INSTRUCTIONAL CHANGE IN ENGINEERING EDUCATION: A CONCEPTUAL SYSTEM DYNAMICS MODEL OF ADOPTION OF RESEARCH-BASED INSTRUCTIONAL STRATEGIES IN THE CLASSROOM

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ACADEMIC ABSTRACT

The overall goal of this study was to better understand how the academic system affects change in instructional practices, referred to as instructional change, in engineering education. To accomplish this goal, the main objective was to create a conceptual System Dynamics Model (SDM) that illustrates how the factors in the academic system interact dynamically to drive or hinder faculty motivation to adopt Research-based Instructional Strategies (RBIS) in their courses. To develop the model, I used a qualitative process that combined research literature with data gathered at an Engineering Department in a South-American country.

To create the model, I used an approach designed to understand and manage a complex system. The model was constructed through an iterative process of three phases: 1) a theoretical Causal Loop Diagram (CLD), 2) an empirical CLD, and 3) a conceptual SDM. Phases 1 and 2 aimed to generate hypotheses for the causal relationships between the factors that affect faculty motivation to adopt RBIS. The theoretical CLD, consisting of 8 reinforcing and 6 balancing causal loops, was based on a systematic review of the literature on instructional change and adoption of teaching strategies in higher education, whereas the empirical CLD, consisting of 10 reinforcing and 13 balancing loops, was based on data collected in semi-structured interviews and a focus group with purposefully selected participants in the selected site. Both CLDs in the first two phases were integrated into a conceptual SDM.

The intellectual merit of this study was to offer a different answer to the calls for change in engineering education toward increasing the pedagogical quality of our learning environments by increasing the adoption of RBIS in classrooms. Noting that previous instructional change initiatives have yielded low to moderate success, I offer another approach to this problem. I argue that this low success is explained because
effective instructional change requires a perspective that accounts for the complex nature of academia. This study provides an understanding of instructional change by using SDM as a system perspective that shows the interactions of elements within a complex system that ultimately influences faculty to adopt RBIS in their courses.
INSTRUCTIONAL CHANGE IN ENGINEERING EDUCATION: A CONCEPTUAL SYSTEM DYNAMICS MODEL OF ADOPTION OF RESEARCH-BASED INSTRUCTIONAL STRATEGIES IN THE CLASSROOM

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GENERAL PUBLIC ABSTRACT

The overall goal of this study was to better understand how the academic system affects change in instructional practices, referred to as instructional change, in engineering education. To accomplish this goal, and acknowledging the complex nature of academia, I used a technique designed to understand complex systems called System Dynamics Modeling. With such technique, I created a conceptual System Dynamics Model (SDM) that illustrates how the factors in the academic system interact dynamically to drive or hinder faculty motivation to adopt Research-based Instructional Strategies (RBIS) in their courses. The creation of this model followed a process that combined research literature with data gathered from 17 professors at an Engineering Department in another country.

The model was constructed through an iterative process of systematically reviewing the literature, gather empirical data and creating Causal Loop Diagrams (CLD). The CLD are representations of the different causal relationships between elements in a system which ultimately create what we called virtuous or vicious (reinforcing) cycles and balancing cycles. The whole idea was not to find the causes for professors’ motivation to change but how the factors in the academic system reinforce or limit such motivation.

With this model I offered a different answer to the calls for change in engineering education toward increasing the pedagogical quality of our learning environments. My biggest argument is that previous instructional change initiatives have yielded low to moderate success, because effective instructional change would require a perspective that accounts for the complex nature of academia. With this study I am providing a different understanding of instructional change by using a system perspective that shows the interactions of elements within a complex system that ultimately influences faculty to adopt RBIS in their courses.
DEDICATION

I dedicate this work to my wife Sandra Patricia and my kids Juliana and David. They accepted the challenge to accompany me in this journey of life. They are the support group that gave me the motivation to persist and finish my doctorate studies.

Los amo con todo mi corazón. You gave my life reason and purpose.
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CHAPTER 1. INTRODUCTION

1.1 Background

Several reports on engineering education make the call to change pedagogical approaches in engineering by increasingly embedding research on learning into teaching practices (Henderson & Dancy, 2008; Jamieson & Lohmann, 2009; National Academy of Engineering, 2005). This type of change, that involves a transformation in instructional practices and adoption of Research-based Instructional Strategies (RBIS), is called instructional change (Lattuca, 2011). Facilitating instructional change in engineering education requires a different approach, one that understands academia as a complex system (Ghaffarzadegan, Larson, & Hawley, 2016) and uses systems thinking to understand how everything is connected to everything else (Sterman, 2000) instead of the traditional approach that is based only on faculty reflection and intuition drawn from their teaching experiences (Jamieson & Lohmann, 2009).

Academia is a complex system, and as such, it does not have isolated drivers or root causes that are individually capable of generating change (Sterman, 2000). Instead, multiple interactions and feedback loops exist that reinforce or balance decisions, motivators, and actions of agents in the system (Senge, 1990). Academia is a system with strong historical roots but loose coupling within its parts (Scott & Davis, 2015), with stated “rules of engagement” but unseen or hidden agendas (Carroll, 2006) and struggles of power (Riley, 2012). It has defined structures yet diverse values and beliefs (Godfrey, 2014), published statements of mission and vision to educate students but with varied willingness to fulfill those statements (Kezar, 2014), and three clear yet unequally distributed pillars that sustain it (i.e., teaching, research, and service) (Boyer, 1990; Henderson, Beach, & Finkelstein, 2011). The effectiveness of change within a complex system diminishes if we consider change as a linear process and we use designs that aim to solve simple and static problems instead of using a non-linear approach designed to deal with complexity (Senge, 1990; Sterman, 2000).

Universities, and particularly colleges/schools of science and engineering, have taken different strategies to promote instructional change but with low or moderate success (Henderson et al., 2011; Kezar, 2014). There are different reasons found in the literature that explain the lack of
success in science and engineering education change initiatives, and Table 1 lists ten of these reasons. For example, McKenna, Froyd, and Litzinger (2014) found that change initiatives focus on faculty but avoid other participants of the educational ecosystem. Henderson et al. (2011) found that the communities that study and lead change (i.e., colleges/schools of engineering administrators, higher education researchers, and universities’ centers for teaching and learning) are isolated from each other. Finelli, Daly, and Richardson (2014) suggested that these communities should be integrated around the characteristics of the local context, such as a particular school of engineering. Other authors argued that the lack of success occurs because change efforts have been driven by implicit, tacit, simplistic, or not-grounded-in-research theories of change (Kezar, 2014; Kezar, Gehrke, & Elrod, 2015). These different reasons suggest that success in change initiatives depends on the integration of several factors and change agents’ actions.

Table 1 Reasons that explain the lack of success in different change initiatives

<table>
<thead>
<tr>
<th>Reasons</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Having isolated research communities that study and enact change</td>
<td>(Henderson et al., 2011)</td>
</tr>
<tr>
<td>Being driven by implicit, tacit, simplistic, or not-grounded-in-research, theories of change</td>
<td>(Kezar, 2014; Kezar et al., 2015)</td>
</tr>
<tr>
<td>Ignoring local context</td>
<td>(Finelli et al., 2014; Kezar, 2014)</td>
</tr>
<tr>
<td>Failing to recognize the collective role instructional faculty must play to be agents of change</td>
<td>(Besterfield-Sacre, Cox, Borrego, Beddoes, &amp; Zhu, 2014; Henderson et al., 2011; Matusovich, Paretti, McNair, &amp; Hixson, 2014)</td>
</tr>
<tr>
<td>Avoiding other participants of the educational ecosystem</td>
<td>(McKenna et al., 2014)</td>
</tr>
<tr>
<td>Expecting that individual change occurs in giant steps</td>
<td>(Froyd, 2001)</td>
</tr>
<tr>
<td>Impacting only the initial stages of the change adoption process</td>
<td>(Borrego, Froyd, &amp; Hall, 2010)</td>
</tr>
<tr>
<td>Not inducing knowledge on how to increase or diffuse the use of the effective teaching methods</td>
<td>(Besterfield-Sacre et al., 2014)</td>
</tr>
<tr>
<td>Making mistakes in the process of dissemination to potential adopters like focusing on a unique practice rather than offering a varied set of practices to choose from</td>
<td>(Litzinger &amp; Lattuca, 2014)</td>
</tr>
<tr>
<td>Advocating for single interventions as the solution to a problem</td>
<td>(Dearing, 2009)</td>
</tr>
</tbody>
</table>
In the academic system, therefore, the integration of its numerous components leads to a complexity that needs to be understood using specialized tools. This research uses one of these tools, System Dynamics Modelling (SDM) (Sterman, 2000), to enhance our understanding of the interactions of academic system factors that impact instructional change in academia. In particular, this research uses SDM to explore how these multiple factors interact dynamically to reinforce or control other factors that ultimately influence faculty to adopt RBIS in their courses. Studying how these factors influence faculty motivation is key to understanding instructional change in academia (Lattuca, 2011) because systemic change in teaching practices must ultimately be enacted by the individual faculty members (Matusovich et al., 2014). That is, instructional change will be unsuccessful if faculty decide not to adopt and sustain such strategies in their classrooms. Ultimately, it is the faculty member who adopts, or not, the RBIS in her or his classes.

1.2 Objective of the Study

In summary, the goal of this study is to better understand how the academic system affects instructional change in engineering education. To accomplish this goal, I created a conceptual SDM that illustrates how the factors in the academic system interact dynamically to drive or hinder faculty motivation to adopt RBIS in their courses. To develop the model, I used a qualitative SDM process that combined research literature with data gathered at an electronics engineering department in a South American country.

The creation of a conceptual SDM followed the process suggested by Sterman (2000) with a qualitative data collection and analysis approach (Luna-Reyes & Andersen, 2003; Vennix, 1996). The creation of the SDM has four main outcomes: 1) a list of factors of the academic system that research has found are drivers or barriers to instructional change, 2) a theoretical Causal Loop Diagram (CLD), which is a CLD based on a systematic review of the literature on instructional change and adoption of teaching strategies, 3) an empirical CLD, which is a CLD based on qualitative data collected with semi-structured interviews and a focus group with engineering faculty at a specific engineering department and, 4) a conceptual SDM, a product of the integration of the theoretical and empirical CLD.

Grounded in literature and following a qualitative SDM process, my research questions are:
RQ1: What are the factors in the academic system that affect instructional change in engineering education?
RQ2: How do the dynamics between these factors affect faculty motivation to adopt Research-based Instructional Strategies?

The answers to these questions require three concepts or processes that merit a more detailed description: System Dynamics Modeling, Faculty motivation, and RBIS.

1.3 Introduction to System Dynamics Modeling

SDM was developed by Jay Forrester in the 1950s at MIT. It is grounded in the theory of nonlinear dynamics and feedback control developed in mathematics, physics, and engineering but also draws on cognitive and social psychology, economics, and other social sciences (Forrester, 1993; Sterman, 2000). SDM is used to understand the sources of policy resistance (i.e., opposition to any intervention intended to create change), to design more effective policies, and to guide decision making (Richardson, 2011; Sterman, 2000). Moreover, SDM is a method to enhance learning in the behavior of complex systems (e.g., understand how the system’s behavior changes through time) and aims to understand the full range of feedback loops operating within the system. This method is intended to analyze complex real-world problems and to catalyze sustained change in organizations.

Causal thinking, which is represented in CLDs (Sterman, 2000), characterizes SDM. Complex behaviors usually arise from the interactions among the components of the system in causal or feedback loops. Such loops arise by noting that every action has a consequence, which subsequently leads to another action which in turn will cause another consequence, and so on, until these cause-and-effect interactions are linked to the original action. All dynamics arise from the interaction of two types of feedback loops: reinforcing and balancing loops (Sterman, 2000). Reinforcing loops are the engines of accelerating grow or decline of whatever is happening in the system and balancing loops are the ways to stabilize the system (Senge, 1990). The result of reinforcing loops is either accelerating growth or accelerating decline, whereas the result of a balancing loop is stability and control (Senge, 1990). That is, reinforcing loops promote change whereas balancing loops resist or oppose change. Although there are only two types of feedback loops, SDM may easily contain several loops coupled with one another.
Figure 1 and Figure 2 show examples of these causal loops. The arrows represent the direction of the causal relationship and the signs represent the sign of their correlation. Figure 1 tells a story: increasing the use of innovative instructional strategies leads to increasing students’ learning. When students’ learning increases, that leads to increasing the positive teaching evaluations. The more positive teaching evaluations, the more the sense of teacher’s self-efficacy. When the sense of self-efficacy increases, the doubts about the effectiveness of the strategy diminishes (see the sign in the arrow). The rest of the figure can be read like this: If doubts increase, the motivation to adopt the new instructional strategy increases or if doubts decrease, the motivation to adopt the new instructional strategy decreases. That is, increasing motivation will lead to increasing the use of innovative instructional strategies. This loop is a reinforcing loop creating a virtuous cycle to change every component of the loop. Reinforcing loops have an even number of links with negative signs. On the other hand, Figure 2, representing a balancing loop, tells another story: If teacher’s motivation to adopt RBIS increases then students’ registration to the teacher’s class increases (i.e., more students are registered in this class). The more students, the more teaching workload, then the time commitment to these classes increases which leads to less motivation to adopt RBIS. Balancing loops have an odd number of links with negative signs.

Although not mutually exclusive, there are two streams for creating an SDM: a qualitative approach that leads to a conceptual SDM or a generally mixed method approach that leads to a simulation SDM. Typically, a simulation SDM requires having a conceptual SDM to have a better understanding of the problem (Vennix, 1996) as defined by the people within the system (Forrester, 1993; Sterman, 2000) and research in the field. A simulation SDM will require the introduction of new diagrams to formulate the model (i.e., adding math equations), and to fulfill several additional steps that go beyond the scope of this project. Nonetheless, the system dynamics community that uses this qualitative perspective agrees that a conceptual SDM can be effective to determine action (Richardson, 2011; Vennix, 1996) because the process to create
such an SDM has helped to change the way people within a system perceive and communicate a particular problem, and it has helped modify their mental models (Forrester, 1993).

**Introduction to Faculty Motivation**

Motivation, as its name indicates, represents the motion or engine that drives and sustains individual physical and mental activity, behaviors, and verbalizations (Jones, 2009). As a rich field of inquiry in the education and psychology literature, motivation consists of many theories and models, each meant to address motivation in different contexts and from different perspectives (Eccles & Wigfield, 2002). To understand faculty motivation, I am choosing the MUSIC model of academic motivation (Jones, 2009) because it has been derived from a contribution of research and theory from multiple fields such as education and psychology. The MUSIC model integrates other theories of motivation such as self-determination theory and Expectancy-Value Theory, and it has been used in general academic settings (Jones, 2010) and in STEM-related contexts (Jones, Li, & Cruz, 2017; Jones, Osborne, Paretti, & Matusovich, 2014; Jones, Ruff, & Osborne, 2015).

The MUSIC model of academic motivation is a theory originally developed by Jones (2009) to provide a tool for educators to intentionally generate ideas to motivate students to engage in academic activities. The MUSIC model includes five different psychological components (Jones & Wilkins, 2013) that motivate people to engage in academic settings: empowerment, usefulness, success, interest, and caring. Empowerment refers to the perception that people have some control over their learning or have the ability to make their own choices. Usefulness refers
to the perception that the content learned is useful for individuals’ short- and long-term goals. Success denotes people’s beliefs that they can succeed if they have the necessary knowledge and skills and put forth the proper effort. Interest entails the positive emotions and cognitive engagement that arises when doing an activity; in particular, interest can be understood as a combination of situational interest and individual interest. Situational interest is a temporary and context-specific value typically activated by the environment, whereas individual interest is the enduring, personal, and topic-specific value activated by the importance that the individual puts on the activity. Finally, caring is related to the human necessity to establish and sustain caring interpersonal relationships. I used these five psychological components of the MUSIC Model to elicit factors that increase or decrease faculty willingness to adopt RBIS in their classrooms.

As noted before, studying how such factors influence faculty motivation is key to understanding instructional change in academia (Lattuca, 2011). This is key because systemic change in teaching practices “must ultimately be enacted at the personal level as individual faculty enter classrooms [and] interact with students” (Matusovich et al., 2014, p.304). Chapter 2 provides a deeper review of the literature used to find evidence of such factors.

1.4 Introduction to Research-based Instructional Strategies (RBIS)

RBIS refers to teaching practices that research shows are effective in improving students’ learning. The term RBIS is used interchangeably in the literature alongside other terms (e.g., Evidence-based Instructional Practices (EBIP), Research-based Practices (RBP), and Research-based Strategies (RBS). EBIP (Bouwma-Gearhart, Sitomer, Quardokus-Fisher, Smith, & Koretsky, 2016; Pembridge & Jordan, 2016) and RBP (Litzinger & Lattuca, 2014) emphasize that the educational research supporting the effectiveness of these instructional practices is based on empirical and convincing evidence. RBS (Marzano, Pickering, & Pollock, 2001) highlights that these strategies arise from research based in different fields of effective instruction. In particular, Borrego, Cutler, Prince, Henderson, and Froyd (2013) use the term RBIS to list the instructional strategies that have documented use and effectiveness in multiple STEM schools or colleges. Typically, the definition and collected evidence of RBIS is compared with the effectiveness of what is called traditional teaching methods (i.e., lecture-based or discussion-based instruction).
Borrego et al. (2013) defined eleven different RBIS and summarized studies that show the effectiveness of these practices on learning. Some widely known examples of RBIS are Think-Pair-Share and Peer Instruction. In Think-Pair-Share, the instructor presents a problem and asks the students to work on it first individually, then form groups to discuss, reconcile, or modify their solutions, and later share their responses to the whole group (Felder & Brent, 2009). In Peer Instruction (Mazur & Somers, 1999), the instructor asks students to respond to conceptual questions from multiple-choice tests typically with the use of technology (e.g., clickers or web polls) and then asks the students to discuss with their peers and again respond to the conceptual questions. Both practices emphasize the positive effect on learning via discussions of concepts or problems with peers. Similarly, other RBIS have been designed around the constructive effect of teamwork on learning. Three examples of these RBIS are Collaborative Learning, Cooperative Learning, and Problem-based Learning (PBL). In collaborative and cooperative learning (Smith, Sheppard, Johnson, & Johnson, 2005), students work in groups toward a common goal with some elements of individual accountability that do not result in strong competitions between students. In PBL (Kolmos & Graaff, 2014) students work in self-directed teams to solve or develop viable solutions to open-ended or ill-defined problems. The instructor’s role in many of the RBIS is being a facilitator, coach, or director instead of being a primary source of information. It is worth noting that despite the fact that STEM faculty are aware or express familiarity with many of these innovations on teaching, their use is not wide-spread (Henderson & Dancy, 2009; Hurtado, Eagan, Pryor, Whang, & Tran, 2012).

1.5 Study Significance

Together, the outcomes of this project contribute to the current body of knowledge on instructional change in engineering education in at least four ways. First, the list of factors that affect change and the theoretical CLD provide a synthesis of the literature on instructional change. This synthesis uses a systems perspective to better understand the balancing and reinforcing effects of the instructional change initiatives on faculty motivation. Second, the conceptual SDM provides insights into those effects on engineering faculty motivation, thus offering additional insights to the calls for change in engineering education toward increasing the pedagogical quality of our learning environments. Third, these outcomes offer an example of an applied method that embraces the complex nature of academia, and could provide insights for
research on other complex problems in engineering education. Fourth, my study contributes to our knowledge about instructional change in engineering education by offering another perspective that accounts for the complex nature of academia. This perspective offers a big picture of the system and how its different variables are interconnected. By integrating field data and previous literature using a systems perspective, I provide another step toward building a unifying theory of transfer research on education into actual instructional practices (Litzinger & Lattuca, 2014) because it describes a structure of the academic system that affects faculty motivation to adopt RBIS. From this structure, we can better understand the behaviors of the factors involved and their policy implications on faculty motivation.

Likewise, this project has policy implications because it shows the feedback loops in the system that explain potential unintended consequences of decisions and policies. It also shows possible sources of resistance to instructional change initiatives in academia, and more importantly, how to improve the behavior of the academic system by small actions (called “leverages” or “leverage points” (Senge, 1990)) that have high impacts on enhancing the loops that reinforce faculty motivation and reducing the impact of loops that hinder it. In Chapters 4 and 5, I will detail policy implications that emerged from the analysis of the CLDs. In these chapters, the policy implications suggested were potential leverages that could create significant improvements in the adoption of RBIS. In the following paragraphs, I summarize such leverages that will be further detailed in the corresponding chapters.

1.5.1 Summary of the Findings

The first leverage is the implementation of formal pedagogical training focused on two aspects: 1) the pedagogical tenets that explain why RBIS work. It will reduce the difficulty to access and discern the research that validates such strategies, and will reduce the apprehension that faculty could have about learning new instructional approaches; and 2) the quality of the adaptation of the RBIS to the individual faculty context by supporting the transition to RBIS and understanding that to stabilize such a transition it would take more than one iteration of the course.

The second leverage is the department head commitment to teaching innovations and her support for building and sustaining local communities of practice. Such actions will encourage faculty to
put a higher value on teaching. Therefore, proper RBIS adoption would be reflected positively during the peer review process for tenure and promotion.

The third leverage is to increase the awareness that good SETs not only depend on the students’ grades and performance but on a smaller class size, a difference in course levels, and higher students’ motivation. Increasing this awareness will reduce the association of the adoption of RBIS with an increase in permissiveness.

The fourth leverage is to increase the perceived validity of the learning objectives. Such perception directly affects the beliefs professors have in regard to the change process. To increase this validity, we need to 1) ensure that professors understand and recognize the objectives’ usefulness; 2) ensure the objectives reflect what students know at the beginning and at the end of the courses; 3) ensure professors know how to assess the objectives; and 4) coordinate constructive discussion between faculty related to the objectives, because during the change process the objectives are not stable and some of them might not be feasible.

The fifth leverage is to set a limit on class size and favor faculty autonomy in their teaching practice to facilitate maintaining effective interactions and engagement with students, and to reduce teaching workload. Class size is highly related to the increase in difficulty of implementing RBIS, a reduction of students’ motivation and engagement, increase in teaching workload, reduction on students’ evaluation of teaching and an increase in timely and quality feedback that can be provided in classes.

The sixth leverage is to manage the sense of urgency by establishing and constantly assessing and communicating the vision and goals of the change initiative. Such vision and goals should be shared by the community and advocate for multiple instructional strategies.

The seventh leverage is to put in place proper measurements of the course objectives without increasing the time commitments of the professors by embedding the measurements in the learning activities or having independent teams to analyze the assessment.

The eighth leverage is to create a reference model that regulates the change process. This model would give feedback to professors about the effects of the decisions in their courses, increase the
quality of the adjustments at the program and course levels, and avoid adjustments that are made sooner or later than appropriate.

The last leverage is to minimize the delays and the propagation of effects to improve the systems’ performance. This can be done by reducing the content to cover in the courses and leave enough room in the syllabus to adjust the content as required by the particular circumstances of the course, or intentionally create overlaps in the topics covered in each course.

