, support, and the freedom to explore. This means that instructors should be encouraged to acknowledge the importance of the LA in ALEKS, as an initial step. Next, they should be trained on how to transform these analytics into concrete learning designs that support the various learning types and enhance the different communication cycles in the CF. Contrasting the advantages of the latter approach with a more traditional learning experience might inspire instructors to take a step forward towards a more learner-focused environment. This requires change in practice and conceptions from instructors and continuous support on an institutional and departmental level. Undoubtedly, the role of the instructor will have to evolve as this study showed. Teacher training programs and workshops might benefit from a scenario-based approach whereby educators are presented with different reports based on a particular point in time and assist them in designing a learning session using the LA from ALEKS. These designs can then be shared and enhanced, which supports the notion of teaching as a design science.

Generalizability and contribution to practice

This study sheds light on an area that has been so far neglected by the existing research on ALEKS. The role of the teacher as an orchestrator, in light of the findings, is crucial to the wellbeing of the learners and the learning environment. According to Dillenbourg and Jermann (2010), "orchestration has a different flavor: teachers are not on the side, they are the conductors, they are driving the whole activity" (p. 3). The teachers in this study benefitted from a suite of LA that amplified the effects of learning in their classes. Future research on ALEKS and ITSs should be mindful of the symbiotic relationship that should exist between the teachers and the AL platform.

Besides, this study offers a set of scenarios for the use of LA from ALEKS reports that facilitate the challenging role of the teacher as an orchestrator. Namely, the *Progress Report* for class management and intervention, and the *ALEKS Pie* report for direct instruction, grouping, and feedback. These can be used irrespective of the mode of ALEKS deployment in the classroom. In the teachers' voices, these tools are fundamental for a thriving learning environment. Therefore, emphasizing the strong connection

between classroom orchestration and LA as orchestration tools. These usage scenarios included in this study are somehow similar to the ones portrayed in du Boulay (2019) and Holstein et al. (2017) about their work on ITSs, which can be considered as efficient as a classroom assistant. The initial ideas upon which this study is founded are also similar to the work of Prieto et al. (2011) on orchestrating CSCL activities and Mavrikis et al. (2019) on the use of LA to support the challenging role of the teacher in an exploratory learning environment. Important to mention that this body of research acknowledges the importance of LA in the service of pedagogy. This study agrees and, in addition, advances the CF as a means of translating LA into insights that serve the different learning types and communication cycles within the framework. Laurillard (2008) states that "technology works best when it has to meet a challenge; and worst when it is a solution looking for a problem" (p. 6). The LA community, it seems, advances steadily to meet that challenge.

Limitations

Contrary to the dominant positivist approach found in the literature around AL and ALEKS, the instructor's role deserved to be acknowledged and explored in subtle details. Therefore, I felt compelled to tell the story of the instructors who used this approach and recount how they used the LA provided by ALEKS to enable the different learning cycles in their classes. Given that the majority of research studies on AL came from schools and colleges in the USA, this study draws evidence from an entirely different culture and context.

One of the limitations of this study originates from the choice of methodology, as the findings from a single case study may not often be generalizable (Cohen et al., 2011; Merriam, 2014; Yin, 2014). However, generalization/ replication was not the focal point in this qualitative case study. In fact, its greatest strength is that it sheds "empirical light about some theoretical concepts or principles" (Yin, 2014, p. 40) – the importance of the LA and the crucial role of the instructor translating these analytics into insights to enrich the students' learning experiences. Moreover, articulating the specific types of learning that materialized in ALEKS classes using an education-driven theoretical framework as

an evaluation and extension tool. According to Stake (1995), "people can learn much that is general from single cases" (p. 85).

Another limitation originates from the choice of the bounded unit of analysis and sampling technique used in this study. For the purpose of obtaining in-depth information on the role of instructors and the classroom experience, I used purposive sampling to include those who taught the only mathematics course that used ALEKS and has been in the system for a minimum of one semester (the bounded unit of analysis). This sampling technique, therefore, yielded a small number of participants, which is considered as a limitation. In addition, the findings reflected the viewpoints of those who agreed to take part in the study and others might have had different perspectives. That being said, the accounts of the instructors involved in this study represented, to a large extent, those who are proficient users of ALEKS and have used the platform as a principal approach to instruction for many years.

Recommendations

All the instructors involved in this study acknowledged that their students were on different learning curves in ALEKS classes. Yet, the majority used the first part of the session to teach for the common denominator, which placed the high and low achievers at a disadvantage. This approach might have been beneficial for the first two or three weeks in the semester when students were in the process of learning how to use ALEKS for the first time. However, the more students become conversant with the AL platform, the more counterintuitive it becomes to maintain that approach. Instructors in this study could have benefited from staging their instruction based on the LA in ALEKS.