In addition, this study has practice implications in two ways. On one hand, the method selected to construct the empirical CLD has challenged, and even modified, the participants’ perception of the causes and consequences of decisions and actions (Forrester, 1993; Richardson, 2011). In this project, through participation, professors had opportunities to reflect on how the academic system is affected and affects their motivation to enact change, whereas administrators, after I share the results of this study, could gain a broader understanding of what elements have to be considered to manage instructional change. On the other hand, noting that perceptions often inform policies and decisions, this research expects that such change in perspectives will increase the likelihood of enacting and sustaining instructional change in the given institution.

Furthermore, by sharing the results of research with participants, I anticipate that they will gain a better understanding of how they can be change agents because my study also provides implications on the dynamics and policies involved in such change efforts.

1.6 Scope of the Study

It should be noted that this study focuses entirely on creating a conceptual SDM from a qualitative perspective using a systematic review of the literature and data gathered from faculty and administrators from a single engineering department. In the future, this work could be expanded to produce a SDM that allows simulation of policies which includes a quantitative analysis and data collection from stakeholders of the same institution. Moreover, future developments could provide an SDM from data gathered in multiple sites.
1.7 Summary

For decades we have been hearing the calls for change in engineering education toward increasing the pedagogical quality of our learning environments, particularly by increasing the adoption of Research-based Instructional Strategies (RBIS) in classrooms. However, the various strategies that universities have taken to promote transformative change in instructional practices, referred to as instructional change, have yielded low to moderate success. One of the reasons suggested to explain this low success is that academia is a complex system, and as such, it does not have isolated drivers or root causes that are individually capable of generating change. Instead, multiple factors interact dynamically to reinforce or balance motivators that ultimately influence faculty to adopt RBIS in their courses. To account for the complex nature of academia, this project offers a conceptual system dynamics model that shows how the dynamics of the academic system factors affect faculty motivation to adopt RBIS in their courses. Such a model is based on an integration of a systematic literature review on instructional change and RBIS adoption with field data gathered in an engineering department in a South American Country.

The following sections of this document describe a literature review on instructional change (Chapter 2), present the methods used to conduct this study (Chapter 3), provide the results of a theoretical CLD (Chapter 4) and empirical CLD (Chapter 5), and, lastly, illustrate a conceptual SDM with discussion and conclusions of the integration of the CLDs (Chapter 6).

To facilitate understanding of the next chapters, the following is a list of definitions of the concepts used in this dissertation:

1.8 Terminology

- **Instructional change**: In this document, instructional changes is defined as a change process that involves transformation in instructional practices and adoption of Research-based Instructional Strategies (RBIS) in academic activities.

- **Academic system**: The connected elements, stakeholders, principles and procedures of higher education institutions that form a complex whole.

- **Factors (of change)**: System entities that affect change.
• **Categories of factors:** A result of the literature review where the different factors of change were classified and categorized into six entities: Faculty motivation, faculty knowledge and skills, institutional support, students’ experience, change management, and culture.

• **(Change) Barrier:** Is a factor that prevents or inhibits change from occurring.

• **(Change) Driver:** Is a factor that promotes change.

• **Components:** Any of the elements or entities of the system.

• **System thinking:** A nonlinear way of thinking about social problems that explains the whole, its components, and the chains of reciprocal causal relationships among the components.

• **System Dynamics Modeling:** A construction process of a complex problem model (i.e., an SDM) that illustrates the dynamic interaction between the factors of a system that affect such a problem.

• **Conceptual SDM:** An SDM used to provide a dynamic hypothesis of a problem and is not intended to the simulation of policies.

• **Feedback or Causal Loop:** A representation of system factors that are connected by causal relationships, thus forming a closed loop or a cycle.

• **Balancing Loop:** A causal loop that stabilizes or controls the growth or decline of components in a system. In control systems, these loops are called negative feedback loops where an increase in the output implies a decrease in the input.

• **Reinforcing Loop:** A causal loop that describes virtuous or vicious cycles representing either accelerating growth or accelerating decline of the components of a system. In control systems, these loops are called positive feedback loops where an increase in the output implies an increase in the input.

• **Causal Loop Diagram (CLD):** A visual representation of a problem that specifies what processes are hypothesized to give rise to problematic behavior in a system. It is composed of multiple causal loops.

• **Theoretical CLD:** A CLD based on the analysis of research literature.

• **Empirical CLD:** A CLD based on the analysis of field data collected at a specific site.
• **Faculty Motivation:** In this document, I use the general term “faculty motivation” to refer to faculty motivation to adopt RBIS or to enact instructional change.
CHAPTER 2. REVIEW OF THE LITERATURE

2.1 Introduction

Answering the research questions begins by reviewing the literature on instructional change in engineering education and other related fields of science and higher education. In particular, this literature review answers the question of what factors are currently known to affect instructional change in engineering, science, and higher education. In addition, this section will argue that the use of an SDM process to understand change is a gap in the literature. This literature review starts by detailing the different factors in the academic system that influence instructional change. It continues with an explanation of why the interactions of such factors lead to a complexity that can be understood using SDM. The chapter ends with an explanation of the relationship between such factors and change theories.

This literature review suggests the existence of 31 factors that can potentially impact the successful implementation of RBIS in the classroom; hence, they could be barriers or drivers to instructional change in engineering education. These 31 factors were classified and organized into six categories: culture, change management, institutional support, pedagogical knowledge and skills, students’ experience, and faculty motivation. The latter, as mentioned in the introduction, is key to understanding instructional change in academia (Lattuca, 2011) because systemic change in teaching practices would be ultimately enacted by faculty (Matusovich et al., 2014). Therefore, it is important to study how the other factors influence faculty’s willingness to adopt such change.

Although there is evidence of other factors of change, external to academic institutions, that could influence institutional policies (e.g., accreditation boards, technology, or the increasingly diverse population of students (Kezar, 2014)), modifying such factors or alter them is beyond the reach of academic change agents. These external factors tend to be perceived as uncontrolled and unfeasible for individuals within the system (Sterman, 2000). Instead, this review focuses on finding the internal and controllable factors of the academic system that could become drivers or barriers to change. During the course of this research, the authors of this investigation disseminated preliminary results of this review at conferences of higher education (Cruz, Hampton, & Hosseinichimeh, 2018; Hampton & Cruz, 2017).
The procedures followed for this review are detailed in Chapter 3 (see the first stage of the construction of the theoretical CLD). A summary of such factors, categories, and brief definitions are shown in Table 2. Appendix A includes a table detailing the classification of the references according to these factors.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Factors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural: Factors related to the cultural elements constructed and shared among members of an organization that inform the meanings that people assign to different situations.</td>
<td>Symbols and artifacts</td>
<td>Rituals, traditions, events or historical representations of the organizational culture.</td>
</tr>
<tr>
<td></td>
<td>Attitudes</td>
<td>The perceived institutional attitudes toward faculty and the faculty attitudes toward change.</td>
</tr>
<tr>
<td></td>
<td>Beliefs</td>
<td>The mental models that faculty share about teaching.</td>
</tr>
<tr>
<td></td>
<td>Assumptions</td>
<td>The predefined interpretations or meanings toward academic activities.</td>
</tr>
<tr>
<td></td>
<td>Values</td>
<td>The different collective importance or reputation that faculty and administrators attribute to the academic activities.</td>
</tr>
<tr>
<td>Change Management: Factors related to the design and management of the change process itself.</td>
<td>Process Design</td>
<td>The planned steps to enact instructional change.</td>
</tr>
<tr>
<td></td>
<td>Vision</td>
<td>A picture of the future communicated to stakeholders that helps clarify the direction in which an organization wants to move.</td>
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<tr>
<td></td>
<td>Goals</td>
<td>The milestones to fulfill the vision.</td>
</tr>
<tr>
<td>Evaluation</td>
<td></td>
<td>The assessment and interpretations of the instructional change process.</td>
</tr>
<tr>
<td>Institutional Support: Factors related to the formal institutional support to the change initiative.</td>
<td>Institutional Policies</td>
<td>The norms and rules of the institution about tenure, promotion, service and teaching.</td>
</tr>
<tr>
<td></td>
<td>Available Resources and infrastructure</td>
<td>The Institutional resources, the allocation of those resources and the physical infrastructure.</td>
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<td></td>
<td>Instructional training</td>
<td>The support resources directed to enhance the faculty’s pedagogical knowledge.</td>
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<td></td>
<td>Flexibility of Curriculum</td>
<td>The flexibility of timing, content, and sequence of the instruction.</td>
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<tr>
<td></td>
<td>Time Allotted</td>
<td>The time allotted and dedicated to adopting the change initiative.</td>
</tr>
<tr>
<td></td>
<td>Emergent</td>
<td>Conditions for networking and community development which naturally arise from faculty.</td>
</tr>
<tr>
<td></td>
<td>Prescribed</td>
<td>Conditions for networking and community development which are designated by administrators and leaders.</td>
</tr>
<tr>
<td><strong>Pedagogical Knowledge and Skills:</strong></td>
<td><strong>Students’ Experience:</strong></td>
<td></td>
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<tr>
<td>Factors related to the level of knowledge or skills that faculty have about RBIS.</td>
<td>Factors related to how students perceive their academic experience in classrooms where RBIS are implemented.</td>
<td></td>
</tr>
</tbody>
</table>

| **Coordination of activities** | The coordination of change initiative activities among change agents, faculty, administrators and staff. |
| **Awareness** | The consciousness that faculty have about the existence and characteristics of different RBIS. |
| **Familiarity** | The understanding of the educational concepts behind RBIS and those concepts’ effect on students’ learning. |
| **Expertise** | The accumulated knowledge of the RBIS that effectively improves faculty teaching methods. |

| **Improvement on students’ learning** | The perception of the improvement that RBIS have on student’s learning. |
| **Evaluation of student’s learning** | The assessment of the students’ performance. |
| **Students’ resistance** | The students’ resistance to engage in classrooms where RBIS are implemented. |
| **Students’ evaluation of teaching** | The feedback and evaluation that students provide to the instructors and their instruction. |

| **Faculty motivation:** | Factors related to the faculty’s willingness to adopt RBIS in their classes |

| **Empowerment** | The perception that faculty have some control over their learning process and a sense of autonomy to make their own choices. |
| **Usefulness** | The perception that adopting RBIS is useful or beneficial for faculty’s short or long-term goals |
| **Value** | The external incentives, rewards, recognition, or benefits of implementing RBIS. |
| **External motivation** | The perception that the benefits of adopting RBIS outweigh its costs or risks. |
| **Cost Benefit Balance** | The faculty’s belief that they can succeed if they have the knowledge, skills, and put forth the proper effort. |
| **Assessment** | The value or importance that faculty put on their teaching. |
| **Self-Efficacy** | |

### 2.2 Factors that Affect Instructional Change

#### 2.2.1 Cultural Factors

The factors associated with this category are related to the cultural elements (i.e., symbols and artifacts, attitudes, beliefs, assumptions, and values) constructed and shared among members of an organization. Such cultural elements inform the meanings that people assign to different situations. Subsequently, these elements are considered the appropriate way of thinking and provide the basis for the actions taken within the organization (Carroll, 2006). Change theorist
(Kezar, 2014) claims that changing the cultural values is one of the key elements for second-order or deep change.

**Symbols and Artifacts** entail rituals, traditions, events, or historical representations of the organizational culture (Schein, 2006). Finelli et al. (2014) and Pembridge and Jordan (2016) found that one of the traditions of the academic culture is the necessity of having a permanent heavy workload, which reflects the importance of being highly busy most of the time. The heavy workload could be a barrier to instructional change because any innovation adds to the current workload sustained by faculty.

**Attitudes** reflect the importance of both the perceived institutional attitudes toward faculty and the faculty attitudes toward change. One barrier to change as described by Finelli et al. (2014) and Litzinger and Lattuca (2014) is that faculty consider many change initiatives demanded or led by the administrators usually ignore the reality of the faculty’s environment, whereas administrators, and many faculty members, consider faculty to be, by nature, resistant to almost any change initiative (Finelli et al., 2014; Finelli, Richardson, & Daly, 2013). Key elements that drive motivation for instructional change are the attitudes among faculty members themselves and between administrators and faculty that reflect an increase of collegial trust and sense of community (Matthew-Maich et al., 2007).

**Beliefs** represent the mental models that faculty share. Matusovich et al. (2014) illustrate that focusing on faculty beliefs can support change in practice. For example, Cooper, MacGregor, Smith, and Robinson (2000) found that a frequent concern for faculty to adopt “Small Group Collaborations”—a type of RBIS—is the belief that if a faculty member is in favor of that strategy, he or she is inevitably opposed to lecture in any form. This kind of belief hinders the motivation to change because any time a teaching innovation is suggested it challenges traditional practices with the consequence of causing feelings of incompetence on faculty accustomed to lectures in their classes (Litzinger & Lattuca, 2014).

**Assumptions** refer to the predefined interpretations or meanings toward academic activities. Such attitudes become a barrier to change when there is a negative assumption toward the RBIS. For example, Finelli et al. (2014) found that many engineering faculty distrust the educational data that show RBIS’ higher impact on learning because many faculty members believe that
traditional teaching methods are accomplishing their goals (Cooper et al., 2000; Dancy & Henderson, 2010; Kezar, 2014). As Handelsman et al. (2004) noted, many faculty assumed such a conclusion because the current educational systems still generate many successful new scientists.

**Values** denote the collective importance or reputation that faculty and administrators attribute to academic activities. Researchers have found that cultural values could be barriers or drivers to adoption of RBIS depending on certain elements: the faculty’s collective value put on traditional teaching methods (Kezar, 2014), the value placed on innovations by administrators (Matusovich et al., 2014), and the importance that both faculty and administrators put on students’ deep approach to learning (Litzinger & Lattuca, 2014). Of high importance in this category is the balance between the collective value given to teaching and to scholarship (Feldman & Paulsen, 1999), and which tends to favor scholarship. This is illustrated by the pressure felt to fulfill expectations of publishing and obtaining funding (Matusovich et al., 2014), thus discouraging faculty to invest their time trying new things in their courses. Another element in this category of cultural factors is the higher value that both faculty and journal editors have put on the creation of new pedagogical methods versus the transferability of instructional strategies to practice (Litzinger & Lattuca, 2014), which discourages faculty from searching the literature about pedagogy in order to apply what has been done in the past.

### 2.2.2 Change Management Factors

The factors associated with change management are related to the design and management of the change process itself (i.e., process design, vision, goals and evaluation). These elements are managed by change agents or leaders in typically top-down approaches. Because change can be planned, it should be directed by a clear vision and goals (Kotter, 1995). Furthermore, change can be managed, therefore its success has to be constantly evaluated and measured (Kaplan & Norton, 1996).

**Process design** refers to the planned steps to enact instructional change. Kezar et al. (2015) illustrate how one of the biggest barriers to change occurs during its design phase, not only when designing for implementation but in the failure to include characteristics aimed to sustain the initiative (Cross, Mamaril, Johnson, & Herman, 2016). Dancy and Henderson (2010) support this
idea by highlighting that successful change occurs when its design includes how change agents will articulate and coordinate activities. From the instructional change initiatives that follow a design process, Kezar et al. (2015) found that many change agents and leaders used implicit views of change (i.e., decisions based on reflection or personal experiences) instead of following methods whose effectiveness is grounded in research. The broad use of these implicit views could also be a consequence of the few existing methods that emphasize adoption of innovations (Litzinger & Lattuca, 2014) rather than the diffusion of innovations (Rogers, 2003).

**Vision** entails a picture of the future communicated to stakeholders that helps clarify the direction in which an organization wants to move (Kotter, 1995). Such vision would be a driver of instructional change if instead of imposing it, the vision is shared by administrators and faculty (Litzinger & Lattuca, 2014).

**Goals** are the milestones to fulfill the vision; they become drivers of instructional change if they are clearly stated and shared by the community (Kezar, 2014), and if they advocate for multiple instructional strategies rather than a single practice (e.g., promoting only the implementation of PBL) (Henderson et al., 2011; Litzinger & Lattuca, 2014).

**Evaluation** in this context denotes the importance of assessment and interpretations of the instructional change process (Borrego & Henderson, 2014). A driver to change is the existence of processes that facilitate both the documentation and evaluation of the instructors’ implementation of their practices, especially when such processes show evidence that teaching has been undertaken in an effective and scholarly manner (Martin, 1999).

### 2.2.3 Institutional Support Factors

The factors associated with this category are related to the formal and informal institutional support to the change initiative (i.e., structures and procedures, and networking and community). These factors illustrate that instructional change is influenced by features of the organization (i.e., the particular academic institution) (Kezar, 2014), and show that keys to enacting change are the modification of elements in the institutional structures and procedures (Lattuca, 2011), the creation of conditions for exercising networking and developing a community (Feldman & Paulsen, 1999), and the consistency between all of these elements (Dancy & Henderson, 2010).
Typically, the institutional support factors depend on the leaders of the academic institution and the administrators, but also some of these factors could emerge from faculty committed to changes within the department (Borrego & Henderson, 2014).

2.2.4 Structures and Procedures

The structures and procedures factors that influence instructional change include the characteristics of institutional and departmental policies, the availability of resources and infrastructure, the implementation of instructional training programs, and conditions like the flexibility of curriculum and time allotted for the change initiative.

Institutional policies vary depending on the institution type (e.g., predominantly research or teaching institution) and the emphasis put on research (Finelli et al., 2014; Kezar et al., 2015). The institutional policies related to tenure and promotion influence the adoption of RBIS (Feldman & Paulsen, 1999; Finelli et al., 2014) predominantly by the weight the policies put on both teaching evaluations and teaching performance as a condition for decisions of advancement and continuation in the academy. Nonetheless, decisions for tenure and promotion are typically made during a peer-reviewed process (Matusovich et al., 2014) and not only are influenced by institutional policies but also departmental norms (Bouwma-Gearhart et al., 2016; Henderson & Dancy, 2007; Kezar et al., 2015). That is, the institutional policies are mediated by peers and administrators in the department, which could limit or reinforce the effect of policies on faculty motivation to adopt RBIS. Such policies could be strong drivers of instructional change if the reward structures are aligned with it (Finelli et al., 2014).

The available resources and infrastructure are also potential drivers or barriers to instructional change. The lack of sufficient institutional resources and appropriate facilities reduces the likelihood of instructional change (Litzinger & Lattuca, 2014; Pembridge & Jordan, 2016) because they impact the expectancy of success of implementation of RBIS (Matusovich et al., 2014). Similarly, allocation of institutional resources can be barriers to change because they are often allocated in ways that can be detrimental to teaching quality or that emphasize productivity over teaching quality (Borrego & Henderson, 2014). Of particular interest is how the physical disposition of classrooms invites or dissuades the use of teaching innovations (Dancy & Henderson, 2010; Henderson & Dancy, 2007). For example, a classroom that could be
rearranged for group work invites small group collaborations, whereas a static auditorium for large classes tends to promote lectures (Pagnucci et al., 2015). In addition, some studies report how human resources also support RBIS’ adoption by providing teaching assistants or technical and logistical aid to instructors (Cooper et al., 2000).

**Instructional training** is a special case of support resources directed to enhance the faculty’s pedagogical knowledge. It is common in universities to offer faculty development programs of varied characteristics and durations (Borrego & Henderson, 2014; Cross et al., 2016; Felder, Brent, & Prince, 2011; Feldman & Paulsen, 1999; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). Researchers have found that to increase positive impact on adoption of innovations, instructional training should include a clear description of the rationale of the innovation (Felder et al., 2011; Matusovich et al., 2014), the procedures for its implementation (Borrego & Henderson, 2014; Matusovich et al., 2014), the opportunities for practice and simulation of the class activities (Borrego & Henderson, 2014; Kezar et al., 2015), and delivery in at least semester-long interventions (Henderson et al., 2011; Yoon et al., 2007).

**Flexibility of curriculum** is another factor that promotes or hinders adoption of RBIS. Instructors are expected to cover all the content of the course syllabi (Cooper et al., 2000; Henderson & Dancy, 2007) and to follow the defined content sequence with a specific timing (Bouwma-Gearhart et al., 2016; Finelli et al., 2014). Typically, content, sequence, and timing were established for lecture-based instructions. Several studies have found that a big barrier to change is the perceived difficulty in covering all the content when using RBIS (Cooper et al., 2000; Cross et al., 2016; Dancy & Henderson, 2010; Froyd, Borrego, Cutler, Henderson, & Prince, 2013) because RBIS usually require different timing than direct instruction (e.g., it is possible that small group collaborations require more class time than lectures (Cooper et al., 2000) or the rearranging of the sequence of content, such as a problem-based learning approach that requires students’ self-directed learning and gathering of content that allows the problem’s solution (Borrego et al., 2013)). Although the content of the course is predefined and static, the flexibility allowed for its coverage is a driver to change.

**Time allotted** and dedicated to adopting the change initiative could be one of the biggest barriers to RBIS adoption. As with many activities within academia, adopting RBIS is also a process that
requires time to learn its pedagogical principles (Dancy & Henderson, 2010; Litzinger & Lattuca, 2014), time for preparation of class activities (Cross et al., 2016; Pembridge & Jordan, 2016) and, as mentioned before, class time for its implementation (Borrego & Henderson, 2014; Cross et al., 2016; Dancy & Henderson, 2010; Henderson & Dancy, 2007; Matusovich et al., 2014; Pembridge & Jordan, 2016). Faculty claim that time is one of their biggest restrictions to engage in instructional activities (Froyd et al., 2013), therefore the perceived effect of adopting RBIS on the faculty’s workload is one strong barrier to instructional change (Hora, 2012; Seymour & De Welde, 2015).

2.2.5 Networking and Community

The conditions for networking and community are also factors that influence instructional change. These factors combine both the emergent or bottom-up development of self-organized groups and the top-down or prescribed opportunities for faculty interacting with peers and administrators around innovations in academia (Borrego & Henderson, 2014). Different forms of collaboration with colleagues and administrators require the coordination of activities to foster the effectiveness of the change initiative (Dancy & Henderson, 2010).

The emergent conditions for networking and community development usually involve participation in self-organized groups that offer opportunities to engage with peers who share common issues (Cross et al., 2016; Finelli et al., 2014) and to learn about the practical concerns of adopting RBIS (Bouwma-Gearhart et al., 2016). Research strongly indicates the positive effect of such communities of practice on the adoption of instructional innovations (Cross et al., 2016; Feldman & Paulsen, 1999; Henderson & Dancy, 2007; Matthew-Maich et al., 2007).

The prescribed conditions for networking and community are manifested in the support from institutional leadership that explicitly value the teaching innovations, their diffusion, and their implementation (Feldman & Paulsen, 1999). Examples of such support occur when change agents develop highly structured and specific interventions to be used by others (Borrego & Henderson, 2014), when the institution facilitates an educational developer consultant who helps to advance the RBIS adoption process (Fowler, Macik, Kaihatu, & Bakenhus, 2016), or when the institution provides support-oriented programs that enhance academic collaborations between faculty themselves and faculty and administrators (Finelli et al., 2014). Such prescribed
conditions become drivers to change depending on the commitment of the department head (Kezar et al., 2015; Matusovich et al., 2014) and other community leaders (Borrego & Henderson, 2014), and the value they place on such institutional interventions.

Both emergent and prescribed conditions require the coordination of activities to support the change initiative, especially during the trial stage when the community is learning and experimenting with the change process (Borrego & Henderson, 2014; Cooper et al., 2000). Research suggests that such coordination shows the commitment from colleagues and administrators toward the change initiative (Feldman & Paulsen, 1999; Finelli et al., 2014); for example; by organizing mentoring processes between senior colleagues and novice and junior faculty (Austin, 2011; Henderson et al., 2011; Matthew-Maich et al., 2007).

2.2.6 Faculty’s Pedagogical Knowledge and Skills Factors

The factors related to this category refer to the different levels of knowledge or skill that faculty have about RBIS. These factors explain that successful instructional change occurs alongside the pedagogical development of faculty, and that this cognitive and practical knowledge is developed through a learning process resulting from conscious thought and reflection about their teaching practices. Research has shown that as a learning process, pedagogical knowledge has at least three levels (awareness, familiarity, and expertise) that must be fulfilled in order to sustain the adoption of RBIS (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010; Finelli et al., 2014). The names of these three levels have been extracted from the names used in the literature about change (Bloom’s taxonomy (Krathwohl, 2002) named these levels remembering, comprehending, and applying).

The first level, awareness, embodies the consciousness that faculty have about the existence and characteristics of different RBIS (Dancy & Henderson, 2010; Finelli et al., 2014). The sheer number of RBIS represents a barrier to adoption (Ambrose et al., 2010; Litzinger & Lattuca, 2014) because it makes more difficult to access and discern the research that validates such strategies (Ambrose et al., 2010; Dancy & Henderson, 2010). The adoption of RBIS usually starts by overcoming the barriers that increase the apprehension about learning new instructional approaches (Finelli et al., 2014; Handelsman et al., 2004).
The second level, **familiarity**, represents the understanding of the educational concepts behind RBIS (Ambrose et al., 2010; Fowler et al., 2016) and its effect on students’ learning (Ambrose et al., 2010; Finelli et al., 2014). A common barrier to adoption of RBIS is that their implementation requires an adaptation of the strategies to the faculty’s particular context (Litzinger & Lattuca, 2014). Sometimes the adaptation does not follow all of the details that make RBIS effective (Borrego et al., 2013; Henderson, Dancy, & Niewiadomska-Bugaj, 2012) or are altered in ways that err on the side of a more traditional approach (Dancy & Henderson, 2010).

The third level, **expertise**, implies the development of practical knowledge of the RBIS that effectively improves their teaching methods (Borrego & Henderson, 2014). Expertise denotes experience in the RBIS implementation, which suggests the effective adoption of the strategy (Ambrose et al., 2010; Dancy & Henderson, 2010). Effective implementation requires awareness, familiarity and, above all, understanding of the pedagogical tenets that explain why the RBIS work (Ambrose et al., 2010; Litzinger & Lattuca, 2014). Expertise is a strong driver of the sustainability of the RBIS’ adoption because at this level faculty’s self-reflection and continuous improvement are an important part of their daily practices.

### 2.2.7 Students’ Experience Factors

The factors associated with this category are related to how students perceive their academic experience in classrooms where RBIS are implemented. Improving the students’ experience is the main objective of enacting instructional change in academic institutions (Kezar, 2014). Barriers and drivers to adoption of RBIS also occur at the students’ level because even though RBIS are intended to improve their learning and provide better evaluation processes, students could resist the instructional change through their evaluations of teaching or by disengaging in the classes. The **improvement of students’ learning** is a driver to motivate the adoption of RBIS (Finelli et al., 2014; Kezar et al., 2015) because, as the definition of RBIS indicates, implementing RBIS is aligned with what is known about how learning occurs (Ambrose et al., 2010). Another driver to instructional change is the multiple opportunities that RBIS offer to transform the **evaluation of students’ learning** (Cooper et al., 2000). By providing clear ways to assess the actual performance of students, faculty modify their perception of teaching effectiveness (Graham, 2012a).
Students’ resistance is a barrier to adoption of RBIS (Dancy & Henderson, 2010; Henderson & Dancy, 2007; Kezar et al., 2015) because it is common that students are not accustomed to these practices (Seymour & De Welde, 2015). Students’ resistance is lowered when more faculty in their schools adopt RBIS, hence students will perceive such practices as more common (Seymour & De Welde, 2015). Faculty also fear that by attempting innovation in practices, the students’ resistance could prompt negative feedback in students’ evaluation of their teaching (Finelli et al., 2014).

2.2.8 Faculty Motivation Factors

The factors related to this category are related to faculty’s willingness to adopt RBIS in their classes. The following paragraphs show characteristics of the empowerment, usefulness, success, and interest elements of faculty motivation that the literature suggest could be drivers to instructional change. Names of these factors have been extracted from the MUSIC model of motivation (Jones, 2009).

Empowerment: To enact instructional change, faculty should feel empowered to adopt RBIS. This implies that faculty should feel autonomy in making adjustments to implement RBIS in the classroom (Bouwma-Gearhart et al., 2016; Cross et al., 2016; Fowler et al., 2016), be continuously engaged in self-evaluation or self-assessment of their own RBIS adoption process (Feldman & Paulsen, 1999), and feel some control over how to integrate their service, teaching, and research activities (Bouwma-Gearhart et al., 2016).

Usefulness: To enact instructional change, faculty’s perception of the balance between the costs and benefits should err on the benefits side. The benefits not only include having financial incentives (Finelli et al., 2014; Kezar et al., 2015), reward systems (Feldman & Paulsen, 1999; Finelli et al., 2014; Kezar, 2014), or other forms of external value aligned to the adoption of teaching innovations (like recognition within the academic culture (Kezar et al., 2015)), but in the perception that adopting RBIS increases value to students (Abrami, Poulsen, & Chambers, 2004; Ambrose et al., 2010; Cooper et al., 2000; Cross et al., 2016; Dancy & Henderson, 2010; Kezar et al., 2015) and the certainty that such practices help faculty to become better teachers (Matthew-Maich et al., 2007). As with any innovation, implementing RBIS brings costs (Abrami et al., 2004; Dancy & Henderson, 2010), like the increase in time commitments when starting
RBIS implementation (Cooper et al., 2000). It also brings risks, like not having certainty on the benefits of the change process (Cross et al., 2016; Fowler et al., 2016) or if there would be potential time savings when adopting such practices (Finelli et al., 2014; Pembridge & Jordan, 2016).

**Success:** To sustain instructional change, faculty should perceive they can succeed with the implementation of RBIS. It starts with attention to faculty’s self-confidence in their professional abilities (Finelli et al., 2014) and their beliefs in their pedagogical competence (Litzinger & Lattuca, 2014; Matthew-Maich et al., 2007; Matusovich et al., 2014). It continues with attention to faculty’s self-confidence in knowing how they could effectively use RBIS (Abrami et al., 2004; Ambrose et al., 2010; Pembridge & Jordan, 2016). The faculty’s perceived success of the innovation (Abrami et al., 2004; Matusovich et al., 2014) increases when there is clear evidence of the RBIS’ effectiveness (Ambrose et al., 2010; Cross et al., 2016) and it is reflected both in their students’ evaluation of teaching (Finelli et al., 2014) and their performance evaluation or feedback from peers and administrators (Borrego & Henderson, 2014; Feldman & Paulsen, 1999).

**Interest:** To enact and sustain change, the adoption of RBIS must be part of the interests and values that faculty give to their own abilities (Finelli et al., 2014). Change is enacted by developing or creating awareness and interest in the use of teaching innovations (Borrego & Henderson, 2014; Matusovich et al., 2014) and making them compatible with faculty’s past experiences and needs (Litzinger & Lattuca, 2014). Change is sustained when faculty believe that by adopting RBIS they can make an impact (Finelli et al., 2014) and they feel compatibility and personal connection to the RBIS (Litzinger & Lattuca, 2014; Matusovich et al., 2014).

### 2.3 Relating Factors of Instructional Change with Theories of Change

Research on change also illustrates different frameworks or theories that change agents could have to understand and enact instructional change. This study is not using them as guiding frameworks to develop the model, but they are the starting point to understand and decipher the effects that the interactions of the multiple factors have on faculty motivation to adopt RBIS. Based on change theories, the following section provides an explanation of how the six categories of factors influence instructional change.
First, the influence of cultural factors on the adoption of RBIS is explained by cultural (Carroll, 2006; Schein, 2006) and political theories of change (Carroll, 2006; Morgan, Gregory, & Roach, 1997). Cultural theories explain that successful change requires changing the institutional culture; that is, the alteration of beliefs, values, assumptions, mission, symbols, rituals, artifacts, and attitudes. The process of changing culture is nonlinear, unpredictable, dynamic, and occurs as a response to alterations in the human environment (Kezar, 2014). Political theories explain that change is the result of opposite or competing belief systems that eventually clash resulting in change. The outcome of change is a modified organizational theory or identity. Similarly, cultural factors are also explained by political theories because individuals in different power positions have different beliefs, assumptions, and attitudes. For example, the pressure to fulfill expectations of publishing comes from institutional leaders as well as from the collective values of other academic colleagues (Matusovich et al., 2014).

Second, the influence of institutional support factors on the adoption of RBIS is explained by scientific management (Kaplan & Norton, 1996; Kotter, 1995), social cognition (Collins, 2005; Senge, 1990), and political theories of change (Carroll, 2006; Morgan et al., 1997). Scientific management theories suggest that successful change can be planned by the institutional leaders or change agents through the modification of the organizational structure. Social cognition theories explain that at the organizational level not all changes occur top-down, but rather emerge from the collective understanding of how to continuously improve the organization (i.e., organizational learning). Political theories explain that although the structures and norms can be organized in a certain way, the real actions and agendas can be in conflict with the structures resulting in opposing or perhaps inconsistent actions with the change initiative that derives in emergent barriers for change.

Third, the influence of change management factors on the adoption of RBIS is explained by scientific management theories (Kaplan & Norton, 1996; Kotter, 1995) and political theories of change (Carroll, 2006; Morgan et al., 1997). Scientific management theories explain that successful change rises from a necessity. Starting with a clear vision and goals, change can be planned, managed, and evaluated. Typically, change can be managed by a top-down approach (i.e., leaders are the change agents) and it can be adapted through thoughtful evaluation. On the other hand, political theories explain that to increase the likelihood of successful change, a leader
must have an agenda and a power base to be ready to bargain and negotiate. Because different individuals have different agendas and interests, and different views of the change process, the goals and visions are not always explicit or commonly shared; thus, conflicts and negotiations between the agents of change and/or leaders are expected.

Fourth, the influence of pedagogical knowledge factors on the adoption of RBIS is explained by scientific management (Kaplan & Norton, 1996; Kotter, 1995) and social cognition theories of change (Collins, 2005; Senge, 1990). Scientific management theories suggest that change in organizations proceeds through stages. The transition between stages is a homogeneous and structured step by step process that involves personal development and knowledge gains in each stage. Social cognition theories explain that change is understood and enacted through individuals and their thought process, and they stress the important role that learning and individual development have to enact and sustain change.

Fifth, the influence of students’ experience factors on the adoption of RBIS is explained by social cognition, cultural, scientific management, and political theories of change (Kezar, 2014). Social cognition theories posit that the typical mission of academic institutions is heavily intentional to the learning gains or improvement that students have, thus learning is in the operating core of the academy. Similarly, cultural theories assert that although learning is part of the culture of academic institutions, it also drives students’ resistance to appreciate and engage in new classroom practices because doing so implies disrupting their comfort zone (Kezar, 2001). Scientific management theories explain how the assessment of students’ learning is part of the continuous improvement in academic organizations to measure the impact of change (Schein, 1999). Assessment procedures are often required by accreditation processes (Spurlin, Rajala, & Lavelle, 2008). Finally, political theories describe that institutions are more accountable for, thus driven by, students’ progress, inclusion, and perceptions of the courses; therefore, academic institutions are not entirely autonomous in their decisions (Kezar, 2014).

Lastly, faculty motivation is also explained by political, cultural, and social cognition theories of change (Kezar, 2014). Political theories explain power as “the ability to get things done” (Carroll, 2006, P.6), suggesting the importance of empowering change agents and allowing them to make autonomous decisions and adjustments to the process (Carroll, 2006). Cultural theories
suggest the influence that institutional values, symbols, artifacts, and underlying assumptions have on individual decisions, meaning making, and actions (Carroll, 2006). For example, collective values that are consistent with the change initiatives will become drivers to individuals’ motivation to adopt such initiatives (Matusovich et al., 2014). Finally, social cognition theories explain that if the change initiative is tied to people’s individual interests and volition, and it is aligned with personal goals, not only is the change enacted, but it is more likely that it becomes a second order or deeper change (Kezar, 2014; Senge, 1990).

### 2.4 Understanding Instructional Change in the Academy

Many of the resources found in this literature review attempted to explain some of the factors that affect change, defining them as either drivers or barriers to change, and providing suggestions for generating the desired outcomes. However, the literature reviewed is narrow in its approach for promoting change because it is evading the implications that the complexity of academia has on change initiatives. Few references used systems science to study change in academia—with the noted exceptions of Borrego and Henderson (2014), Kezar (2014), and Lattuca and Stark (2011)—limiting the discussion to linear models focused on strategies to either reduce barriers or increase drivers with expected change outcomes (Kezar, 2014). Although these models seem logical, they have been proven largely unsuccessful (Dearing, 2009; Henderson et al., 2011; Kezar, 2014; Kezar et al., 2015) as increasing certain drivers can lead to increasing barriers and, similarly, reducing certain barriers can lead to reducing other drivers (Senge, 1990; Sterman, 2000). For example, one could think that increasing incentives for achieving better performance in students could be a strong driver for faculty, but it may also result in behavioral misconduct for teachers and students like teaching-to-test strategies (Ghaffarzadegan et al., 2016). Such behavior is resultant of one characteristic of the complex nature of academia: every action has consequences and many of these consequences are unexpected (Sterman, 2000).

In addition, many of the reviewed literature resources rightfully use theories of change as their framework (see for example Finelli et al. (2014) or Litzinger and Lattuca (2014)); however, even if used properly, isolated theories of change are limited to fit specific problems or ignore other aspects that impede change (Kezar, 2014). Some have tried to combine such theories (Borrego & Henderson, 2014), but others suggest that it is impossible (Carroll, 2006) because either they are
focused on different aspects of the system, consider the system from different perspectives, or could be contradicting to each other. The difficulty of combining perspectives is characteristic of the nonlinearity of a complex system (Sterman, 2000).

From a complex system perspective, such non-linearity explains that there are factors that could be both barriers and drivers depending on the context and timing. For example, one factor that seems to be a driver, dedication of faculty’s time, could become a barrier. Indeed, there is evidence of potential time savings when faculty adopt RBIS (Finelli et al., 2014; Pembridge & Jordan, 2016) but, at first, the adoption of RBIS will likely increase the faculty’s time commitments (Cooper et al., 2000). Moreover, complex systems do not have a right answer or root causes; they have, in its place, causal relationships (Sterman, 2000).

In summary, in the academic system the interactions of its numerous components lead to a complexity that needs to be understood using a process that accounts for the interrelations of the elements of the academic system (Ghaffarzadegan et al., 2016), and such an approach is the creation of a System Dynamics Model (SDM) (Sterman, 2000). To explain the effects of the interactions, SDM uses the particular causal relationships between the components of the system to understand their dynamic complexity. Although it seems consistent to apply the lessons of SDM in instructional change, because SDM has been heavily used to model problems in complex organizations and to understand their dynamic complexity in change efforts (Forrester, 1993; Sterman, 2000), very few studies have used SDM to understand change in academia (as a notable exception see Zaini et al. (2017)).

This literature review provides a description of the detail complexity of the academic system providing an answer to the first research question of this dissertation: what are the factors in the academic system that affects instructional change in engineering education. To understand the dynamic complexity of academia, it is necessary to understand the interrelations between the factors of the academic system. The following chapters will answer the second research question: How do the dynamics between the factors affect faculty’s motivation to adopt RBIS?
2.5 Summary

The review of the literature shows 31 factors, classified into six categories, that affect instructional change. The interaction of such factors creates a complexity that can be understood using SDM. Faculty motivation is one of these factors. Using SDM, I seek to understand how the dynamics of the other five categories of factors influence faculty motivation. Different change theories show a starting point to hypothesize the possible interactions between the factors and their effect on instructional change.
CHAPTER 3. RESEARCH METHODS

3.1 Introduction

In this chapter, I describe the research methods used to complete this study. First, I provide a discussion of the philosophical perspective taken with respect to the research methods and its influences on the methodological decisions within my research design. Next, I give an overview of the research process and describe the data collection and analysis procedures of each phase. Finally, I discuss the validity of the research as well as the limitations and bias I could have brought to the study.

In summary, to answer the research questions\(^1\), I created a conceptual SDM following the process suggested by Sterman (2000) with emphasis in its qualitative approach to data collection and analysis (Luna-Reyes & Andersen, 2003; Vennix, 1996). The creation of the model had three main phases: 1) The creation of a theoretical Causal Loop Diagram (CLD) based on a systematic review of the literature, 2) the creation of an empirical CLD based on the qualitative data collected at an electronics engineering department, and 3) the integration of the CLDs created in the first two phases into a conceptual SDM.

3.2 Philosophical Perspective

My philosophical worldview as a researcher has a strong influence on my research design. I brought a pragmatic perspective (Creswell, 2009) because I am concerned with a real-world, practice-oriented problem and I searched for a feasible method that fits the purpose of the research. As a long-term goal, I aim to promote instructional change in academic institutions. As a pragmatist, I wanted to bring to this study a systems perspective that accounts for the complex nature of academia (Ghaffarzadegan, Larson, & Hawley, 2016). In alignment with my worldview and the purpose of the study, I chose SDM as a research design that involved strategies and

\(^1\) RQ1: What are the factors in the academic system that affect instructional change in engineering education? RQ2: How do the dynamics between these factors affect faculty’s motivation to adopt Research-Based Instructional Strategies?
methods suitable to analyze complex real-world problems and has been used to catalyze and sustain change in organizations (Forrester, 1993; Sterman, 2000).

The process of creating an SDM also brings a postmodernist (Kvale, 1995) and constructivist (Von Glasersfeld, 2001) philosophy that influenced the research design. On one hand, SDM brings a postmodernist worldview because its purpose is to elicit a particular reality conceived by the individuals, instead of finding an incontrovertible and generalizable truth (Forrester, 1993; Sterman, 2000). On the other hand, SDM brings a constructivist epistemology, because creating an SDM is an active cognitive construction process (Schwaninger & Groesser, 2011) based on the interpretation of people’s experiences with the purpose of understanding a particular problem (Richardson, 2011; Sterman, 2000) and to offer a solution that fits a particular reality (Von Glasersfeld, 2001).

As a postmodernist and constructivist perspective, an SDM is built in a single site to understand and solve a particular problem (Sterman, 2000). Schwaninger and Grosser (2008) calls this SDM process a local or middle-range theory building because the theory is created as the SDM is constructed. In addition, SDM building has an orientation to action (Schwaninger & Grosser, 2008) because it consists of generating and formalizing a theory that has practical implications. In this sense, literature supports that creating an SDM can be a powerful tool to build theory on the basis of single site data (Hall, 1976; Luna-Reyes et al., 2006; Schwaninger & Grosser, 2008; Woodside, 2010), because it involves extracting theoretical constructs from case-based empirical evidence (Eisenhardt, 1989). For that construction process, I have to elicit the mental models of the participants through a process of communication between me (i.e., the modeler) and the participants (Sterman, 2000). Forrester (1993) argues that the ultimate success of an SDM is to give a more effective understanding of an issue inherent to the particular system and to change the way people think about it (i.e., their mental models).

In addition to postmodernism and constructivism, the other philosophical base for creating an SDM is its endogenous perspective (Richardson, 2011). This perspective considers that all the central causes of the issues are internal elements to the system (i.e., endogenous factors) instead of uncontrollable external causes (i.e., exogenous factors). Even though the external causes could
generate inputs to the system, they do not change the structure of the system itself (Sterman, 2000).

In summary, I approached the SDM process with a pragmatist, postmodernist, constructivist and endogenous philosophical perspective. Pragmatist, because although I followed a qualitative approach, I chose SDM as a non-traditional method that fits the purpose of the study. Postmodernist and constructivist because the SDM process aimed to elicit faculty’s perception and particular realities instead of an incontrovertible truth. Endogenous, because this study aimed to find the internal causes or elements for change, in other words, the internal elements in the academic system that faculty could modify to sustain instructional change.

3.3 Research Design: The System Dynamics Modeling Process and Methodological Aims

3.3.1 Research Process Overview

The creation of a conceptual SDM follows the general process suggested by Sterman (2000). Vennix (1996) and Luna-Reyes and Andersen (2003) provide details on the qualitative data collection and analysis approach of this process. The process I followed consisted of three main phases: a theoretical CLD, an empirical CLD, and a conceptual SDM. The first phase, a theoretical CLD, employed a structured approach to incorporate findings from a systematic literature review into a causal structure of the academic system that affects faculty motivation. The second phase, an empirical CLD, created a CLD based on the content analysis of data collected in semi-structured interviews and a focus group with purposefully selected faculty members at a department of electronic engineering in a South American country. Finally, the third phase, a conceptual SDM, integrated the previous CLD in a conceptual SDM and provided insights about its dynamic and policy implications.

3.3.1.1 First Phase: A Theoretical Causal Loop Diagram

a) Overview

This stage consisted of reviewing the literature to find the systems factors and to create a hypothesis or a working theory of how the motivation to adopt RBIS is influenced by internal variables of the system (Sterman, 2000). This hypothesis took the form of a theoretical CLD.
This stage, called *problem articulation* and *dynamic hypothesis* by Sterman (2000), was entirely theoretical and grounded in current research on instructional change and adoption of RBIS in higher education. A colleague and I conducted this stage together, and the results were disseminated at two higher education conferences (Cruz et al., 2018; Hampton & Cruz, 2017).

We divided the process to create a theoretical CLD into two stages. The first stage entailed an initial conceptualization, and the second stage was the establishment of the different causal loops whose integration shaped the theoretical CLD. The first stage produced the literature review in Chapter 2 and informed the second stage, which produced the theoretical CLD described in Chapter 4. The process as a whole consisted of several iterative procedures. Essentially, both stages followed content analysis procedures to reach their products. The first stage analyzed documents related to change in higher education, STEM education and engineering education, and extracted 99 barriers and drivers, classified into 31 factors and ultimately organized into six categories (i.e., faculty motivation, faculty knowledge and skills, institutional support, change management, culture, and students’ experience). In the second stage we analyzed a larger number of documents that allowed us to build the theoretical CLD. The following paragraphs describe the process followed for these analyses.

b)  **First Stage. Finding the Factors Affecting Instructional Change**

This stage sought to provide an initial search of the factors that could be either barriers or drivers to instructional change in engineering education. The purpose of the first stage was to find and explore literature discussing instructional change, and to analyze this literature to determine and categorize the factors that drive or hinder change.