The '*ready to learn*' report, for example, gives a clear indication to where students are in terms of the content. There are many variations to how instructors could have used this report. For instance, instructors could have approached this report differently to design a collaborative learning environment for the majority while allowing freedom for the high achievers to progress on their own as a group. Instructors might want to choose direct instruction for those who need more guidance. The consensus among the instructors in this study that one size does not fit all should have encircled the whole ALEKS session and not only the practice part.

> Faculty still commonly object, for instance, to the ways in which adaptive learning alters the process and practice of teaching. Other concerns revolve around the complexity of using these products and the added workload (Bryant, 2016, p. 6).

Knowledge of ALEKS features was highlighted as a crucial attribute for a successful learning experience (know-what). Understanding what ALEKS does should be supplemented by specific strategies that exploit how to benefit from the LA to promote learning (know-how) (Mavrikis et al., 2019). This study advanced the CF as a natural progression of the kind of learning environment that is impactful, be it adaptive or otherwise. The discussion in chapter five showed that an AL classroom environment required fundamental changes in how instructors perceived their roles. Therefore, this study should be supplemented by further research into the role of the instructor in turning the LA into insights. Successful implementation strategies depend on how instructors view their roles in Al environments and their ability to work with the AL platform, among other factors. Decision-makers and institutions should be mindful of these factors in order to provide the support that goes beyond the know-what.

> Adopting mastery approaches to learning, where learners aim to improve on their previous performance and continue to develop their knowledge and skills without reference to the progress of other learners, enhances motivation (Hallam, 2005:24).

Motivation to learn was one of the advantages cited by the instructors in ALEKS classes – what ALEKS allowed to happen. In this study, students were motivated when they were able to monitor their own progress and see how their pie scores increased as a result of their hard work. This is an essential aspect of an AL environment, and future research should explore further elements that are related to motivation in AL classes.

Reflexive Account

My intention in this reflective account is to endorse Malterud's (2001) call to make visible my background in relation to the topic under investigation, and highlight my position as a future practitioner-researcher.

I developed an early interest in AL as an approach to instruction during my taught modules of study at the University of Liverpool (UoL). The various assignments and the collaborative learning activities within each of the nine modules in the Doctoral program enabled me to develop a deeper understanding of learning within a higher educational setting. In addition, the focus on pedagogy and the social environment of learning in many modules influenced my approach to instruction using ALEKS.

In parallel, I have been using ALEKS in different courses at my workplace and became a part of a diverse cultural community of enthusiasts that shared the same purpose – exploring the full potential of this approach to instruction. For this group of practitioners, the main concern was how to take advantage of ALEKS to bring our students in foundations courses to par with direct entry students. Together, we experimented, shared our experiences, and learned from each other. The traits shared within this group represented the defining characteristics of a community of practice; the domain, community, and practice (Wenger, 1999).

Informed by my own practice and the breadth and depth of knowledge that I have been exposed to during my study modules at UoL, I started exploring relevant literature and building a repertoire of research studies on AL, and ALEKS specifically. In doing that, I benefited from the presence of two communities of practice that shaped my identity – a group of practitioners that used ALEKS to improve learning at my workplace, and a community of peers and mentors at UoL that addressed issues pertinent to theory, research and practice. Central to my thinking has been the question of how to bring together the practitioner role that I have been assuming with the researcher that I aim to become. Wenger (2010) asserts that learning transcends "acquiring skills and information; it is becoming a certain person - a knower in a context where what it means to know is negotiated with respect to the regime of competence of a community." (p. 2). For me, this communicative-reflective cycle, and overlap, of learning within these two communities has enabled the gradual shift from a practitioner to a practitioner-researcher (C. Taylor & Hicks, 2009).

Negotiating the time and place of the interviews with the instructors required a lot of effort and persuasion. At times, I thought that I would not be able to recruit the necessary

number of candidates for my study. However uncertain these instants were, I appreciated and enjoyed every moment that I spent listening to these participants, their stories, the challenges they encountered, and their successes. It was a genuine "social encounter, not simply a site for information exchange" (Cohen et al., 2011, p. 410). These instructors were trying to discover, through trial and error, the best approach to promote learning in their classes. I felt the satisfaction they displayed when they were able to provide feedback or differentiated instruction for their students. Many told me after the interview that it was an excellent opportunity for them to reflect on their roles in AL classes. I felt the same too!

The stories of these instructors deserve to be expressed in the best way possible. Embracing that heavy burden, I believe, became a part of my role as a practitioner-researcher. Now that I conclude this study, I have a renewed appreciation for my new role and a commitment to extending the AL landscape through the insights I gained from this study within the institution and elsewhere.