I.  **Sources of Information**

To accomplish the objectives of this stage, we explored literature in the Journal of Engineering Education database, and the EBSCOhost database. We followed multiple steps to search and select literature. First, to gather initial articles, we used broader search criteria with terms like

\[ \text{Terms} \]

2 I am using the term “we” instead of “I” in the description of this stage to acknowledge that it was conducted in collaboration with Cynthia Hampton, a colleague from the Department of Engineering Education.
“instructional change AND STEM,” “STEM AND evidence-based instructional practices,” “Higher education AND RBIS,” “faculty AND instructional change.” We read the abstracts to determine if the references discussed practices, barriers, or drivers to instructional change in STEM or higher education and excluded those oriented exclusively toward the methods of such practices (e.g., articles dedicated to describe or establish the effectiveness of certain RBIS). We refined the search by browsing the articles and looking for language related to barriers, drivers, adoption, or implementation of instructional change. Such references were registered in a spreadsheet to later read in detail. This process also assisted us in identifying new search terms and start establishing important authors in the particular field. The refined search ended with 19 documents (11 journal papers, two books, one book chapter, one report, and four conference papers).

II. Analysis

We conducted a content analysis (Miles, Huberman, & Saldaña, 2014) of the 19 documents. The result of this analysis informed the literature review described in Chapter 2. The following paragraphs detail the process followed. A table with the categorization of such information is shown in Appendix A.

To analyze each document, we transcribed and organized them in a shared document by entering their title, author(s), summary, factors, and context. To select the information in the documents, we defined factors as any resource, structure, or other content that was described as driving change or hindering change from occurring. Factors were understood as barriers if they inhibit change, or they were understood as drivers if their presence supports or promotes change. However, some elements were not clearly defined as barriers or drivers. To keep record of the context of the documents, we created a general description of the sources, including where the study was held, whether the document was theoretical or empirical, and which methods they followed.

The process of organizing, analyzing, and coding the information from the literature consisted of several steps of content analysis. Open coding (Strauss & Corbin, 1990) was initially used to designate the name of a factor represented. In weekly meetings, we discussed the factors extracted from the literature and reached an agreement of the meaning and naming of such codes.
As new codes were added, previous codes were revisited. We extracted and coded all the factors from the selected references, which we organized, classified in related groups, and categorized using axial coding (Strauss & Corbin, 1990). As we refined these codes, we created definitions to appropriately understand what the classifications represented. Categorical axial codes were further refined by comparing the codes to literature related to change in higher education (Kezar, 2014) or organizational change (Carroll, 2006; Collins, 2005; Kaplan & Norton, 1996; Kotter, 1995; Morgan et al., 1997; Schein, 2006; Senge, 1990). This first stage resulted in 99 drivers and barriers that affect instructional change, classified into 31 factors, and ultimately organized into six categories: faculty motivation, student experience, faculty knowledge and skills, institutional support, change management, and culture. Because faculty motivation to enact and sustain change is one of the key factors (Lattuca, 2011) and understanding that the other factors interact dynamically with faculty motivation, we conducted a second stage of this process.

c) **Second Stage. Combining the Factors to Create a Causal Loop Diagram**

This second stage consisted of a systematic literature review and analysis process to establish a hypothesis of how the dynamics of the factors in the academic system affect faculty motivation to adopt RBIS. It followed a qualitative process based on recommendations of Vennix (1996), Luna-Reyes et al. (2006), and Kim and Andersen (2012). To accomplish this, we explored causal links between the factors, found literature that supported each causal link, and created causal loops. This stage resulted in a theoretical CLD created through a systematic and highly iterative process of searching and analyzing literature, hypothesizing causal links, team meetings with an expert, validating changes, and establishing the systems’ boundary. This process allowed us to remain open to re-analysis, re-interpretation, and re-elaboration of the narratives that explained the feedback loops in the CLD. This stage is represented in the five steps shown in Figure 3.
Step A, *Literature search*, consisted of finding supportive literature for the factors and the potential causal links between them. Step B, *Hypothesis linking*, consisted of hypothesizing causal links between the factors and drafting causal loops based on the analysis and interpretation of the literature found in Step A. Step C, *CLD team meeting*, consisted of regular team meetings to discuss the rationale of the causal links, defining how such links influenced the causal diagram, and establishing a narrative or story that explained the causal loops. It is worth to note that if two or more studies suggested different causal links, in the team meeting we discussed whether such differences implied different dynamics, another loop, or additional auxiliary variables. We also conducted weekly team meetings with a system dynamics expert, who is also an engineering faculty member. In these meetings we checked and revisited the interpretations of factors, loops, and narratives. After conducting the literature searches, hypothesizing links, and team meetings, a step D, *Validation*, was conducted to recheck any additional loops, causal links, and factors that were added in each iteration of the process, and to ensure that the narratives were accurate with changes made to the overall CLD. Step E, *Systems’ Boundary*, was focused on determining the boundary of the model. In this step, we checked if the

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3 Dr. Niyousha Hosseinimichieh who is an assistant professor of the Industrial and Systems Engineering Department at Virginia Tech. Her research focuses on healthcare systems engineering and policy modeling using the system dynamics approach and statistical methods. Her methodological contributions include expanding calibration methods for dynamic models and developing techniques for system dynamics group model building. More information at https://ise.vt.edu/people/faculty/hosseinichimeh.html
model included all relevant endogenous factors that affect faculty motivation to adopt RBIS, and the consistency between the loops and the elicited narratives.

Step A started with the factors found in the 19 articles selected in the first stage, and chain referencing (backward citation search) the citations used in these articles. In Step B we created a spreadsheet to capture the hypothesized causal links, and we registered the factor, its direct cause or its direct consequence, a citation that supported the link, an excerpt that described the causal link, and a memo explaining or interpreting such causal link. As we were analyzing the literature, we were finding and registering potential new causal links and factors. For these newly found links and factors, we conducted additional literature searches (Step A) using refined search terms in the EBSCOhost or Google Scholar databases. We selected highly cited sources (according to Web of Science or Google Scholar) or peer-reviewed articles. This portion of the iterative process also included a literature search using refined terms for previously found factors. That is, if a new term was found to describe a factor in an article or if we hypothesized a new causal link between two factors, then we went back to Step A and conducted an additional literature search. After we found new causal links and factors, we updated the CLD and checked for new causal loops.

The discussions in the team meetings of Step C also allowed us to gain insights and to check interpretations of factors, loops, and narratives. During these meetings, we explained the refined causal loops, factors, and causal links to the expert. The team meeting stage allowed us to add clarity and depth to the model. As the expert provided feedback and recommendations, we developed new criteria for the literature searches (Step A), edited or created new hypothesized links (Step B), or validated some narratives of the loops (Step D). Through this process of literature searching, hypothesizing, meetings, and validation, we established the system’s boundaries (Step E), by determining if the factors were endogenous or exogenous. That is, an endogenous factor is internal to the system (i.e., caused by other factors described in the loops), whereas an exogenous factor is external to the system (i.e., not caused by other factors in the loops). The iterative process ended if the new literature searches, the meetings, or the new links did not create a new causal loop narrative, thus reaching the point of saturation Vennix (1996).
3.3.1.2 Second Phase: The Empirical Causal Loop Diagram

Similar to the first phase of creating the theoretical CLD, the second phase also aimed to create a causal structure of the academic system that influences faculty motivation. However, an empirical CLD is characterized by eliciting such causal structure from the analysis of data collected at the selected site. This project used ten semi-structured interviews with ten faculty members and a focus group with seven other faculty members as data collection methods for the selected site.

a) Overview

As will be explained further in section 3.4.1, to minimize researcher bias the construction of the empirical CLD followed a reflexive bracketing procedure (Gearing, 2004). I temporarily set aside the theoretical CLD and approached this second phase as an exploratory inquiry. This bracketing procedure was not intended to validate or test the theoretical model, instead, it was intended to create a CLD based entirely on the experiences and beliefs of the study participants. Furthermore, the data collection protocols were designed purposefully to elicit dynamics that included the factors affecting change found in the literature review but not including findings of the theoretical CLD.

The stages of this phase followed the qualitative data collection procedures of SDM as suggested by Luna-Reyes and Andersen (2003) and (Vennix, 1996), and an analysis procedure based on suggestions of Luna-Reyes et al. (2006) and Kim and Andersen (2012). In a similar manner to the creation of the theoretical CLD, this phase was an iterative process of collecting and analyzing data. It consisted of two stages: data collection, and data analysis and integration.

b) First Stage: Data Collection Procedures

The first stage was the data collection process through ten interviews and one focus group. Each interview and the focus group were informed by previous data collection and analysis. In this stage, eight CLDs were built and revised during the collection process (I did not have time to build a CLD in two of the ten interviews), and each of the ten interviews provided narratives that added depth and meaning to the elicited factors, links, or causal loops. After the interviews and a
preliminary data analysis, I conducted a focus group with seven other faculty members following the methodology of Group Modeling Building (GMB) (Luna-Reyes et al., 2006; Vennix, Akkermans, & Rouwette, 1996). The purpose of this focus group was to discuss, critique, and add depth to the CLDs created during the interviews. The result of this phase was a set of eight CLDs that described different dynamics affecting faculty motivation to adopt RBIS.

The following paragraphs provide details of the data collection procedures in this phase: site selection, population and sampling, and description of the instruments. Figure 4 illustrates the process of this phase.

![Figure 4. Phase 2. Construction process of the empirical CLD](image)

I. **Site Selection**

I selected an electronics engineering department in a South American country (subsequently referred to as the ‘Department’) as the site to develop this empirical CLD. The rationale for this selection was consistent with the requirements of a site selection for both a single-case research study and an SDM research process. Typically, an SDM is built in a single site to understand and solve a particular problem (Sterman, 2000). Schwaninger and Grosser (2008) calls this SDM process a local or middle-range theory building because the theory is created as the SDM is constructed. A single-site study could constitute a powerful and more complicated theory than multiple-site studies if the site selected has unique features, such as being an extreme or unique case, or provides opportunities for unusual research access (Eisenhardt & Graebner, 2007; Yin, 2003). The site selected has these features and other characteristics that made it suitable for an SDM in a single site (Schwaninger & Groesser, 2011).
The first feature is that the site is characterized by dynamic complexity (i.e., feedback mechanisms, interdependence of elements, nonlinearities, and delays between causes and effects (Sterman, 2000)). First, as part of academia, the Department is a complex system (Ghaffarzadegan et al., 2016). As a complex system with numerous components and procedures, it has frequent interactions over time among its elements (Sterman, 2000). Second, the richness and variety of the ongoing circumstances within the current curriculum and instructional change initiatives suggest the numerous interdependencies of the system’s elements and the high probability of finding feedback loops that reinforce situations or resist policies. Some of these initiatives at the Department include: ABET accreditation, changes in university policies, administrative reorganization, and the Conceiving, Designing, Implementing, and Operating (CDIO) initiative (Crawley et al., 2007).

The CDIO initiative is an international engineering education initiative implemented in more than 130 programs around the world. The CDIO initiative aims for a student-centered curriculum stressing engineering fundamentals required to Conceiving, Designing, Implementing, and Operating (CDIO) real-world systems and products. This initiative is rich in student design-build-test projects, integrating learning of professional skills, and featuring active and experiential learning. There are many institutions around the world implementing this initiative whose competencies and guidelines come from engineers in the industry and academy (Arlett, Lamb, Dales, Willis, & Hurdle, 2010; Borrego & Bernhard, 2011). CDIO’s underlying values are similar to problem/project-based learning (PBL) (Edström & Kolmos, 2014) and, ultimately, its purpose is to drive change in engineering education toward the inclusion and adoption of instructional strategies of PBL small group collaborations and active learning (Crawley, Malmqvist, Oslund, & Brodeur, 2007).

In addition, as an academic system, the Department is history-dependent and the effect of policies could need 10 to 12 years to emerge (Ghaffarzadegan et al., 2016). The latter provides the opportunity to make inferences about the probability of having delays between cause and effects in the decisions taken and in the policies implemented.

The second feature is that the study entails a bounded system (Creswell, 2013); that is, the object of study is defined and has boundaries (Merriam, 1998). The boundaries are the elements that
constitute the Department and the object of study is the dynamics of the Department that influence the faculty motivation to adopt RBIS in their courses. However, the Department is embedded in a larger academic system, and therefore its dynamics are also influenced by elements of the larger system (e.g., the institutional policies or the mission of the university). The SDM process searched for the components internal to the larger academic system that influence the dynamics of the Department relevant to the faculty motivation to adopt RBIS.

The third feature is that the site has a combination of events and unique characteristics (Yin, 2003) to study instructional change. There are four events of ongoing change processes at different levels that have implications for the adoption of RBIS in the Department. The site selected is immersed in an ongoing curriculum change process at the Department level that started in 2015 (i.e., CDIO). In addition, at the engineering school level, it has recently (2017) acquired the ABET accreditation, which also entails a curriculum change process. As the Department and school make changes, the university is changing its policies about teaching requirements, promotion, and teaching evaluation. Furthermore, the university is constructing a new engineering building with new laboratories and classrooms using CDIO and ABET recommendations. The latter involves changes and reorganization of the administrative staff, logistics, and office spaces. In addition, at the time of data collection the site also had the following unique characteristics that made it interesting for studying an academic system: 1) it was coordinating the implementation of CDIO initiatives with ten other universities across the Latin-American region, 2) it was the oldest electronics department in its country, 3) it was one of the only three ABET-accredited engineering schools in its country, and 4) it was embedded within the oldest and biggest private university with the biggest alumni population in the country. This history suggests the ample tradition of its internal systems and allowed me to find faculty that had been part of the Department for more than two decades and had participated in several previous change processes. The aforementioned characteristics speak to the influence the Department had in the electronics engineering academic community in the country.

The fourth feature is that the site offered opportunities for unprecedented research access that provided depth in the research and offers the opportunity to conduct follow-up research projects (Eisenhardt & Graebner, 2007). On one hand, I have a strong relationship with the Department, and thus I had the opportunity for significant access to information, people, and support. On the
other hand, I have been involved in previous change initiatives at the program, course, organizational, and administrative level, and I expect to be a consultant for the ongoing and future change initiatives. Additionally, based on my knowledge of the site, I hypothesized and confirmed that it embodies several of the categories and factors that impact faculty motivation to adoption RBIS and therefore enabled me to collect pertinent information. These categories and factors (as described in Chapters 5) included, for example, a clearly stated mission and vision of the CDIO and ABET initiatives, established support mechanisms for teacher training programs, distinct policies about teaching workload and faculty research expectations, and specific requirements on learning environments.

II. Participants, Recruitment, and Sampling

The study followed a purposeful sampling (Creswell, 2009), drawing participants from the population of 57 faculty members in the Department. At the time of data collection, the Department had a total of 27 full-time faculty members, 2 on doctoral study leave, and 5 in administrative positions (i.e., Dean of the School of Engineering, Head of the Department, Chair of the Electronics Engineering Undergraduate Program, Chair of the Electronics Engineering Master Program, and Chair of the Engineering Ph.D. Program). In addition, there were 30 non-tenured adjunct professors\(^4\). The rank distribution among faculty was 5 Full Professors, 5 Associate Professors, 15 Assistant Professors, 2 Instructors, and 1 Emeritus Professor. Of the 27 full-time faculty members, 21 were tenured, 1 was on the tenure-track, and 5 were non-tenured\(^5\). Of the 27 full-time faculty members, 4 were female and 23 were male, 14 Senior (more than 10 years in the Department) and 13 Junior (less than 10 years in the Department). The leaders of the CDIO process were two full-time faculty members who had received assistance from two other

\(^4\) Part-time academics who teach one or two courses per semester. They support the faculty workload and help to maintain a relatively low-class size.

\(^5\) The concept of tenure is understood differently at the Department as compared to academic systems in the United States. All full-time professors that have held permanent positions for more than 3 years are considered tenured because they have indefinite term contracts, full-time professors with less than 3 years are considered tenure-track, and professors in temporal positions are considered non-tenure track.
tenured faculty members and one non-tenured. The following table shows the population and sample.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Population (57)</th>
<th>Interview Sample (10)</th>
<th>GMB Sample (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time (27)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full professors</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Associate professors</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Assistant professors</td>
<td>15 (1 tenured, 3 non-tenured, 1 on tenure-track)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Instructor professors</td>
<td>2 (non-tenured)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Emeritus Professor</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Adjunct (30)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-tenured</td>
<td>30</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Other demographics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Male</td>
<td>23</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Senior</td>
<td>14</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Junior</td>
<td>13</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

Based on this distribution, I selected 17 participants from different categories to conduct ten in-depth interviews and one GMB. This sample represented approximately 30% of the population with varied teaching experience, characteristics, and workloads. Participants for the interviews were different from the GMB participants. The interviews included faculty who have held administrative positions in the past and included a varied sample of the population. The focus group included experienced faculty and decision makers for the ABET and/or CDIO initiative.

For the interviews, I selected ten participants\(^6\) that reflected rank and tenure differences. Participants had experienced the new curriculum, and all of them had taught classes within the new curriculum for at least two semesters or had been assistants to the CDIO’s leaders. Thus, I

\(^6\) Originally, I had planned to interview 8 participants to gather data for each of the 4 categories from two professors. After a preliminary analysis of data, I concluded that I needed two more interviews to collect enough data for the culture and pedagogical knowledge categories. In the WIRB protocol I have stated that I would enroll an estimate of 15 participants; however, this was not considered an enrollment limit.
selected the following faculty members: tenured (four Associate Professors and four Assistant Professors), and two non-tenured adjuncts. Four participants had a high teaching load (e.g., 14 to 16 hours per semester) and six a low teaching load (e.g., none to 8 hours per semester). Two of the participants held administrative positions (i.e., Department Head and Undergraduate EE Head). Table 4 shows a description of the interviewees with the categories that were explored during the interview session. In the preliminary data analysis, I determined which categories were explored during the interview process.

*Table 4 Interview participants and categories explored*

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Categories Explored</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Full-Time (senior), Assistant, High Teaching Load</td>
<td>Students’ Experience – Culture</td>
</tr>
<tr>
<td>Male Full-Time (senior), Associate, High Teaching Load</td>
<td>Culture</td>
</tr>
<tr>
<td>Male Full-Time (senior), Associate, Low Teaching Load</td>
<td>Students’ Experience</td>
</tr>
<tr>
<td>Male Full-Time (junior), Assistant, High Teaching Load</td>
<td>Pedagogical Knowledge – Institutional Support</td>
</tr>
<tr>
<td>Male Full-Time (junior), Assistant, High Teaching Load</td>
<td>Institutional Support</td>
</tr>
<tr>
<td>Male Full-Time (junior), Associate, Low Teaching Load</td>
<td>Change Management</td>
</tr>
<tr>
<td>Male Adjunct (junior), Low Teaching Load</td>
<td>Pedagogical Knowledge</td>
</tr>
<tr>
<td>Female Adjunct (junior), Teaching Load: Low</td>
<td>Student’s Experience - Institutional Support</td>
</tr>
<tr>
<td>Department Head, (junior), Associate, (No classes assigned)</td>
<td>Institutional Support</td>
</tr>
<tr>
<td>Undergraduate EE Head (junior), Assistant, (No classes assigned)</td>
<td>Institutional Support – Change Management</td>
</tr>
</tbody>
</table>

For the GMB, Luna-Reyes et al. (2006) suggest five to seven participants for manageability. I selected seven participants with experience in the CDIO and ABET initiative: five tenured professors (three associates, two assistants), one full-time non-tenured, and one non-tenured adjunct. Four professors had high teaching loads (14 to 16 hours), 2 medium teaching loads (8 to 14 hours) and two low teaching loads (none to 8 hours). Table 5 provides details of the GMB
participants. I contacted all participants by personal communications with the acknowledgment of the Department head. A gatekeeper, the assistant Department head, helped me to coordinate and confirm the schedule for the data collection activities.

Table 5 GMB participants

<table>
<thead>
<tr>
<th>GMB Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Full-Time (senior), Associate, High Teaching Load</td>
</tr>
<tr>
<td>Male Full-Time (junior), Non-tenure, High Teaching Load</td>
</tr>
<tr>
<td>Male Full-Time (senior), Assistant, Medium Teaching Load</td>
</tr>
<tr>
<td>Male Full-Time (junior), Associate, High Teaching Load</td>
</tr>
<tr>
<td>Male Full-Time (senior), Assistant, High Teaching Load</td>
</tr>
<tr>
<td>Female Full-Time (junior), Associate, Medium Teaching Load</td>
</tr>
<tr>
<td>Female Adjunct (junior), Low Teaching Load</td>
</tr>
</tbody>
</table>

III. Description of the Instruments

Interviews

The purpose of the interviews was to create a preliminary CLD by eliciting relevant information about what motivates or inhibits faculty to adopting RBIS in their classes. Vennix (1996) suggests a guided interview approach for building SDM. This interview approach employs a list of predetermined topics, but the interviewer is free to determine the sequence of topics and the wording of questions without losing the focus the interview. Appendix B shows the protocol for these interviews. Table 4 shows the categories explored in each interview, which defined the type of questions asked according to the protocol. This protocol was pilot tested and refined with three faculty members fluent in Spanish from Virginia Tech and Old Dominion University. The main change informed by these pilot sessions was that the interview should be focusing in no more than two categories to maintain the first part of the interview within 30 minutes. They also provided clarity of the explanation required to introduce the CLD process to participants and what kind of questions to ask to create the CLD with them.
In general, the interview questions aimed to elicit opinions, values, and knowledge about the participants’ willingness to adopt RBIS, and the elements of the academic system that affect such adoption. Vennix (1996) stresses the importance that the questions in these interviews, in addition to being open ended, should also be neutral, singular, and clear. Neutral means that I did not frame any leading questions or make any presuppositions with regard to the respondent’s answer. Singular means I asked one question at a time. Additionally, to increase clarity, questions were formulated in different ways as I saw fit based on the interviewee’s responses.

Another characteristic of the questions, as strongly suggested by Vennix (1996), is to be built around the “why” of the statements because it helped to elicit causal arguments from the respondents. Even if the interviewee was not able to answer such questions, it revealed unwarranted assumptions in his or her mental model, which might also be valuable. To avoid the interviewee feeling shame with such lack of response, I stated from the beginning that several questions might prove difficult and that it was expected that he or she may not have all the answers.

Interviews consisted of two sections. Both were audio recorded with the interviewee’s acknowledgement and permission. The first one consisted of open-ended questions related to identifying the factors and reasons that positively and negatively affected their motivation to adopt RBIS. To identify and to ensure exploring a variety of factors, the questions were framed into the categories of factors, besides faculty motivation, found in the literature review (i.e., pedagogical knowledge, cultural, institutional support, students’ experience, and change management). The questions directly related to faculty motivation were framed into the MUSIC model of motivation (Jones, 2009). The second section of the interview focused on building a CLD with the interviewee. First, I explained the purpose of this part and the basic notions and notation of a causal loop. Based on their previous responses, I identified key factors that affected their motivation. From each of these factors, I asked their perceptions on what caused these factors and then I asked their perceptions on the consequences of increasing or decreasing such factors. To make the discussion more appropriate, key factors were stated as variables that could be quantified (e.g., class time using RBIS, number of RBIS activities, workload, class size, or motivation) and they were drawn in a diagram. The elaboration of these diagrams was video recorded with the acknowledgement and permission of the interviewee. Lastly, I asked for the
possible links (and their rationale) between the causes and consequences and the other variables in the diagram. The CLD created in this section was a way to synthesize the stories about how the dynamics of the system worked (i.e., the dynamic hypothesis (Sterman, 2000)). I did not need to show them previously hypothesized causal loops because the participants were highly engaged in providing answers and shared specific information and explanations on the relationships between the variables.

Finally, as an interviewer, I had to be aware of the required skills to increase the quality of the elicited information. This included gaining rapport, conducting the interviews in the native language of the participants, maintaining the flow of the conversation in an open communication climate, creating a high-quality interaction process, and keeping the interviewee motivated. Some strategies included: stating clearly the purpose of the interview, making sure the respondents understood what was expected from them, maintaining awareness of the perceived relevance of the questions, being neutral with regard to the content, being genuinely interested in the participants’ ideas and opinions, and maintaining reflective listening (Creswell, 2009; Vennix, 1996). To further develop such skills, I conducted three pilot interviews with people who shared or had familiarity with the context of the participants (e.g., had been an engineering faculty member in Latin America and Spanish was their native language).

After conducting the interviews, I conducted a preliminary synthesis aimed at constructing several CLDs that included all causal loops created during the interviews. I kept track of the similarities and differences between the loops as well as additional information (e.g., variables, narratives, definitions, stories, or lessons) that could or could not be included in the consolidated CLD. Such distinct possibilities, possible contradicted information, and questions that were unanswered after my attempt at merging the loops provided the starting point for the focus group discussion.

**Focus Group: A Group Model Building (GMB) Process**

The focus group followed the guidelines of the Group Model Building (GMB) process (Andersen & Richardson, 1997; Hosseinichimena et al., 2017; Luna-Reyes et al., 2006; Vennix et al., 1996). GMB is designed to elicit the dynamics of a problem from the mental models of teams. In particular, the purpose of this focus group was to discuss, critique, add depth, and
evolve the CLD created from the interviews. Appendix C shows the protocol followed in the GMB. This protocol was pilot tested with two groups of faculty and graduate students who had experience in teaching.

There are three main reasons to use a GMB as part of an SDM. First, it helps to inductively discover the key issues, ideas, and concerns about the adoption of RBIS from multiple participants at once (Marshall & Rossman, 2014). Second, it uses the interaction among participants to gather better data and to triangulate previous findings (Denzin & Lincoln, 2003). And third, it involves the participants deeply into the model-building process in order to enhance team learning, foster consensus, and create commitment with the outcomes (Vennix, 1996).

The GMB consisted of two sections. Both were audio and video recorded with the participants’ acknowledgement and permission. The first section, following similar guidelines to the first part of the interviews, consisted of asking open-ended questions aimed at identifying (individually and then collectively) as many possible factors and reasons that positively and negatively affect faculty motivation to adopt RBIS. To help the participants generate ideas and to focus the conversation, I showed them the five categories of factors, besides faculty motivation, found in the literature review. Participants were asked to explain, discuss, select, organize, and prioritize such factors. The second section of the GMB focused on incorporating those variables into the CLD created after the interviews. This second part included discussing, complementing, and reaching a consensus of the causal loops and their rationale. The result was a refined version of the empirical CLD that later (in the creation of the empirical CLD) were enhanced with a deeper data analysis.

Vennix (1996), Andersen and Richardson (1997), and Luna-Reyes et al. (2006) emphasize the importance of group facilitation for a successful GMB. These suggestions implied that there are different roles that had to be fulfilled to facilitate the process. These roles included a gatekeeper, a content and process coach, a recorder, a modeler, and a facilitator. The gatekeeper was one of the Department’s administrators interested in solving the problem focused on motivating the participants to engage in the group activity, such gatekeeper did not participate in the GMB to avoid skewed the conversation due to the power dynamics that this person could bring into the group. The content and process coach focused on the group process and dynamics, and she
observed the group and helped the facilitator to identify strategies to keep the group effective. The recorder took notes that were used to keep the discussion on track and inform the report. The modeler was knowledgeable of the subject matter and focused on drawing the model and aided in preventing the group from developing a one-sided view of the problem. Lastly, the facilitator (the most important role) asked the questions, guided the group discussion, maintained the flow of the conversations, and took notes on the white board to keep track of the so-called group memory. These roles were not performed by different people as suggested by the literature, especially when the goal of the GMB is to create a qualitative model (Andersen & Richardson, 1997; Vennix, 1996).

I fulfilled both the role of the facilitator and modeler. Two additional people fulfilled the roles of the coach, recorder, and gatekeeper. There were some requirements for creating this team: the recorder and facilitator needed to understand the philosophy of SDM. Both coach and facilitator had knowledge about group process. The recorder, modeler, and facilitator were capable of listening very carefully and translating people’s ideas into brief key phrases or words. I had previous meetings with this team to coordinate and prepare for these roles. My experience and personal skills allowed me to be confident in having a successful facilitator role as I have conducted other focus groups; coordinated and facilitated activities with groups of faculty members; conducted small GMB discussions in class projects, research group discussions, and a conference workshop (Cruz et al., 2018); and conducted the session in the native language of the participants (i.e., Spanish). The two people who had the roles of coach, recorder, and gatekeeper signed a statement of confidentiality and received the same compensation as the participants.

c) Second Stage: Data Analysis and Integration

Similar to the construction of the theoretical CLD, this stage consisted of a qualitative analysis process to establish a hypothesis of how the dynamics of the factors in the particular academic system affect faculty motivation to adopt RBIS. It followed the recommendations of Vennix (1996), Luna-Reyes et al. (2006), and Kim and Andersen (2012). The second stage entailed a further analysis of the data to add depth, provide evidence, and integrate the CLDs constructed in the data collection process.
This stage started by conducting a content analysis (Miles et al., 2014) of the interviews and focus group data. Its purpose was to extract all the factors, causal links, and narratives elicited during the interviews and the discussions within the focus group. To classify the information, I used open and a-priori coding. The 31 factors defined in the literature review (Chapter 2) constituted the a-priori codes and five additional codes were the result of open coding. The complete code book is detailed in Appendix D.

To add more depth and support to the empirical CLD, this second stage involved associating the codes with the feedback loops created during the data collection by checking if such codes were explained or were included in the loops, or if they added new loops or factors. That is, I decided if a new factor arose, if data substantiated a causal relationship already defined, or if data suggested a new one. After adding depth to each causal loop and substantiating each causal connection with quotes and a descriptive narrative, I looked for similarities between different CLDs (e.g., similar variables, similar dynamics) and combined them into a comprehensive CLD. The result of this stage is the empirical CLD described in Chapter 5.

One particularity of this project is that the data collection was held in Spanish. Codes were defined in English but to data that were also transcribed in Spanish. Nonetheless, I translated to English the quotes used in this document. However, there are natural differences between the two languages that introduce in this translation additional layers of interpretation. For example, in Spanish we use tacit pronouns (e.g., to say “el uso” (he uses), we can just say “usa” (uses) and it would have correct grammar), neutral gender pronouns to non-neutral gender nouns (e.g., “Si le conociera bien, estaría interesado en utilizarla” (If I would know it well, I would be interested in using (her)), and naturally, different grammar rules in punctuation (e.g., use a period after the end of the quotes, instead of before (“algo”. (“something.”)).

In every translation there is a natural interpretation of the context that the participants were referring to. In this case, I used brackets to introduce that context. Also, the apparent cultural difference of not being concise or precise in the words, or using many analogies, sarcasm, and hyperboles in spoken language means that at best they would not read well in written English and at worst they could be offensive, very confusing, and not make sense at all. Thus, a literal translation was not suitable for this project. Therefore, I made modifications to the quotes to
ensure the translation was understandable in written English and two additional fluent Spanish and English speakers reviewed the quotes and their translations.

This is an example of an original quote in Spanish without brackets and its literal translation to English (see quote No. 30):

“Si le conociera bien, estaría interesado en utilizarla, pero solamente en momentos en que realmente eso sea lo que se necesita, Por ejemplo, digo por mi formación y todo eso, para introducir un concepto... introducir el concepto de qué es un voltaje, de qué es una corriente, una malla, etcétera todo eso, para presentarlo todo inicialmente ésa puede ser una forma, pero ya con ese concepto de pronto para anclarlo mejor, ya se puede pasar a una parte enfocada en un proyecto... porque no sabría en este momento si definitivamente es mejor PBL en todo instante por ejemplo para explicar eso”.

“If I would know it well, I would be interested in using it, but only at moments where it is really what is needed, for example, I mean because of my formation and all of that, to introduce the concept... to introduce what is voltage, what is a current, a loop, etc., all of that, , that can be one way to present it at first, but now with that concept, maybe to anchor it, it can move it to a stage focused on a project... because at this time I don’t know if it is definitively better PBL at every moment, to explain that.”

A modified version of the quote facilitates its translation and reading in standard English.

“Si conociera bien [PBL] estaría interesado en utilizarla, pero solamente en momentos en que realmente eso sea lo que se necesita, ... para introducir el concepto de qué es un voltaje, de qué es una corriente, una malla, etcétera, prefiero presentarlo todo inicialmente... de pronto para anclarlo mejor, ya se puede pasar a una parte enfocada en un proyecto... No sabría en este momento si definitivamente es mejor [usar] PBL en todo instante como para explicar [esos概念os].”

“If I would know [PBL] well, I would be interested in using it, but only at moments where it is needed... to introduce the concept of what is voltage, what is current, a loop, etc., I prefer to present everything first... maybe to anchor it, we can focus on a project... I don’t know if it is definitively better [to use] PBL at every moment, for example, to explain [those concepts].”

The original quotes in Spanish were included in Appendix E as endnotes.
3.3.1.3 Third Phase: CLD Integration to Create a Conceptual SDM

The last phase of the study focused on creating a conceptual SDM by integrating the theoretical CLD with the empirical CLD. Such integration was a comparison between the causal loops found in the CLDs plus an interpretation of their similarities and differences using motivation theory and literature. The categories used for this comparison were the five categories defined in the literature review besides faculty motivation. Results of this phase are included in Chapter 6.

Although the MUSIC model of motivation was the best fit to classify the factors that influence instructional change as emerged in the literature review, it did not necessarily provide enough detail of other motivation theories that could help better describe the differences and similarities in the loops. Therefore, To supplement this phase, I also used concepts and constructs from other theories like Expectancy-Value Theory (Eccles & Wigfield, 2002), Self-Determination Theory (Deci & Ryan, 2000) or Self efficacy theory (Bandura, 1997). Nonetheless, such theories are also related to the MUSIC model as described by Jones (2018).

The interpretation also brought policy implications that are also hypotheses of the key factors that could potentially become leverage points (Senge, 1990). That is, factors based on the dynamics of the system will have higher impact with lesser effort.

3.4 Establishing Validity and Transferability

3.4.1 Validity

The validation process of the model is embedded throughout the various stages of the study. This validation process helps to establish sufficient confidence in the SDM process, its suitability for some particular purpose (Coyle & Exelby, 2000; Senge & Forrester, 1980), and to present evidence of the model’s limitations to avoid its misuse (Sterman, 2000). Although not intended to assure perfect accuracy, there are several processes or tests for validating an SDM (Coyle & Exelby, 2000; Groesser & Schwaninger, 2012; Schwaninger & Groesser, 2011; Senge & Forrester, 1980; Sterman, 2000). I selected five tests that fit the scope of this project because they could be done qualitatively and none of them required computer simulation nor real-world experiments of policies. Using the definitions in Schwaninger and Groesser (2011), these tests
were: 1) issue identification, 2) adequacy of methodology, 3) system configuration, 4) structure examination, and 5) boundary adequacy tests.

The purpose of the Issue Identification Test is to check whether or not the identified problem is meaningful. This is a procedure applied repeatedly during the initial phase of the modeling process by reflecting regularly on the correctness of the identified problem. Based on this definition, this study has validity because the problem statement addressed the origins of the motivation to adopt RBIS instead of only its superficial symptoms, and it is using a systems perspective to understand it.

The purpose of the Adequacy of Methodology Test is to check if the SDM methodology is best suited for dealing with the problem stated. As mentioned in the philosophical perspective in this chapter and in the literature review (Chapter 2), the stated problem is better addressed by this methodology because it is not a static or simple problem, instead it is characterized by dynamic complexity, feedback mechanisms, interdependence of elements, and delays between causes and effects.

The System Configuration Test was conducted during the GMB and the interpretation of the data. This test entails checking that the model represents not only the actual working of the system under study, but it can also be used to change the participants’ mental models. Examples of the questions asked to enhance validity according to this test were: Can the model be used to identify policy implications? Can it be used to capture new conditions (such as different causes of the problem or unexpected consequences)? Does this model enrich the participants’ knowledge of the system? Policy implications are described after the description of the theoretical and empirical CLD in Chapters 4 and 5. The different conditions and unexpected consequences are described in the details of both the empirical and theoretical CLDs, and the enrichment of the participants’ knowledge of the system occurred during the second part of the interviews and GMB, particularly when discussing the elements in the causal loops. However, I plan to present these results at the site where this study was conducted and prompt a conversation around the conclusions. Similarly, these questions will inform the design of presentations and workshops in different conferences where the results of this project will be shared.
The purpose of the *Structure Examination Test* is to make a direct comparison between the original system structure and the model structure. The idea is to increase validity by ensuring that the model contains those structural elements and interconnections that exist in the real system. During the GMB, data analysis, and additional member checks with the participants, I identified if the conceptual SDM matched elements and dynamics of the real system. This validity increases by comparing the model structure with literature about academic systems. The model did not contradict the evidence or the members’ knowledge about the structure of the real system, although it helped to contrast some professors’ mental models against the evidence in previous research. An example of this contrast occurs with the belief that SET scores are associated with more permissiveness. In the empirical model, I explained that an increase in the SET scores increased the belief that professors were easy with their students, therefore more permissive. However, research suggests that better SETs are not necessarily correlated with better grades; therefore, the association between permissiveness and grades is not necessarily granted in the literature, but is a belief that professors have which in turn hinders the motivation to adopt RBIS.

The purpose of the *Boundary Adequacy Test* is to check if the model includes all relevant internal structures or endogenous factors that affect faculty motivation to adopt RBIS. As part of the model construction, this test involved discarding other system factors that did not affect the stated problem and developing a convincing hypothesis with the remaining factors to explain the problem. This procedure has been part of the analysis procedures of the theoretical and empirical CLDs.

### 3.4.2 Transferability

Noting that the site selected has special features and characteristics that make it suitable for an SDM in a single site, this can also impact the transferability of the model (Schwaninger & Groesser, 2011). It is a limitation of this study that an SDM built in a single site is not expected to be representative of a broader population (Eisenhardt, 1989). Findings of an SDM could be transferred or replicated into other similar systems (Eisenhardt, 1989; Sterman, 2000) by looking for similar cases and trying to replicate findings from the original study (Creswell, 2013) or by looking for a family of social systems to which the particular case belongs and enhance and test.
the findings (Schwaninger & Groesser, 2011). Building a general SDM would require following a similar method used to build broader theories from multiple case studies (Eisenhardt & Graebner, 2007; Schwaninger & Grosser, 2008; Yin, 2003), but it goes beyond the scope of this study.

However, the potential transferability of the model to other academic systems is supported by the notion of isomorphism described in the institutional theories of change (Kezar, 2014). Isomorphism theory suggests that “universities with even distinctive missions, have shifted over time to become more similar in character in terms of their student bodies, mission statements, focus on research over teaching, curriculum, and other components that make up the organizations” (Kezar, 2014, p.38). That is, academic institutions tend to be very similar even in different countries and educational systems. This is not to say that the SDM will fit perfectly into other academic systems but that it increases the likelihood that some elements of the model could be adapted to a different system. Nonetheless, by following the bracketing process and other validity procedures described later in this chapter, it is possible to argue that the relationships found between the theoretical and empirical CLDs were not a product of confirmation bias, instead it could be due to this isomorphism.

Nevertheless, to increase the transferability properties, this study provided good documentation of qualitative procedures (Creswell, 2013), thick descriptions (Borrego, Douglas, & Amelink, 2009), and strong relation to the literature (Creswell, 2009). The different stages of the SDM process provided clear opportunities to document the procedures and findings (Luna-Reyes & Andersen, 2003).

3.5 Bias

It is appropriate to discuss why an SDM process demands a deep involvement between the modeler and the participants of the site. Fundamental to conducting qualitative research is the researcher as research instrument (Denzin & Lincoln, 2003) and the key person in obtaining data from respondents (Poggenpoel & Myburgh, 2003). Sterman (2000) claims that SDM requires even deeper involvement between the researcher and the participants because SDM is an iterative process of joint inquiry and discovery. Forrester (1993) adds to that claim by stating that one of the purposes of SDM is to reach, for both participants and researchers, new
understandings of how the problem arises, and later, use those understandings to improve the performance of the system as defined by the participants. Although the purpose of this study was not to change the participants’ mental models, Forrester (1993) and Senge (1990) suggested that the effectiveness of a model also depends on its ability to communicate with and to modify the participants’ mental models because only people’s mental models will determine action. As Sterman (2000) summarizes it, SDM built without deep involvement with the client “will never lead to change in deeply held mental models and therefore will not change client behavior” (p. 80).

Such involvement with participants is highly difficult for outsiders of the system unless they are expert modelers (Sterman, 2000). It is also difficult for outsiders to capture or observe the necessary information and the intricacies for building and validating the SDM in such a complex system as academia. Conversely, my familiarity with the site lowered these difficulties by allowing me to build rapport with participants and thus better engagement.

However, the required involvement with the participants and my familiarity with the site increased the risk of bias threat to the research. Nonetheless, bias in qualitative research exists regardless of the effort to stay neutral (Mehra, 2002) because, by being a vital part of the process, researchers cannot detach themselves from the topic or the people they are studying. As Sterman (2000) posits, bias in SDM also arises because “there are no value-free theories and no value-free models” (p. 851). Literature suggests that bias threats to the research’s trustworthiness could have two main sources: respondent and researcher bias. Respondent bias refers to the ways that the presence or the interaction with the researcher impacts respondents’ actions or responses (Miyazaki & Taylor, 2008; Singleton Jr., Straits, & Straits, 1993) and researcher bias refers to researcher beliefs, values, and predispositions that may shape their inquiry (Creswell & Miller, 2000).

Respondent bias sources come from the social situation surrounding the data collection process (Singleton Jr. et al., 1993). Frequently, there is a tendency of respondents to favor social desirability responses, which involves respondents answering questions in a way that they consider will lead to being accepted or make a good impression on the interviewer or on the group. On one hand, my familiarity with the site could have a negative impact on the social
desirability bias by: 1) increasing power issues (Creswell, 2009), that is, potential discrepancies or conflicts between the participants’ ideas and what they believe I am expecting to hear; 2) by compromising the possibility to disclose information (Creswell, 2009) because they could believe that what they say would be used against them in the future; or 3) by raising issues too sensitive that do not allow me to do member checking on findings (Poggenpoel & Myburgh, 2003). On the other hand, my familiarity with the site could have a positive impact on reducing the threat from social desirability bias by increasing the rapport with respondents (Singleton Jr. et al., 1993), which motivates them to cooperate and give complete and candid answers. The rapport I built with the Department’s faculty was increased by the possibility of conducting the interviews in Spanish (their native language) and my sensitivity toward the University’s culture that allowed me to discern what questions to ask and the proper way to make the required inquiry. In addition, other ways of reducing social desirability bias were the use of indirect questions (e.g., asking about what a third party thinks) and phrasing questions in a way that did not imply there was a right or socially desirable answer (Singleton Jr. et al., 1993).

Another source of respondent bias is the tendency for respondents to agree with and be positive about whatever the interviewer presents. This bias source is called acquiescence bias (Singleton Jr. et al., 1993). The negative impact of this bias relies on the fact that by presenting participants with a hypothesis, they would tend to agree with that hypothesis, which could lead to confirmation of the hypothesis on the basis of skewed data (Zuckerman, Knee, Hodgins, & Miyake, 1995). Because of my familiarity with the site, participants could tend to agree more with what I present instead of questioning or critiquing it, even though it is not uncommon that as part of the academic culture faculty tend to be more skeptical or more challenging (Gerholm, 1990). To reduce this bias’s impact, I developed the interviews and GMB protocols around presenting both causal loops hypothesis and open questions to inquire about the existence of causes that increase or decrease one factor, and inquire for the meaning of these relationships. So there was a combination of testing hypothesis questions (i.e., confirmatory), creating hypothesis questions (i.e., exploratory), and explaining hypothesis questions (i.e., explanatory) (Creswell, 2009; Singleton Jr. et al., 1993).

Research bias sources come from the researchers’ beliefs, values, or culture influencing their research (Creswell & Miller, 2000; Denzin & Lincoln, 2003). There is a natural tendency that
leads researchers to misinterpret new data as supportive of their current hypotheses or beliefs, while dismissing data that does not confirm them (Frey, 1986). Such bias is called confirmatory bias (Rabin & Schrag, 1999) and often occurs when the researcher approaches the analysis of data with preconceived ideas (Glaser & Holton, 2004; Glaser & Strauss, 1967), overconfidence (Rabin & Schrag, 1999), or with mental and other discomfort when gathering or analyzing data (Poggenpoel & Myburgh, 2003). My familiarity with the site could have a negative impact potentially leading to confirmatory bias by: 1) being too involved with the research topic, thus increasing the difficulty of bracketing my own experiences (Gearing, 2004); 2) by growing the expectations of the project, making it harder to delimit its extent (Creswell, 2013); or 3) by limiting the inquiries to discover what I think I do not know, rather than opening up my inquiries to embrace also what I do not know that I do not know (Chenail, 2011). Conversely, my familiarity with the site is a source of high motivation and personal investment in the project because of its potential usefulness and personal interest (Jones, 2009). Furthermore, such familiarity also increased the convenience of data collection because it offered unusual access to information, people, and support, which allows me to maximize the range of information uncovered (e.g., by using the process of theoretical sampling (Glaser & Holton, 2004)).