Summary

The collective evidence from previous research has been inconclusive in regard to the benefits and impact of AL on students' learning and progress (D. Johnson & Samora, 2016; Murray & Pérez, 2015; Tesene, 2018). The focus on the learner, as depicted in previous studies, however necessary, should not deter us from acknowledging the vital role of the instructor empowering the learner to attain their full learning potential. Therefore, the study's main aim was to make visible the role of the instructor in ALEKS classes and highlight the importance of LA as an influencing factor that can contribute to a better learning environment. In doing that, I aim to pave the way for further research on how instructors see their roles in AL classes and discover ways in which they support their students in such an environment.

Utilizing the CF as a theoretical framework in this study provided further insights into the kind of learning that took place in ALEKS classes from an education-driven perspective. In an AL environment, creating computer-supported learning designs using the students' LA in ALEKS is the added value of the instructor, and this requires a change in practice and conceptions. Therefore, the CF revealed how impactful learning would be when

translated into what the students need to be successful, lifelong learners. This renewed understanding of the possibilities that AL environments bring deserves to be explored in greater detail in different contexts. In specific, translating the LA from the AL platform to support the various learning types and communication cycles within the CF.

This study showed that in ALEKS classes, instructors were able to provide just-in-time feedback and guidance and monitor and track their students' progress. This, in turn, led to the positive classroom experience, unlike what their students endured during their school years. Empowering instructors by providing proper training and support is a must in order to improve the students' learning experiences at the college level and beyond.

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APPENDIX 1

Virtual Programme Research Ethics Committee Approval

Dear Ziad Rafhi,				
I am pleased to inform you that the EdD. Virtual Programme Research Ethics Committee (VPREC) has approved your application for ethical approval for your study. Details and conditions of the approval can be found below.				
Sub-Committee:		EdD. Virtual Programme Research Ethics Committee (VPREC)		
Review type:		Expedited		
PI:				
School:		Lifelong Learning		
Title:		Building on the Affordances of Adaptive Learning Technologies: The experiences of Mathematics Faculty in the Foundations Year Program		
First Reviewer:		Dr. José Reis Jorge		
Second Reviewer:		Dr. Arwen Raddon		
Other members of the Committee		Dr. Lucilla Crosta, Dr. Kalman Winston,		
Date of Approval:		1/03/2018		
The application was APPROVED subject to the following conditions:				
Conditions				
1	Mandatory	M: All serious adverse events must be reported to the VPREC within 24 hours of their occurrence, via the EdD Thesis Primary Supervisor.		

This approval applies for the duration of the research. If it is proposed to extend the duration of the study as specified in the application form, the Sub-Committee should be notified. If it is proposed to make an amendment to the research, you should notify the Sub-Committee by following the Notice of Amendment procedure outlined at http://www.liv.ac.uk/media/livacuk/researchethics/notice%20of%20amendment.doc. Where your research includes elements that are not conducted in the UK, approval to proceed is further conditional upon a thorough risk assessment of the site and local permission to carry out the research, including, where such a body exists, local research ethics committee approval. No documentation of local permission is required (a) if the researcher will simply be asking organizations to distribute research invitations on the researcher's behalf, or (b) if the researcher is using only public means to identify/contact participants. When medical, educational, or business records are analysed or used to identify potential research participants, the site needs to explicitly approve access to data for research purposes (even if the researcher normally has access to that data to perform his or her job).				
Please note that the approval to proceed depends also on research proposal approval.				

Kind regards,

Lucilla Crosta

Chair, EdD. VPREC

APPENDIX 2

Participant Information Sheet

Participant Information Sheet

You are being invited to participate in a research study about adaptive learning ALEKS that is currently being used to deliver LSM-1000. As you know, **A**ssessment and **LE**arning in **K**nowledge **S**paces is a Web-based, artificially intelligent assessment and learning system (www.aleks.com). This approach to learning is currently being used only in the mathematics course that you are teaching. Before you decide whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and feel free to ask us if you would like more information or if there is anything that you do not understand. We would like to stress that you do not have to accept this invitation and should only agree to take part if you want to.

Thank you for reading this.

1. **Title of Study**

   Building on the Affordances of Adaptive Learning Technologies: The experiences of Mathematics Faculty in the Foundations Year Program

2. **What is the purpose of the study?**

   Adaptive learning (AL) technology is a promising field where published research is at its infancy. Past and current research reveal a significant gap in our understanding of the role of teachers and how they adapt to this relatively new approach to learning. This case study aims to understand and describe in detail the nature of the experiences of instructors involved in teaching mathematics using adaptive learning technology (ALEKS) in a higher educational institution in

UAE. Findings from the case study will inform the changes needed in the mathematics curriculum and teacher training program at the institution, and elsewhere.

3. **Why have I been chosen to take part?**

   You have been chosen to take part of the study because you are involved in teaching a mathematics course (LSM-1000) using adaptive learning (ALEKS).