To minimize researcher bias, the literature suggests following bracketing procedures (Fischer, 2009; Gearing, 2004; Tufford & Newman, 2012). Bracketing has a different focus based on philosophical worldviews (e.g., positivism, postmodernism, or pragmatism). Because of the nature of SDM, I chose to use the process of reflexive bracketing (Gearing, 2004). This pragmatic view of bracketing is the scientific process of setting aside theories, presuppositions, or ready-made interpretations and focusing on the structures and essences of the phenomenon as described by the participants. Setting aside theories does not mean approaching the data collection without any preset theoretical framework of reference, or in this case, a theoretical CLD, but to temporarily set aside the theory and approach data collection as an exploratory inquiry. Temporarily means that the researcher decides when to start and end the bracketing process. I have bracketed the hypothesis in the interviews and the GMB to make them an exploratory inquiry. That is, I did not use the theoretical CLD loops to start or enhance the discussions. I made that decision purposefully to approach the interviews as an exploratory process and the GMB both as an exploratory and an explanatory process of the findings on the
preliminary analysis on the data. Nonetheless, the interview and GMB protocols were designed based on the results of the literature review but not on the results of the theoretical model.

To collect data using reflexive bracketing and thus reduce the effect of bias, the first step was identifying my personal suppositions and disclosing them (Gearing, 2004). Although I have found theory that supports it, these suppositions are embedded in the theoretical CLD. Clarifying the suppositions that I brought to the study helped me to be continuously aware of how they are influencing the assumptions, methods, and results of the project (Tufford & Newman, 2012). It also allows other researchers to understand my worldview from where I am making the interpretations and analysis (Fischer, 2009). The second step to identifying potential researcher bias was by pilot testing the interview protocols to see if the planned procedures perform as envisioned (Creswell, 2009; Poggenpoel & Myburgh, 2003). I used a pre-pilot study inquiry called “interviewing the interviewer” (Chenail, 2011) by assuming the role of a study participant and asking for a colleague to conduct the interview, which served both as a bracketing procedure (e.g., by disclosing the personal assumptions or responses to the interviews) and a validation procedure (e.g., by confirming and changing the interview until its results are satisfactory). I also pilot tested the data collection protocols with people who share similarities with the participants (e.g., fluent Spanish speakers and faculty). The third step was selecting when to set aside the theoretical CLD (as an exploratory process) during the interview process and when to include the results of the literature review (as an explanatory or confirmatory process) (Gearing, 2004; Luna-Reyes & Andersen, 2003; Turner, Kim, & Andersen, 2013). The last steps were held during data analysis by employing multiple strategies of validity to increase confidence in the accuracy of the findings. Such strategies included: 1) revisiting the data to look for contradictions and alternative hypotheses that explain the information in the diagrams (Richardson, 2011; Sterman, 2000), 2) trying to identify the implicit assumptions of my own mental models considering how the outcomes of the model might change if different assumptions were used (Sterman, 2000), and 3) documenting thoroughly every step of the process and results and using quotes of participants in each step (Mehra, 2002). Lastly, I solicited the judgments, reviews, and opinions of a diverse group of people that joined this modeling and validation venture (Schwaninger & Groesser, 2011; Sterman, 2000). These reviews included member checks with four professors who were participants of the study, feedback from members of the SMILE research group at Virginia Tech (researchers savvy in theories of motivation), two colleagues who speak fluent English and
Spanish to review the quotes and their translation to English, and an additional expert in motivation research (Dr. Brett Jones).

3.6 Limitations

In addition to my researcher biases and the limitations of creating a study in a single site, seven other methodological limitations arise from the design and analysis of this study. The first limitation is a consequence of the SDM process. Although the study tries to understand better an issue embedded in a complex system, its focus is to model the issue, not the entire system. I have narrowed the project to understand the dynamics of the endogenous elements that affect faculty motivation to adopt RBIS based on previous research and based on data collected at the Department. For example, I was not focused on understanding the trends or level of adoption of RBIS nor modeling other variables of the academic system such as the diversity of population or the influence of technology. As I stated before, although these variables could affect faculty motivation, they are exogenous to the problem and therefore not caused by the Department’s faculty motivation.

The second limitation is that the empirical model came from faculty members. The participants who are administrators are also faculty in the Department. Thus, I did not include other stakeholders of the academic system. Such inclusion would reduce the feasibility of the project and deviate from the idea that the causes of the issue could be endogenous to the Department. That is, one of the underlying hypotheses of the project was that “faculty has agency and ownership to systemic change in the context of a larger system of influence” (Matusovich et al., 2014 p. 304). At the end, it is the faculty member who adopts, or not, the RBIS in her or his classes.

The third limitation of this project is its extent. I have mentioned that the goal was to create a conceptual SDM, not a simulation SDM. A conceptual SDM is the basis for a model formulation and simulation, but to reach those stages the project would have to be extended and the data collection would have to include quantitative historical data. Although it is possible to gather these data to create a simulation model, such information is not easy to acquire in social systems (Sterman, 2000). Formulation and simulation would be next steps after the conclusion of this investigation.
The fourth limitation occurs in the timing of the GMB. Because I conducted the GMB before I had the opportunity to analyze the interviews in-depth, I could not ask questions in the GMB that arose from such analysis, and it was not easy to corroborate if all the individual faculty members’ narratives were also shared by the group. This limitation is partially alleviated because the method aimed to relate such narratives to theory, and I conducted member checks to increase the model validity.

The fifth limitation is that data were collected in Spanish. As explained in the analysis section of the empirical CLD, I modified the wording of the quotes to make sure they were understandable in standard English. Such additional layers of interpretation could have introduced more bias to the process; however, I asked two other bilingual researchers to review the quotes and their translations to minimize changes to the meaning of the original participants’ quotes.

The sixth limitation is associated with context. Each System Dynamics Model varies depending on the context. Although it could be similarities between several academic systems, it is not expected that the empirical CLD would be directly transferable. As mentioned in the transferability section of this chapter, an SDM built in a single site is not expected to be representative of a broader population (Eisenhardt, 1989). Findings of an SDM could be transferred or replicated into other similar systems (Eisenhardt, 1989; Sterman, 2000) by looking for similar cases and trying to replicate findings from the original study (Creswell, 2013) or by looking for a family of social systems to which the particular case belongs and enhance and test the findings (Schwaninger & Groesser, 2011). This is also a limitation of the theoretical CLD, although it was based on research literature, the majority of the references found analyzed research-focused institutions instead of teaching-focused institutions whose policies for tenure and promotion could not err on the side of research. Such difference would modify the dynamics of some of the loops. This SDM, therefore, is more oriented to faculty in research-oriented institutions.

The seventh limitation is that the most common RBIS used at the selected site are PBL (i.e., project-based learning in design courses and problem-based learning in courses with more theoretical content), small group collaborations, and active learning. Therefore, the loops of the empirical CLD are oriented to the adoption of these three strategies. Nonetheless, the assumption
in this study is that the adoption of other RBIS, like peer instruction or think-pair-share could have similar dynamics than the three strategies mentioned above.

3.7 Summary

Chapter 3 describes the SDM process I conducted in this research project, which aimed to create a conceptual SDM that explains how the dynamics of the academic system affects faculty motivation to adopt RBIS. I discussed the pragmatic philosophical perspective to design and conduct this study. I described the qualitative methods for the three main phases of the study: theoretical CLD, empirical CLD, and conceptual SDM, and these methods included the data collection and analysis procedures. Lastly, I also discussed the validity, effects of bias and limitations of the study.
CHAPTER 4. A THEORETICAL CAUSAL LOOP DIAGRAM OF FACULTY MOTIVATION TO ADOPT RBIS

4.1 Introduction

As mentioned in Chapter one, the goal of this study was to better understand how the academic system affects instructional change in engineering education. To accomplish this goal, I created a conceptual SDM that illustrates how the factors in the academic system interact dynamically to drive or hinder faculty motivation to adopt RBIS in their courses. To develop the model, I used a qualitative SDM process that combined research literature with field data gathered at a specific site. The first phase of the SDM involved the construction of a hypothesis that offers a big picture of the academic system and how its different variables can be interconnected to affect faculty motivation to adopt RBIS. This hypothesis is shown in the form of a theoretical CLD, which is derived from a systematic review of the literature on instructional change in engineering and higher education, and provides a preliminary answer to the research questions of this study.

The theoretical CLD shows the interaction of the academic system components influencing change in the form of eight reinforcing and six balancing causal loops that drive or hinder the faculty motivation to adopt RBIS in their courses. The details of the research process to create this CLD were shown in Chapter 3. The results of this study will be described across Chapter 4 and Chapter 5 (which will show the description of the empirical CLD).

4.2 A Theoretical CLD

As mentioned, the theoretical CLD provides a hypothesis of how the academic system factors that affect instructional change would drive or hinder faculty motivation to adopt RBIS in their courses. To provide more readability and clarity to the model, I illustrate the CLD incrementally by organizing the loops according to the other five categories besides faculty motivation of the instructional change factors (i.e., faculty pedagogical knowledge, students’ experience, culture, institutional support, and change management). I introduce new variables and their dynamic relationships in each loop description. Nonetheless, as a characteristic of complex systems, the individual factors interact dynamically, hence one factor could belong to multiple causal loops and each loop could belong to different categories.
As mentioned, feedback loops arise from the interactions among the components of the system. Every action has a consequence, which subsequently leads to another action which in turn causes another consequence, and so on. All dynamics arise from the interaction of two types of feedback loops: reinforcing and balancing loops (Sterman, 2000). Reinforcing loops, denoted with an “R1, R2… R8” in the CLD, are the engines of advance or decay (i.e., upward and downward trends) of whatever is happening in the system. Balancing loops, denoted with a “B1, B2… B6,” are the ways to stabilize or control the system (Senge, 1990). The resultant behavior of reinforcing loops is either accelerating growth or accelerating decline, whereas the resultant behavior of a balancing loop is stability and control (Senge, 1990). That is, reinforcing loops promote change whereas balancing loops oppose change. Although there are only two types of feedback loops, a CLD may easily contain several loops coupled to one another. The change in dominance between reinforcing and balancing loops creates growth, decay, or control of the different variables of a system.

There are a number of important exogenous variables that create the environment in which faculty adopt RBIS; for example, institutional policies on tenure and promotion, and stakeholders’ assessment of learning. These exogenous variables set the stage for how endogenous factors (e.g., faculty workload or perceived effectiveness of teaching strategies) interact with, but are not affected by, the causal loops. The exogenous variables are considered outside of the boundary of the problem modeled. A summary of the causal loops is provided in Table 6 at the end of the description of the model (see page 81).

4.3 Faculty’s Pedagogical Knowledge and Skills Loops

To increase the faculty motivation to adopt RBIS it is necessary to increase the knowledge or skills that faculty have about RBIS (Darby & Knight-McKenna, 2016; Finelli et al., 2014; Lattuca, 2011). In other words, successful instructional change occurs alongside the pedagogical development of faculty because such knowledge will shape the beliefs faculty have about new teaching methods (Lattuca, 2011), how students learn (Ambrose et al., 2010), and their self-efficacy, or the belief in their own capability of using RBIS in their teaching (Darby & Knight-McKenna, 2016). This pedagogical knowledge is developed through a learning process as a result of formal or informal training processes, and conscious thought and reflection about their
teaching practice and experience. Such knowledge is embedded in three reinforcing loops (Formal Training (R1), Informal Training (R2), and Practical Knowledge (R3)) as shown in Figure 5.

**Formal Training (R1):** When faculty are motivated to adopt RBIS, they seek support from the university or department for tools and resources to attempt this change (Felder & Brent, 2010; Finelli et al., 2014; Finelli et al., 2013; Gorozidis & Papaioannou, 2014; in de Wal, den Brok, Hooijer, Martens, & van den Beemt, 2014; Martin, 1999). Typically, institutions respond to such requests for support through on-campus and off-campus teaching training or professional development programs (i.e., institutional support) aimed to increase pedagogical knowledge and spread reform in teaching pedagogical practices (Coburn, 2003; Lattuca, Bergom, & Knight, 2014). Subsequently, faculty’s self-efficacy is increased by their participation in such programs (Felder et al., 2011).
**Informal Training (R2):** Academic institutions also respond to faculty who are seeking support through encouraging collaboration with other faculty about their teaching (Finelli et al., 2014; Finelli et al., 2013; Moursedh, Chijioke, & Barber, 2011). This participation and sharing with the community also increases the collective pedagogical knowledge of the faculty (Cox, 2004; Finelli et al., 2013), which, as described before, increases the faculty’s motivation.

**Practical Knowledge (R3):** In addition, when a faculty member is motivated to use RBIS, he or she will be devoting more class time to the use of such strategies (Abrami et al., 2004; Finelli et al., 2014; Gorozidis & Papaioannou, 2014). The more that professors invest class time using RBIS, the more content is collectively covered using RBIS (Olson & Riordan, 2012). More content covered using RBIS provides more opportunities to practice such strategies, hence more opportunities for faculty to build knowledge of what is effective for them and for the class (Butler & Schnellert, 2012; Pascarella & Terenzini, 2005).

As these examples show, each link illustrates a causal connection between two variables. For example, a variable like pedagogical knowledge is caused by multiple factors. To determine polarity of each arrow, consider only two variables at a time and check if they move in the same direction (positive sign) or opposite direction (negative sign). For example, if everything else is stalled, an increase in teacher training leads to an increase in faculty pedagogical knowledge, even if the correlation between both variables is small.

By elaborating on the dynamics shown in the three loops, I continue to build the model by introducing additional loops. Figure 6 shows a balancing loop (Faculty Workload (B1)) where the growth of faculty motivation is hindered by the effect of the increased workload caused by the implementation of RBIS. Added variables at each loop are shown in blue, and new feedback loops added are shown as thicker lines.
Faculty Workload (B1): Faculty workload is influenced by the time necessary to implement RBIS. More class time invested in RBIS will require additional time for grading, providing feedback, and preparing classes (Abrami et al., 2004; Finelli et al., 2014; Gorozidis & Papaioannou, 2014), which increases the perception of an increase in teaching workload. The teaching workload adds to the overall workload that faculty have on top of research and service activities dictated by the already existent institutional policies (Finelli et al., 2014). If faculty perceive an increase in this workload, the usefulness to adopt new practices and activities of RBIS decreases because the available time to implement them is scarce (Finelli et al., 2014; Hora, 2012; Olson & Riordan, 2012; Seymour & De Welde, 2015) or investing time in such
practices reduces the time devoted to other important activities (Cohen & Ball, 2007; Froyd et al., 2013; Litzinger & Lattuca, 2014; Matusovich et al., 2014). This negative correlation between faculty workload and faculty motivation is shown in Figure 6 with a negative sign.

**Practical Teaching Experience (R4):** The increase in teaching workload is reduced by another reinforcing loop, R4, which is a consequence of more time invested in teaching. That is, the teaching workload is decreased when the faculty’s practical pedagogical knowledge is increased. As a product of increasing pedagogical knowledge, the instructor has more and better ideas on which practices are appropriate and feasible, how to be more efficient to provide feedback, and how to be more effective in the logistics necessary to implement RBIS.

**4.4 Students’ Experience Loops**

To increase the faculty motivation to adopt RBIS, it is necessary to increase the faculty’s perceived effectiveness of the teaching practices (Elmore, 1996; Felder & Brent, 2010; Finelli et al., 2014; Froyd et al., 2013; Graham, 2012a). The faculty’s perceived success of their teaching practices is primarily caused by their students’ evaluation of teaching (Finelli et al., 2014; Hora, 2012) and by their students’ learning (Graham, 2012a, 2012b). The loops associated with this category are also related to how students perceive their academic experience in classrooms where RBIS are implemented. At the end, improving the students’ experience is usually the main objective of enacting instructional change in academic institutions (Kezar, 2014).

In this category there are two reinforcing loops (R5 and R6) and a balancing loop (B2), shown in Figure 7. The loops are described below.
Students’ Learning (R5): The faculty motivation to use RBIS is driven by the understanding that students learn better with RBIS than with traditional teaching strategies. By assessing or observing that RBIS are more effective teaching strategies, instructors are more inclined to spend more time implementing RBIS in the classroom (Gorozidis & Papaioannou, 2014), which, as described in the Practical Knowledge (R3) loop, increases faculty’s pedagogical knowledge. Implementing RBIS requires an adaptation of the strategy to the faculty’s particular context (Hutchinson & Huberman, 1994; Litzinger & Lattuca, 2014). The more pedagogical knowledge, the higher the quality of the implementation because for any strategy that the instructor wants to
introduce, the method must be adapted to use core elements of RBIS that makes the strategies more useful for engagement and learning (Olson & Riordan, 2012). Student’s academic motivation is increased when quality of teaching increases either because good teaching enhances students’ success (Finelli et al., 2014) or the general learning environment is improved (Jones, 2009). When students are more motivated, they are more engaged in deep learning activities (Cruz, Hasbun, Jones, & Adams, 2017; Pascarella & Terenzini, 2005), which subsequently leads to better learning (Astin, 1985; Pascarella & Terenzini, 2005), greater educational gains, higher grades, and greater satisfaction with college (Laird & Shoup, 2005). The result of instructors observing deep learning occurring in their students increases the perceived success of the strategies (Graham, 2012a, 2012b). In addition, adopting RBIS offers multiple opportunities to transform students’ learning assessment (Cooper et al., 2000), and by providing clear ways to assess the actual performance of students, faculty increase their perception of teaching effectiveness (Graham, 2012a) and therefore their motivation to further adopt RBIS in the classroom.

**Student Evaluation of Teaching (R6):** As explained in the previous loop, a higher quality of teaching drives students’ academic motivation. Research has found that this increased motivation is also reflected in better results of the students’ evaluation of teaching (Jones, 2010; Laird, Shoup, Kuh, & Schwarz, 2008; Narayanan, Sawaya, & Johnson, 2014), which increases the effectiveness that is perceived by faculty (Finelli et al., 2014; Hora, 2012), therefore increasing the faculty motivation to adopt RBIS.

Both reinforcing loops are met with a balancing loop (B2) driven by the students’ resistance to engage in RBIS.

**Students’ Resistance (B2):** Students’ resistance in response to implementation of RBIS affects the motivation of faculty to adopt the strategies. Even though RBIS are intended to improve student’s learning and to provide better evaluation processes, students could resist instructional change through their evaluations of teaching or disengaging in the classes. When the class content is covered using RBIS, students may resist because either the strategies are not familiar to them or there is an increase in their workload (Henderson et al., 2012; Seymour & De Welde, 2015). Such resistance hinders the students’ perception of success in the class, decreasing their
academic motivation (Finelli et al., 2014; Finelli et al., 2013; Seymour & De Welde, 2015). Students manifest this displeasure by either lowering the scores of the evaluation of teaching (Jones, 2010; Laird et al., 2008; Narayanan et al., 2014) or restraining their engagement. When instructors observe the unsatisfactory evaluation or their students’ disengagement, they tend to question the effectiveness of the RBIS used in the class (Hora, 2012). This decrease of perceived effectiveness thereby demotivates the instructor to continue the use of RBIS. Although students’ resistance is described as a balancing loop or a barrier to faculty motivation, such resistance is reduced when more faculty adopt RBIS because students will find such strategies more familiar, and, students could even demand more such practices in their overall academic experience. This change in the dynamics is produced by a long delay in the effect of the content covered with RBIS on the students’ resistance (this delay is shown as a “II” symbol in the arrow), and research suggests that innovating faculty could expect at least two semesters of student resistance to the RBIS implementation (Seymour & De Welde, 2015).

4.5 Cultural Loops

Another key element that increases motivation to adopt RBIS is an increase in the faculty’s collective value on teaching innovations. That is, the higher the importance or reputation to improving their teaching strategies by other faculty members, the higher the motivation for individual faculty to adopt RBIS (Feldman & Paulsen, 1999; Finelli et al., 2014; Froyd et al., 2013; Handelsman et al., 2004; Lawrence & Blackburn, 1991; Matusovich et al., 2014; Olson & Riordan, 2012; Prosser & Trigwell, 1997). This increase in motivation is explained by the effect that collective faculty values have on personal values (Matusovich et al., 2014). The value of teaching innovations is a factor of an RBIS’ supportive institutional culture that provides continuous feedback about teaching but does not represent a threat to individual faculty members (Feldman & Paulsen, 1999), and that helps to maintain enthusiasm and overcoming obstacles for the adoption of RBIS (Prosser & Trigwell, 1997). This cultural value can also decrease motivation to RBIS’ adoption if there is an increase in the collective value put on traditional teaching methods (Kezar, 2014). The reinforcing loops associated with this category (i.e., Collective innovation (R7) and Faculty collaboration (R8)) represents how the attitudes, beliefs, and assumptions of faculty and administrators (i.e., the institutional culture) favors an increase in
the collegial trust and sense of community (Matthew-Maich et al., 2007). These loops are shown in Figure 8.

**Collective Value on Teaching Innovations (R7):** Previous loops (see R2) have explained that when faculty are motivated to adopt RBIS the institution could respond properly by offering them opportunities to establish collaborative practices between faculty that promotes discussion, reflection, and peer exchange about teaching and learning. Such collaboration between faculty can lead to the creation of local communities of practice in the form of faculty learning communities (Cox, 2004; Finelli et al., 2014). More faculty participating in such collaborations increase the faculty’s collective value on teaching innovations because communities of practice create connections for teachers, establish networks for those pursuing pedagogical issues (Cox, 2004), allow faculty to exercise influence in other colleagues’ teaching practices (Elmore, 1996), and could favor intentional community building (Finelli et al., 2014).

**Faculty Collaboration (R8):** As mentioned in the previous loop (R7), more participation in communities of practice increases the collective value on teaching innovations. The virtuous cycle occurs because such increase influences other faculty to participate and engage in community of practice activities (Cox, 2004; Feldman & Paulsen, 1999). As faculty see more value in engaging in such collaborations (Matusovich et al., 2014), this community grows and provides more opportunity for interactions, hence growing the collective value for innovations in teaching, which drives the motivation to adopt RBIS (Cox, 2004; Finelli et al., 2013).
4.6 Institutional Support Loops

Faculty motivation to adopt RBIS is also driven by the institutional and departmental structures and procedures (Lattuca, 2011), and how faculty perceive their alignment and consistency with the instructional change initiative (Dancy & Henderson, 2010). Beyond the support provided to enhance pedagogical skills with training and communities of practice (see faculty pedagogical knowledge and skills loops), there are other factors that increase the perception of alignment between the institutional support and the adoption of RBIS: the availability of resources and
infrastructure, the flexibility of curriculum, and the time allowed for the adoption of RBIS. The availability of resources and infrastructure is manifested in the physical disposition of classrooms where the class size is a key element (Pagnucci et al., 2015; Prosser & Trigwell, 1997). The flexibility of curriculum is highly influenced by the required content to be covered in a class (Cooper et al., 2000; Henderson & Dancy, 2007), and the time allowed to adopt RBIS is an effect of the faculty’s workload (Hora, 2012; Seymour & De Welde, 2015). Within this category, the analysis of literature revealed three balancing loops around these three key elements (i.e., content coverage (B3), class size (B4), and workload of larger classes (B5)). They are shown in Figure 9.

**Content Coverage (B3):** The perceived effectiveness of the RBIS in a classroom is also affected by the content that is covered; that is, excluding all other variables, the more content covered, the more effective is the strategy used to teach such content. However, implementing RBIS changes the focus to more student-centered activities, requiring faculty to invest class time for students to interact, practice, and receive feedback (Abrami et al., 2004; Finelli et al., 2014; Gorozidis & Papaioannou, 2014). If faculty believe or perceive that the time dedicated to such activities reduces the content that can be covered, then they would believe that covering all topics using RBIS may not be possible, hence decreasing the motivation to adopt such practices (Froyd et al., 2013; Henderson et al., 2012). Faculty cope with this limitation by either choosing where and how to use RBIS (Henderson et al., 2012) or reducing its use in the classroom (Froyd et al., 2013). In summary, the more content that needs to be covered, the less motivated faculty are to adopt RBIS.

**Class Size (B4):** Previous loops (see R5 and R6) have explained that motivation to adopt RBIS could lead to an increase in students’ academic motivation. The effect of students’ motivation on class size can be seen in the long term and in the short term. In the long term, higher motivation leads to higher student success (Astin, 1985; Laird et al., 2008; Pascarella & Terenzini, 2005), thus higher retention. As Zaini et al. (2017) suggest, increased retention numbers tied to higher quality of teaching increases the institutional reputation, thereby increasing enrollment yield and the number of students. Consequently, the class size increases as the number of students increase. In the short term, more students motivated in an instructor’s class encourages, by word of mouth, other students to register for the class, thus increasing the class size. Larger classes
affect faculty’s perception of the feasibility of implementing RBIS in such classes, thus decreasing their motivation to adopt RBIS (Finelli et al., 2014; Henderson & Dancy, 2007; Prosser & Trigwell, 1997).

**Workload of Larger Classes (B5):** In addition to teaching workload caused by the implementation of RBIS (see B1), increasing the class size also increases the teaching workload because of the increase in grading and feedback activities (Henderson & Dancy, 2007; Pagnucci et al., 2015; Zaini et al., 2017). As explained in B1, this increase in teaching workload, along
with institutional policies affecting the overall workload of faculty, decreases the motivation to adopt RBIS.

4.7 Change Management Loops

Faculty motivation to adopt RBIS is also influenced by the sense of urgency for change (Cohen & Ball, 2007; Dearing, 2009; Graham, 2012b; Kotter, 1995; Litzinger & Lattuca, 2014; Mourshed et al., 2011). That is, faculty are more willing to change if they are conscious of and have accepted the need for change. Some management theorists (Kaplan & Norton, 1996; Kotter, 1995) consider this sense of urgency as a powerful ignitor for change, a notion also shared in educational settings (Mourshed et al., 2011). Such behavior is modeled in balancing loop B6. The complete CLD, including this loop, is shown in Figure 10.

**Sense of Urgency to Change (B6):** This loop explains that the perceived effectiveness of the teaching practices is mediated by several other variables, such as market position compared to the competitors (Olson & Riordan, 2012), pedagogical evidence that suggests that traditional teaching does not work (Seymour & De Welde, 2015), performance evaluation or feedback from peers and administrators (Borrego & Henderson, 2014; Feldman & Paulsen, 1999), or other contexts where faculty acknowledge the need to change (e.g., special reports and participation in education conferences and workshops, the stakeholders’ assessment of students’ learning, or the need for constant improvement) (Elmore, 1996). These variables set an expected quality of teaching practices that would create a discrepancy between them and the perceived effectiveness of the current teaching practices (Martin, 1999). If this discrepancy is low, then the sense of urgency to change instruction is also low, decreasing the motivation to adopt new RBIS. For example, faculty could be certain that traditional teaching practices are effective because such practices were used to teach them and they worked for them effectively (Olson & Riordan, 2012). In this case, there is not an apparent and compelling reason to change (Elmore, 1996). However, if this discrepancy is high, then there is an increased sense of urgency, thereby driving
motivation for RBIS and, as previous loops have shown, driving the perceived effectiveness of the teaching practices.

Table 6 offers a summary and a brief description of the causal loops in the Theoretical CLD.
<table>
<thead>
<tr>
<th>Causal Loop Category</th>
<th>Definition of Causal Loop Category</th>
<th>Causal Loop Name</th>
<th>Description of Causal Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedagogical Knowledge</td>
<td>The different levels of knowledge or skills that faculty have about RBIS implementation</td>
<td>Formal Training (R1)</td>
<td>Reinforcing effect on faculty motivation caused by increase in pedagogical training offered by institutions, organizations, and established networks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Informal Training (R2)</td>
<td>Reinforcing effect on faculty motivation caused by increase in pedagogical training resultant from an emergent collaboration between faculty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Practical Teaching Knowledge (R3)</td>
<td>Reinforcing effect on faculty motivation caused by an increase in knowledge product of the experience gained by implementing RBIS.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Faculty Workload (B1)</td>
<td>Balancing effect on motivation caused by the increase in teaching workload attributed to the adoption of RBIS.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Practical Teaching Experience (R4)</td>
<td>Reinforcing effect that reduces teaching workload when faculty gain more experience implementing RBIS.</td>
</tr>
<tr>
<td>Student Experience</td>
<td>The perception that students have about their academic experience in classrooms where RBIS are implemented</td>
<td>Student’s Learning (R5)</td>
<td>Reinforcing effect on faculty motivation driven by the understanding that students learn better with RBIS than with traditional teaching strategies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Student Evaluation of Teaching (R6)</td>
<td>Reinforcing effect on faculty motivation caused by the positive evaluations of teaching.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Student’s Resistance (B2)</td>
<td>Balancing effect on faculty motivation caused by students’ resistance to RBIS implementation. Such resistance is manifested in reduction of the SET scores.</td>
</tr>
<tr>
<td>Culture</td>
<td>The collective faculty values, beliefs, assumptions, symbols, or attitudes that affect RBIS implementation in the classroom</td>
<td>Collective value on teaching innovations (R7)</td>
<td>Reinforcing effect on faculty motivation driven by the value that faculty as a whole give to the adoption of RBIS.</td>
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</tr>
<tr>
<td></td>
<td>Faculty Collaboration (R8)</td>
<td></td>
<td>Reinforcing effect on the collective value on teaching innovations driven by the growth and participation in communities of practice.</td>
</tr>
<tr>
<td>Institutional Support</td>
<td>The formal and informal institutional structures that affect implementing RBIS in the classroom</td>
<td>Content Coverage (B3)</td>
<td>Balancing effect on faculty motivation caused by the reduction of the content that can be covered when adopting RBIS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class Size (B4)</td>
<td>Balancing effect on motivation caused by how faculty perceive the feasibility of adopting RBIS in courses of larger class sizes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Workload of Larger Classes (B5)</td>
<td>Balancing effect on motivation caused by the increase in teaching workload attributed to the growth of class size.</td>
</tr>
<tr>
<td>Change Management</td>
<td>The design and management of the process associated with adopting RBIS in the classroom</td>
<td>Sense of Urgency to Change (B6)</td>
<td>Balancing effect on the sense of urgency to change caused by the difference between the actual and expected effectiveness of the teaching practices.</td>
</tr>
</tbody>
</table>

### 4.8 Policy Implications

As mentioned, the purpose of this theoretical CLD is to describe the structure of the academic system that affects faculty motivation to adopt RBIS from a theoretical perspective. From this structure, we can better understand the behaviors of the factors involved and their implications on faculty motivation. The complexity of the system is modeled in the eight reinforcing loops and the six balancing loops in the CLD; however, the dominance of each loop has to be established in every academic context to predict the behavior of the factors over time. Such differences in dominance affect the dynamics of the system. A specific example of establishing dominance is the role of pedagogical knowledge in a department. An engineering department that has higher levels of faculty pedagogical knowledge will have a lesser impact in their faculty
workload when adopting RBIS because such knowledge will encourage faculty to manage the time to create and implement the instructional strategies. Conversely, engineering departments that have lesser pedagogical knowledge could perceive a substantial increase in their teaching workload because they will have to invest more time to learn about the implementation of the strategies. Another example is the amount of content that students have seen covered with RBIS. Engineering colleges/schools that have more classes with content covered with RBIS will experience less student resistance than the schools that are starting to implement RBIS.

Behavior of complex systems can be improved by small actions that have high impacts, coined as “leverage” or “leverage points” by system thinkers (Senge, 1990). Based on the described structure, I suggest potential leverages that could create significant improvements in adoption of RBIS. These policy implications are simply starting points and are not exhaustive. Many of the potential areas for implications in policy deal directly with the support of RBIS from faculty and administrators as well as the quality and evaluation of RBIS strategies, essentially, who supports RBIS, why, and how RBIS can be improved. In the following paragraphs, I provide one hypothesis of such leverage points per categories of loops.

4.8.1 Leverages in the Faculty Pedagogical Knowledge Loops

A leverage point in the faculty pedagogical knowledge factors is the formal training focused on the pedagogical tenets that explain why RBIS works (Ambrose et al., 2010; Litzinger & Lattuca, 2014). Although informal training increases awareness of the RBIS, it is not enough to acquire expertise because of the sheer number of RBIS (Ambrose et al., 2010; Litzinger & Lattuca, 2014) and the perceived difficulty to access and evaluate the research that validates such strategies (Ambrose et al., 2010; Dancy & Henderson, 2010). Both barriers add to the apprehension that faculty could have about learning new instructional approaches (Finelli et al., 2014; Handelsman et al., 2004).

4.8.2 Leverages in the Students’ Experience Loops
The quality of RBIS adaptation is another leverage point for strengthening reinforcing loops in the students’ experience. The model suggests that if this quality is low, or suffers a decay, some reinforcing loops could instead create a balancing effect: lower quality of RBIS adaptation leads to a lesser quality of teaching, causing a decrease in the students’ motivation and all the subsequent factors (see R5). As mentioned, implementing RBIS requires an adaptation of the strategy to the faculty’s particular context (Hutchinson & Huberman, 1994; Litzinger & Lattuca, 2014), which sometimes does not follow all of the details that make RBIS effective (Borrego et al., 2013; Henderson et al., 2012), or the strategy is altered in a way that errs on the side of a more traditional approach (Dancy & Henderson, 2010). As any new practice, it cannot be expected that it reaches its maximum quality in the first attempt, thus the necessity of providing support for faculty during this transition (Seymour & De Welde, 2015). In this same sense, formal training focused on the pedagogical principles that make RBIS effective could also facilitate this transition.

4.8.3 Leverages in the Cultural Loops

An additional leverage point that strengthens or hinders the cultural reinforcing loops is the department head commitment to teaching innovations (Graham, 2012b; Litzinger & Lattuca, 2014; Matusovich et al., 2014). The higher the value that the department head places on teaching, the higher the value faculty place on innovations. Similarly, several studies suggest that the institutional policies about tenure and promotion, especially those that place greater importance on research and productivity, could reduce the perceived value of teaching innovations (Elmore, 1996; Feldman & Paulsen, 1999; Handelsman et al., 2004; Jamieson & Lohmann, 2009; Martin, 1999; Olson & Riordan, 2012; Savkar & Lokere, 2010; Seymour & De Welde, 2015). However, as Matusovich et al. (2014) suggest, faculty have the power to change such cultural value even against institutional goals focused on research. This is because tenure is a peer-reviewed process where faculty judge the fitness of their peers; thus, if faculty put a high value on teaching innovations, proper RBIS adoption would be reflected positively in the review.

In the same category of cultural loops, another key element that enhances an accelerated growth in community building is the formal and intentional support for the local community of practice,
noting that informal collaborations between faculty are not enough for successful community building (Finelli et al., 2014).

### 4.8.4 Leverages in the Institutional Support Loops

One more leverage point that would help to weaken the effect of the balancing loops in the institutional support loops category is a clear and strong institutional policy that sets a limit on the class size (e.g., defining a maximum capacity for each class) and favors faculty autonomy in their teaching practice (Hora, 2012); for example, by allowing faculty to focus the content to be covered, evaluating the feasibility of the learning goals, or reducing the number of such learning goals.

### 4.8.5 Leverages in the Change Management Loops

Finally, from the change management loops, another leverage point for change agents is to manage the sense of urgency. Literature suggests that a sense of urgency increases by establishing and constantly communicating the vision and goals of the change initiative (Kotter, 1995). Such vision would be a driver of instructional change if instead of imposing it the vision is shared by administrators and faculty (Litzinger & Lattuca, 2014). The goals would become drivers of instructional change if they are clearly stated and shared by the community (Kezar, 2014), and if they advocate for multiple instructional strategies rather than for a single practice (e.g., promoting only the implementation of PBL) (Henderson et al., 2011; Litzinger & Lattuca, 2014). In addition, change agents can also nourish this sense of urgency by constantly assessing and communicating the successfulness of the change process by formally established measures (Borrego & Henderson, 2014; Kaplan & Norton, 1996; Martin, 1999).

### 4.9 Summary

This chapter details the eight reinforcing loops and six balancing loops that when pulled together constitute the theoretical CLD. Those loops are organized into five categories to facilitate the description of each loop in the diagram. In addition, policy implications are suggested by the structure described in the CLD.
CHAPTER 5. AN EMPIRICAL CAUSAL LOOP DIAGRAM OF FACULTY MOTIVATION TO ADOPT RBIS

5.1 Introduction

As mentioned in Chapter one, the goal of this study was to better understand how the academic system affects instructional change in engineering education. To accomplish this goal, I created a conceptual SDM that illustrates how the factors in the academic system interact dynamically to drive or hinder faculty motivation to adopt RBIS in their courses. This SDM was developed in three phases that illustrates such interactions. The objective of this chapter is to show the results of the second phase, an empirical Causal Loop Diagram (CLD). This empirical CLD also involved the creation of a causal structure of the academic system that influences faculty motivation to adopt RBIS based on empirical evidence. It provides an additional answer to the second research question of this dissertation: How do the dynamics between these factors affect faculty motivation to adopt Research-based Instructional Strategies? The third phase involves the integration of the theoretical and empirical CLD, which is developed in Chapter 6.

5.2 An Empirical CLD

The empirical CLD shows the interaction of the academic system components influencing instructional change in the form of 10 reinforcing and 13 balancing causal loops that drive or hinder faculty motivation to adopt RBIS in their courses. To provide more readability and clarity to the model, in a similar way as Chapter 4, I will introduce the empirical CLD by describing each loop separately starting from its connection with variables detailed in previous loops. Each new loop description introduces new variables, their dynamic relationships, and provides details of the key connections between the variables by showing examples of quotes that describe the dynamics of the loop. At the end of this chapter is a section with the policy implications inferred from the description and analysis of the empirical model.

As the name denotes, an empirical CLD differs from a theoretical CLD (phase 1) in the sense that the causal structure was elicited from the analysis of data collected at the selected site. As described in the methods chapter (Chapter 3), data included ten semi-structured interviews with ten faculty members, and a focus group with another seven faculty members. The site selected
was an engineering department with several features and characteristics that made it suitable for the construction of an SDM: 1) It has dynamic complexity (i.e., feedback mechanisms, interdependence of elements, nonlinearities, high interactions over time among its elements, history dependence, and delays between causes and effects (Sterman, 2000)); 2) It is a bounded system (i.e., has a clear boundaries); 3) It has a combination of events and unique characteristics (i.e., it is immersed in an ongoing curriculum change process called CDIO, it has recently acquired ABET accreditation, it has recent changes in its policies about promotion and tenure, the university is constructing new laboratories and classrooms, and it has ample tradition and faculty with more than two decades of experience in the department; 4) It provided ample access and support for this investigation; 5) It embodied several of the categories and factors that impact faculty motivation to adoption RBIS; and, 6) It has professors who have adopted RBIS, and others with different levels of willingness to adopt these strategies.

Related to item 6, the most common RBIS used at this site are PBL (i.e., project-based learning in design courses and problem-based learning in courses with more theoretical content), small group collaborations, and active learning. Although the original data were referring to a specific RBIS, in the description of the empirical CLD I used the general term RBIS and made no distinction between each strategy. Nonetheless, the quotes that showed evidence of the loops and their effects on faculty motivation used a particular RBIS term like PBL or small group collaborations.

![Diagram](Figure 11 Implementation and adjustments in the curriculum design at the program level (B1) Balancing Loop)
Implementation and adjustments in the curriculum design at the program level (B1): At the site selected, many of the discussions about changing instruction were prompted and mediated by the ongoing curriculum change process following ABET and CDIO criteria. Typically, a curriculum design following ABET requirements defines the program outcomes and their expected level of achievement by students in the form of rubrics. The program director or a committee adjust the curriculum design based on the discrepancy between the expected level and the actual level of achievement of such outcomes. The implementation of the adjustments to the curriculum will occur after a delay (shown as two horizontal lines in the link) caused by the time invested in the design of such adjustments. After an even longer delay, it is expected that the implementation of the adjustments will lead to an increase in the actual level of achievement of the program outcomes, which in turn reduces the discrepancy that prompted the adjustments. Ideally, this balancing loop will lead to a stabilization where all the graduates fulfill the program outcomes.

The previous balancing loop has enormous delays or “dead-times” to observe the actual effects of the adjustments. Because of those dead-times, large time delays between the implementation of the adjustments and their actual effects are expected. At the program level, the smallest lapse to perceive the actual effects of the changes is one entire program cycle (i.e., 5 years).

Data suggest that such delays are more complex than they were described above. There are additional levels of delays between the implementation of the adjustments and the level of achievement of the program outcomes. Thus, the actual results of the adjustments could be delayed by more than one entire program cycle. The additional levels of delay occur because every change in the curriculum has to be implemented in the courses, consequently adding another level of complexity to the change process. In Figure 11, the link between the implementation of the adjustments and the level of achievement of the program outcomes is dotted and in green to indicate that this link summarizes the following loops (see Figure 12):
Implementation and adjustments in the curriculum at the course level (B2): Once the changes are defined at the program level, the implementation at the course level starts by defining the course objectives and their expected level of achievement. Ideally, the discrepancy (i.e., discrepancy 2 in Figure 12) between the expected level and the actual level of achievement of the course objectives prompts professors to make adjustments in their courses. It is expected that such adjustments would lead to an increase in the level of achievement of the course objectives, therefore reducing the discrepancy. However, the effect on the actual level of achievement is delayed, at least until an entire course cycle occurs.

Implementation and adjustments in the curriculum at the class level (B3): Similarly, this delayed effect exists because the course objectives have to be implemented gradually in the class sessions and activities. Professors are challenged with the day-to-day implications of designing, implementing, and adjusting the academic activities to help students achieve the class session objectives. Professors will be motivated either to adopt RBIS or traditional instruction as a consequence of this discrepancy, the overall experience of adopting RBIS, that students are learning and engaged, and that professors are receiving the proper recognition (these conditions will be detailed later in other loops (see Figure 28). After a while, the instructional strategies implemented in each class will allow the achievement of the course objectives. Details of the dynamics that occur in each class session or activity will be described later (see Figure 18).
Data indicate that professors require more than one iteration of the course to be satisfied with the actual level of achievement of the course objectives. That is, professors need to teach more than one iteration of the course to reach a point where the discrepancy only leads to minor adjustments. This additional requirement of more course iterations impacts the achievement of the program outcomes by adding other delays. Data suggest that professors consider they need more than one iteration of the course with adjustments to be certain the students have achieved the expected level of the course objectives. The effect of these delays propagates, resulting in an even more delayed response in the level of achievement of the program outcomes. It is necessary, therefore, to wait for more than one program cycle to attribute the level of achievement of the program outcomes to the adjustments in the curriculum design.

An associate professor, experienced in administration and control systems models, acknowledges the delayed effect of the adjustments in the curriculum:

“If we make a decision [about the curriculum], we can’t change it before the dead-time allows us to see the actual results. For example, if I apply a stimulus today, I have to wait until the effect stabilizes in several samplings. Hence I reduce bandwidth [quickness of the response to changes]. I can’t immediately make corrections six months later because I have not seen the effect [of the stimulus].”

And he relates the delayed effect in the program outcomes with the delays at the course level.

“The minimum [we have to wait] is six months, which is one sample, but surely in six months I have not seen the changes..., I should wait for two or three iterations of the course, so the professor is stabilized in teaching that new course... This is a slow process, I am going to change my course, I prepared it
The dynamics described in Figure 13 have four consequences on the motivation of professors to adopt changes in their instruction. The first consequence occurs at the course level, which ultimately introduces another difficulty in achieving the program outcomes: if every adjustment requires time to settle, every change in the course objectives will introduce an additional delay that accumulates and propagates to the subsequent courses reducing the perceived validity of the learning objectives. This dynamic is explained in the perceived validity of the learning objectives reinforcing loop R1 (Figure 14). The second consequence is the potential increase in the content to cover in each course, which in turn decreases the feasibility of covering the expected content and the achievement of the learning objectives designed for each course. This dynamic is described in the content to cover reinforcing loop R2 (Figure 15). The third consequence is that professors are less motivated to adopt RBIS if they believe that their students would be frustrated for not being able to succeed in the learning activities. This is caused by professors observing that the actual students’ skills and abilities to solve problems are inferior to what is expected. If this occurs, professors would likely use direct instruction aiming to provide students with the required skills to succeed in the learning activities. Both dynamics are described in the students’ ability to succeed in the learning activities reinforcing loop R3 (Figure 15) and the use of direct instruction balancing loop B4 (Figure 16). The fourth consequence relates to the fact that having a stabilized curriculum could require many years; thus, professors are reluctant to implement changes because they are not certain that those changes will prompt better positive effects in students. They would have to wait a long time to assess if such changes were positive and produced the expected outcomes. An assistant professor illustrated this reluctance to adopt RBIS:

“let’s say that we do an experiment [adopting RBIS] and we wait for several cycles to obtain results; but, what if we notice five years from now that all of our graduates had certain failures? No! The feedback has to be in a much shorter term, and I don’t believe the rubrics (beyond fulfilling [The ABET and CDIO reports] that provide some information) are not enough to give feedback in the short term.”

Perceived validity of the learning objectives (R1): The first consequence of the dynamics in Figure 13 occurs because every curriculum has a sequence of courses (i.e., prerequisite courses).
Even if the course objectives follow a sound instructional design process, the delay between the adjustments and results implies that the next course’s professor could perceive that students do not have the expected level of knowledge described in the prerequisite course’s objectives. In other words, while the professor of one course is still adjusting their course to attain the course objectives, and therefore students have not necessarily learned everything that is described in the curriculum, the next course’s professor is expecting certain knowledge from their students that, due to this delay, they do not necessarily have.

Data suggest that when professors perceive that students have mastered the prerequisites of the course, the more inclined the professors are to adopt RBIS in their courses because of their increased belief in the positive results of using RBIS. Conversely, a reduction in the perceived validity of the learning objectives of previous courses hinders faculty motivation to adopt RBIS and limits the feasibility to achieve the new course’s learning objectives.