4. **Do I have to take part?**

   We would like to stress that you do not have to accept this invitation and should only agree to take part if you want to. Please note that participation is voluntary and that participants are free to withdraw anytime without explanation and without incurring a disadvantage. We would like to stress that the researcher is not associated with your department and program of study and does not teach the math course under study.

5. **What will happen if I take part?**

   The research study investigates the use of ALEKS in a classroom setting. A single case study approach will be used where the faculty using AL in a single mathematics course at a higher educational institution in the Middle East will be the focus of the study. The instructor's role and the richness of the classroom experience deserve to be portrayed and explored in subtle details. Therefore, Interviews, classroom observations, and documentary information will be the primary data collection methods for the case study.

   If you agree to take part of the study, you will be asked to invite the researcher, Ziad Rafhi, to attend one of your classes to observe how adaptive learning is being used in a classroom setting. You will also be asked to print out a couple of class reports provided by the platform (ALEKS) prior the class observation. A copy of the observation sheet will be provided when you agree to participate in the research study. Please note that the researcher will not participate in any way during the observation (non-participant observer). After concluding the classroom observation, you will be asked to sit for an audio recorded interview that will last for 40-50 minutes. Because the targeted population is relatively small, you are

encouraged to treat this information as confidential and respect the privacy of those you think they are participating in this research study.

6. **Are there any risks in taking part?**

   we appreciate the time that you will allocate for this research out of your busy teaching schedule. You can expect to spend between 40-50 minutes in the interview. There is a minimal risk that your students may become confused about the nature of the observation. However, you will be able to explain that during the classroom observation, the researcher will be a non-participant observer and that the observation is only concerned of how the adaptive learning platform works in the classroom and their performance is not being observed.

7. **Are there any benefits in taking part?**

   The aim of the study is to make visible the role of the instructor in adaptive learning classes. You will be part of a project that benefits the research community, instructors, students, and institutions that are involved/ considering adaptive learning platforms. Also, your participation will shed light on an important topic where research is in its infancy. By taking part in the research, you may learn more about how to use adaptive learning more effectively. The researcher will be happy to provide some of the key readings on the conversational framework that is being used to evaluate adaptive learning plus information on where you can learn more about ALEKS. A PowerPoint presentation that will highlight how adaptive learning is currently being used in the world will also be provided.

8. **What if I am unhappy or if there is a problem?**

   If you are unhappy, or if there is a problem, please feel free to let us know by contacting the researcher, Ziad Rafhi on 0505269122 or email at ziad.rafhi@hct.ac.ae. You can also contact my supervisor, Dr Eileen Kennedy through email at Eileen.kennedy@online.liverpool.ac.uk and she will try to help. If you remain unhappy or have a complaint which you feel you cannot come to us with then you should contact the Research Governance Officer at liverpoolethics@ohecampus.com or call the US number 001-612-312-1210.

When contacting the Research Governance Officer, please provide details of the name or description of the study (so that it can be identified), the researcher(s) involved, and the details of the complaint you wish to make.

9. Will my participation be kept confidential?

All data related to your participation will be kept anonymous and confidential at all times. As mentioned in the consent form document, data from the classroom observation and interview will be coded so that it won't reveal any information related to identity or location. For example, a pseudonym will be used instead of your real name in all notes and the publication of any findings.

All data will be stored on my personal computer and backed up on an external hard drive. It is important to note that these will be password protected with access restricted to the researcher where data will be stored for 5 years before it gets destroyed. The researcher will use an audio recorder and a laptop recorder as a backup. These belong to the researcher. The audio recording will not specify the name or the location of the participant. After the interview, data from the audio recorder will be transferred to the laptop and deleted from the audio recorder. The laptop will be password protected and the name of the file will be coded. Codes will be random for an extra layer of security.

10. What will happen to the results of the study?

Results from the research study will be made available by the researcher in the form of a thesis document. The results will potentially be published through journal articles. Upon request, the researcher will be happy to share these with the participant through email. Participants will not be identifiable in any case or under any circumstances.

11. What will happen if I want to stop taking part?

Note that participation is voluntary and that you are free to withdraw at any time without giving any reason and without your rights being affected. Please understand that, under the Data Protection Act, you can at any time ask for access to the information you provide and you can also request the destruction of that

information if you wish. However, the results may only be withdrawn prior to anonymization.

12. Who can I contact if I have further questions?

In case you have any questions, you can contact the researcher using the information below.

Researcher: Ziad Rafhi

Address: Al Reef Villas, Desert Community, street 1, villa 54, Abu Dhabi, United Arab Emirates

Mobile: +971505269122

Email: ziad.rafhi@online.liverpool.ac.uk

ziad.rafhi@hct.ac.ae