This dynamic is illustrated in the CLD of Figure 14. The CLD shows how faculty motivation to adopt RBIS increases when the belief that RBIS works also increases. This belief depends on the credibility that a professor attributes to the assessment of the learning objectives achieved by
their students in courses where RBIS were used. Such credibility increases when the uncertainty professors have about their students’ knowledge decreases. This uncertainty is a consequence of the validity of the learning objectives. That is, the more valid the objectives, the more certain professors are about what students know. The validity of the learning objectives is caused by several factors, including the comprehensiveness and clarity of the assessment instruments, and the discrepancy between the expected achievement and the perceived achievement of the learning objectives by the students. The loop closes when professors attribute the achievement of the learning objectives to the depth in student’s learning caused by the adaptation and adoption of RBIS in the classroom. The effects of this dynamic spread to future courses. If the discrepancy is high at the end of one class, professors of the following classes will perceive less validity in the learning objectives achieved by students and therefore will be less motivated to adopt RBIS.

Figure 15 Content to cover (R2) and students’ ability to succeed in the learning activities (R3) Reinforcing Loops

**Content to cover (R2):** Such discrepancy impacts the dynamic that hinders faculty motivation to adopt RBIS in another way. When the discrepancy is positive (i.e., the learning objectives achieved by students are below the expectations), professors would need to cover the content that students should have learned in previous courses.
Consequently, the *content to cover* increases and the *time available* in the course decreases; thus, professors are less motivated to adopt RBIS because these strategies would require more of the reduced class time. To cover more content, professors prefer lectures. However, they acknowledge that such content is covered more superficially, and consequently reduces the *deep learning* and the *achievement of the expected learning objectives*. Also, with less *time available* in class, there is a decrease in the *feasibility that students achieve the desired learning objectives*. Therefore, the discrepancy between the desired achievement and the actual achievement of the objectives is higher. Similar to the previous CLD, this dynamic also spreads to future classes. If the *discrepancy* is high at the end of one class, professors of the following classes will be inclined to include more content in their classes and therefore will be less motivated to adopt RBIS.

**Students’ ability to succeed with learning activities (R3):** Another consequence to faculty motivation caused by the implementation of the adjustments occurs when professors consider how the ability to succeed with the learning activities would impact their students’ motivation. Professors expect students to have a minimum level of skills to be able to succeed in the proposed learning activities (e.g., problems or projects). If the students have this minimum level, professors are more motivated to adopt RBIS in their courses because they expect their students will be successful in the activities and therefore more motivated to learn. In this case, increasing RBIS adoption will increase students’ learning, which subsequently increases their skills and the achievement of the learning objectives. This positively reinforcing scenario will further reduce the *discrepancy* between the *actual and expected students’ level of learning objectives*.

Conversely, if the discrepancy is high, professors are less motivated to adopt RBIS because they believe students would be frustrated for not being able to succeed in the learning activities (e.g., not being able to solve the problems). Such frustration would decrease their *students’ motivation*, thus reducing learning and skill acquisition, and ultimately increasing the *discrepancy*. Again, an increase in the discrepancy will propagate to future courses and negatively reinforce faculty motivation to adopt RBIS in future courses.
As described by one professor who is willing to use PBL in his courses, the students’ motivation could be reduced when the academic demands of PBL increase to a point where students cannot succeed:

“This discrepancy will have an impact on student motivation or demotivation depending on the experience the student had. If we asked them something outside of their ability, students wouldn’t reach a solution, and they will feel they didn’t learn anything.”

If students cannot succeed, this could lead to professors’ frustration about students’ performance, which in turn will further reduce the students’ motivation and consequently their learning. Another faculty member observed this reaction in a professor who is trying to use PBL in his course:

“For [another senior professor], there is a huge difference [between the actual and expected problem-solving ability], and sometimes he yells, because he is frustrated and notices that the students seem like they are not responding to him, and he reacts. Sometimes, that leads to problems with the students. Hence they don’t learn, they are less engaged with the class and the professor, and that will become something negative.”

The fear of the possibility of such negative effect on students’ learning is a powerful negative motivator to adopt PBL in their courses. To some faculty, using PBL with students that do not have the necessary knowledge or skills to solve the proposed problems is a risk that they are not willing to take. A professor who uses traditional instruction regularly highlighted the lack of faculty motivation to use PBL. In general, this is attributed to the lack of sufficient student ability or knowledge to solve problems.

“I have seen in [students] a tremendous number of gaps in knowledge; I fear to start doing such [PBL] trials … If they have such failures and don’t have the basic concepts, and I start doing experiments… then, there is no guarantee [they learn]”

For some professors, the alternative to reduce the discrepancy leads to an increase in the use of direct instruction (i.e., explanations in the form of lectures), which ultimately hinders faculty motivation to adopt RBIS. Professors use direct instruction aiming to increase students’ learning and their problem-solving ability up to the point where students can solve the proposed learning
activities by themselves. This alternative creates the following balancing loop (B4) (see Figure 16).

**Use of direct instruction (B4):** This loop stalls faculty motivation to use RBIS in their courses. First, contrary to what some professors believe, research on learning suggests that the continued use of lectures is less effective to students gaining the required problem-solving abilities, teamwork, or other non-technical skills (Prince, 2004) to reduce the discrepancy and make the professors feel motivated to adopt RBIS. And second, even if this alternative increases the students’ achievement of the learning objectives, professors would attribute such learning to the use of direct instruction, reinforcing the idea that lectures work sufficiently to increase students’ non-technical skills. Both possibilities decrease professors’ motivation to adopt RBIS in their courses.

![Figure 16 Use of direct instruction Balancing Loop (B4)](image)

Previously, I have described reinforcing loops that motivate professors to adopt RBIS. In summary, those loops describe how an increase in adoption of RBIS leads to an increase in
learning, which subsequently motivates professors to adopt RBIS. As a professor who uses RBIS regularly puts it:

“I believe that what motivates me the most is that students learn and develop skills.”

One indirect measure of students’ learning is their engagement. This leads to another reinforcing loop:

**Students’ motivation and engagement in class (R4).** A powerful factor to increase faculty motivation is the positive effect that the adoption of RBIS has on their students’ engagement in class. The more that students are engaged as a consequence of the use of RBIS in class, the more likely it is that professors will adopt these strategies because they recognize and value that students who are engaged in class will learn more and are enjoying it.

![Figure 17 Students’ motivation and engagement in class (R4) Reinforcing Loop](image)

According to the interviewed professors, students’ motivation is increased when they implement RBIS because it increases explanations of how things work or are useful to student’s daily life.
experiences and technology. An associate professor noted the positive effect of showing how things work on students’ motivation when using PBL in his courses:

“In my personal experience, it always has been a cause of great joy to see that things work, that is, that [the class content] is not only theory... To me, when things work, it is really good. I believe that to others it can be good too. Maybe it will not be the same to everybody, but I have seen that many of the students have the same response.”

“The fact that [students] could see [things working] and could experiment... the awe in their faces was really gratifying!”

Similarly, another assistant professor acknowledged the high positive effect on students’ engagement in using in-class projects related to daily life technologies:

“I proposed students to substitute the final exam for their participation in a national contest [of reception of satellite images]. It was a nice experience because the class transformed entirely. That is, I was not the master imparting the knowledge, we started to lay out the project, to read about it, to understand different alternatives to solve it... Then they understood [the project] with something very simple, they never imagined in their lives a satellite image reception, because to them satellites are science fiction, completely Star Trek, but it is something so simple when they see it, that it helps them bring it back down to something they can accomplish. That was super motivational! Students began to participate, to make their designs, they did spectacular things, the simulations, the model, everything!... A group won the prize!”

In another example, one professor was motivated to use RBIS in his class because he noted the increase in students’ motivation to continue in a specialization (i.e., minor) related to the class content.

“When we are in the lab... where there is also a theoretical presentation and an immediate verification [of the lab problems] and not in the next semester when the knowledge has lost validity, or it has been a little forgotten... I like [PBL] very much, especially when I see that the students have liked it so much and many have followed the specialization of power electronics in the master’s degree.”

Expressing a similar opinion, another professor was motivated because alumni have continued in a line of work related to the content taught in the class:
“When I see that after graduation at the professional level, they [students] are working in that area and they tell you ‘I am working on this,’ and I see they keep working on that area... somehow that makes me happy.”

As data suggest, adopting RBIS is not a process that occurs instantaneously. That is, to implement the strategies in their courses, professors need to adjust or adapt them according to their context and requirements. Such adaptation leads to another reinforcing loop that occurs at the class level.

**Adjustments in the implementation of RBIS (B5, B5.1):** In a class session, professors who are motivated to adopt RBIS are expecting that such strategies increase students’ learning and engagement up to a point where they consider it acceptable to move forward with the content. During the implementation, professors adapt or adjust the strategy to balance the level of students’ engagement and learning, and the time available for the learning activity or content they are teaching.

![Figure 18 Adjustments in the implementation of RBIS Balancing Loop (B5, B5.1)](image-url)
A professor who regularly uses RBIS in his courses described the process to modify the strategies to increase students’ engagement. He acknowledges that he intends to avoid his students’ boredom:

“If I see that [the strategies] are not working, I change them. I invent another different strategy, or I adjust it and use it again with the intention of increasing the attention level of students… that is, I had to invent strategies to make the class more dynamic. Otherwise people are bored.”

Similarly, he and other professors adapt the strategies to increase engagement because they consider that this will lead to better learning. An assistant professor who uses RBIS regularly described how observed student engagement is an indirect measure of the level of students’ learning and the trial and error process he uses to adjust the strategies:

“Let’s say that exam results can reflect what students are learning… but I do need to sense that they are learning, how can I know they are learning? With the quality of their questions… that is, if I believe that the quality of the questions decreases, then the students are learning less… Changes are made by trial and error. [I notice if the strategies are working] because of students’ performance, or their feedback, and then we refine… I used to frequently ask them how did they like what we did in this class, [to which they answer] ‘no, we didn’t understand anything’, or ‘it worked, we love it’.”

Even if students did not acquire the expected level of learning and engagement, professors would feel the need to move forward with the class content, thus making a decision that could imply reducing the levels of acceptable engagement and learning in the current instructional strategy or the class session. The adjustments professors make will affect the practical experience they are gaining on the implementation of the instructional strategies, which in turn will affect their motivation to adopt RBIS as described in the following reinforcing loop.

**Positive experience of implementing the RBIS (R5):** At the end of the activity or the class session, the bigger the discrepancy between the expected and observed levels of engagement and learning, the less positive the practical experience professors will have about the RBIS implementation. The experience would be more negative if the levels of acceptable learning and engagement are far below the initial expectations. If professors consider the adoption of the RBIS as a positive experience, that will increase their belief that they could be successful on that strategy and thus more motivated to adopt it. Conversely, if professors consider the adoption of
RBIS as a less positive or even negative experience, their belief that the RBIS worked will decrease and, ultimately, this will negatively affect the faculty motivation to adopt the RBIS.

The positive practical experience professors are gaining is a product of the knowledge gained by the implementation and adaptation of the RBIS. As a professor who regularly uses RBIS commented, his development as a teacher was more the result of his field experience than trying different instructional strategies in his classes:

“I am very reflexive, I came up with [class activities] when I was asking myself how do I learn, how do I solve the problem better in my daily life. At that moment I said, ‘Let’s try this, let’s say, let’s not do the laboratories in this way, rather this other way. So, I was acquiring experience as a teacher because I just have graduated, and in my first week of class, I was teaching students who were my classmates. As I was moving forward, I was gaining experience, removing my fears, because I was also beginning to manage the public. That is a practical experience on how to interact with people. That helped me to think in other things [for the class activities].’”

The value (e.g., positive or negative) that professors give to such practical experience would be mediated by their beliefs. For example, professors who strongly relate RBIS with deep learning
are more likely to perceive its implementation as a positive experience. On the contrary, professors who strongly believe that traditional instruction works well enough are more likely to consider that the effort invested in making the RBIS function is not worth it, thus perceiving its implementation as a less positive experience.

An adjunct professor who uses RBIS regularly acknowledges that adopting RBIS requires persistence from professors. Implementing the strategies properly requires an investment of time to learn and adjust their practices and, unless there is enough support, such a process could motivate professors to keep using traditional instruction.

“These [RBIS] don’t work because you look in Google or watch a video. You have to do them; you have to polish them. We learn that way, adjusting in the next semester. If this didn’t work then try it again, try it again, try it again, and polish it. And yet, we have our doubts, and sometimes we get out of the classroom, and we say: ‘Did I make this clear?, or, was this other [objective] achieved?’ But if we do not have a thorough process with the teachers [to learn how to adapt PBL], they are not going to do it. They do what they have always done: traditional teaching. They say ‘I have to teach the class, that’s why they hired me, I do it the best I can, and see how it goes’…”

As a professor whose belief is that RBIS are more effective to learning, he is more inclined to adopt RBIS instead of direct instruction when he needs to make changes in his courses in response to his students’ progress. In the following remarks, he discussed his conclusions after reflecting on his practice in a course where he applied PBL:

“Courses like mine are constantly under construction; it is not a predetermined course where I can say I came with a topic to explain something. Instead, those are courses that have to change over time according to what [students] are doing. That implies changes. I look for alternatives to my teaching because by default my personal policy is not lecturing, unless there are specific topics where I made presentations of no more than 20 minutes.”

An assistant professor who uses RBIS regularly described that sometimes the adjustments in his courses led him to use direct instruction. He believes that direct instruction works to increase students’ learning, but acknowledges that RBIS works better. Therefore, he tries to reduce the use of direct instruction but not to avoid it entirely.

“Sometimes my adjustments are additional classes, if a class was more of discovery, I give a class with more theory. I go back a little to traditional
instruction because at the end we have to acknowledge that direct instruction works... we are not going to disregard it, it is only that I have been reducing such component [traditional instruction] because I also know that we learn more when we find our own patterns, when we have an 'aha' moment."

**Quality of timely feedback (R8):** Another factor that increases faculty motivation to adopt RBIS is how these strategies are helpful in increasing the content and timing of the feedback students are receiving and thus impacting their learning because quality feedback provides information about the students’ current state of knowledge and it can guide them in working toward the learning goal (Ambrose et al., 2010). Using RBIS allows students to receive quality and timely inputs and guidance from the professor to correct methodological mistakes, misconceptions, or misunderstandings. In turn, this timely and quality feedback leads to better learning, and as described before, it increases faculty motivation to adopt RBIS.

![Diagram of Quality of timely feedback Reinforcing Loop (R8) and Time to cover content Balancing Loop (B6)](image)

An experienced associate professor who has used PBL in his classes explained how the timely feedback he provided to the students in class helps them to avoid misunderstandings or myths during the solution of a problem, which helps students learn better.
“[Using PBL with small collaborative groups] is more effective and efficient; at the end of the class, [students] could use the simulation software to achieve good results. When they develop the problems in class, we reduce the possibility of errors, false ideas, their “hunting and guessing” [i.e., trial and error], or that another friend tells them that [the simulation] works in a specific way. When I can advise each group in class, we avoid those kinds of problems or mistakes, and it is better for their learning... there are risks when they are home alone [without someone who supervises them], myths are created, myths that [problems] are solved in a unique way.”19

**Time to cover content (B6):** To provide timely feedback, professors will likely need to increase the time dedicated to implementing the RBIS during class. In turn, this increase limits the time available to cover content. When professors believe that implementing such strategies do not allow them to cover the required content, they feel less motivated to adopt RBIS.

An associate professor stated that he does not use PBL in certain courses because of the limitation that PBL has on the extent of content that could be covered in a class.

“[I don’t use PBL in some courses] because of reduced resources and time. It’s possible to guide a few students, I can correct 1 or 2 people that have mistakes, but with 24 or 30 it would be very difficult to apply this methodology. I have used it in courses of 20 students or even 24 and I observed that when working in pairs, they produced a good simulation, but yet, it took me 3 hours of the class to work a problem [that should have taken me] one hour because I had to give advice to each person... it is hard”.20

In his comments, the professor suggested that one of the highly important factors when providing quality feedback to students is to have a manageable class size. Class size is potentially one of the big factors that hinder faculty motivation to adopt RBIS.

**Class size (B7):** Smaller class size increases faculty motivation to adopt RBIS because it allows professors to provide better feedback and increases the easiness to apply RBIS. That is, the bigger the class size, the less time available to give in-class feedback to individual students or small groups of students. Larger class sizes increase the difficulty of implementing RBIS, which increases the fear to innovate in the class. In general, a smaller class size facilitates the adaptation of the strategies and helps to have a more positive experience when professors adopt RBIS. In consequence, professors who have a high motivation to adopt RBIS tend to increase the pressure to change policies to maintain a reduced class size.
An adjunct professor, who uses RBIS regularly, has experienced that a smaller class size facilitates the implementation of RBIS because it allows more time to work with students in class.

“... one feels the difference when working with smaller classes: the class flows, the designs flow, the activities flow, we can do activities like sharing, so everyone is engaged and learns from everybody. Students don’t pay attention when they have to listen to seven presentations from their classmates.”

Conversely, he illustrates that in large classes the difficulty of using RBIS is bigger compared with traditional instruction.

“Other professors who have not taught courses with RBIS don’t realize the implications of having 24 students in a classroom. In class, we can’t be as effective as we want. [those professors] keep lecturing... that’s why they say ‘what is the problem [of having larger courses]?’ believe me, when you are...
there and have to make those activities, those dynamics can’t be done in a large class.”

He acknowledges, also, that he periodically presses to change policies that reduce the class size because he wants to adopt RBIS properly. His students also have supported him on this pressure.

“Every semester I keep asking to reduce the class size, and I will keep doing that until I make it. Even my students wrote a letter to the administrators telling them that the class size is too big that we can’t do our class as we want it. I have asked to change the classroom or expand the class hours because the class is too large and a one-hour class is not enough to correctly apply [PBL].”

Similarly, other professors shared how an increase in the class size increases their apprehension to innovate in their classes. They believe that using PBL in large classes will increase their workload up to the point that it is not feasible to use strategies where students design big projects and therefore hindering their motivation to adopt PBL:

“That is one of my biggest fears; it is not possible to teach a class of 36 people using projects. I have a course of 24 people where we do small projects, and sometimes I feel that I need to be ubiquitous. This class size only allows working in small projects, not the design projects we want students to develop.”

Other dynamics that reinforce faculty motivation to adopt RBIS appear when professors find ways to facilitate the implementation of RBIS in the classroom.
Number and extent of feasible learning activities (R9): Data suggest that one of the requirements for this perceived easiness is the number and extent of feasible learning activities that students can accomplish in a course (e.g., selected projects for a PBL strategy). That is, the more ideas of possible activities related to RBIS, the easier it gets to use them in the classroom and thus professors are more motivated to adopt RBIS.

Data also suggest that courses with high abstract or theoretical content were perceived as more difficult to implement RBIS. Therefore, professors were more inclined to use traditional instruction in these courses, whereas courses designed around projects instead of content (e.g., electronic design or laboratory) were perceived as easier to implement RBIS like PBL or small group collaborations.
Increased faculty motivation leads to greater RBIS adoption and, therefore, students’ learning of foundations and concepts is enhanced. When the students’ learning of theory and concepts increases, the activities that students can accomplish also increase, which in turn raises the number of possible activities to implement in a course. Data also show the influence that previous experiences in industry or academy have on increasing the ideas for possible activities or projects, especially projects that can be useful to the students’ daily and professional lives. In summary, a higher number of feasible activities leads to an increase in the perceived easiness of using RBIS in class and thus more faculty motivation to adopt RBIS.

As acknowledged by an adjunct professor who is willing to use PBL in his second-semester course of electric circuits, having clear ideas of activities or projects that are adjusted to the students’ current level of knowledge increases the ease of using RBIS:

“To create a product in electronics, one needs to know many things. With basic circuits, what products can we do? I don’t know; it is not easy... How do I integrate [the basic circuits course] with PBL?... We need the idea of which project can be proposed, or with which specifications [the students] can develop it.”

Although his students have experienced PBL in a previous first-semester design course, he recognized that the difficulty of using PBL to teach the content of this new course increases because he considered that students do not know enough concepts to create a higher-level electronic product.

“To what extent is the knowledge of a second-semester student? There are projects that first-semester students are doing... I see that they do little things, but they don’t have any clue about electronics. They know that if they use a battery the engine moves... to move it faster or slower it is more by using “muscles” [i.e., trial and error]. But when we are at another level, sometimes it is not easy for me to generate those ideas and to conclude which type of projects can be done.”

Also, he acknowledged that the difficulty of using PBL in a course increases due to the type of theoretical concepts required in such a course.

“It is not that PBL does not produce learning, but it is harder to use PBL in these types of courses which have more theoretical or abstract concepts.”
To reduce such difficulty, an associate professor recognized that having more ideas for projects facilitates the use of active learning in their courses even if the course is loaded with theoretical concepts:

“I could teach a class of signal analysis that requires a lot of math. It can be an entirely theoretical class, or I could show some of these theories while analyzing a predetermined signal... I can do it easily with a computer... I can show [the students] the analysis of an image.”

To increase the ideas of possible projects, an adjunct professor recognized the influence of previous industry experiences associated with PBL:

“Although my academic training was not associated with PBL, in my professional activity I have experienced PBL. Because I have been involved in research and development, then, to me that is the way of applying electronics: always something practical... It is not that I don’t have the familiarity with PBL. Instead it is more about how do I transfer this it to a circuit so [students] can see it?”

Also, he claimed that with more pedagogical knowledge about PBL, he would be more inclined to use it in his course. However, he was also conscious that PBL has its limitations and that he did not expect to use it all the time.

“If I would know [PBL] well, I would be interested in using it, but only at moments where it is needed... to introduce the concept of what is voltage, what is current, a loop, etc., I prefer to present everything first... maybe to anchor it, we can focus on a project... I don’t know if it is definitively better [to use] PBL at every moment, for example, to explain [those concepts].”

The ease of applying a strategy does not necessarily depend on the strategy itself, but in the knowledge a professor has about how to apply such a strategy. Therefore, another reinforcing motivator to adopt RBIS is pedagogical training (see Figure 22).

**Pedagogical training (R10):** When professors are motivated to adopt RBIS, it is common that they seek opportunities to increase their knowledge about such strategies. Data indicate that professors who are more motivated to be more innovative in their teaching look for participation in the pedagogical training opportunities offered by the university. Such training, which also involved informal encounters or meetings with faculty from diverse departments, increased their knowledge about how to apply RBIS in their courses. In particular, this training gave them more
ideas about how to use RBIS in courses with a high content of theoretical foundations or abstract concepts. As it was described in the previous loop, more ideas lead to more faculty motivation.

An assistant professor who regularly applied RBIS in his courses commented on the effect that pedagogical training, formal and informal, has on providing more feasible ideas and learning activities to implement in the classroom:

“[to have ideas of feasible learning activities] I read about pedagogy and found ‘supplies.’ I don’t see it in any other way: there are always ideas that are hanging around. It is listening to people who have had interesting experiences, to knowing people... to having conversations, to networking. There are people [a female professor from a different department] that has come to my class... at some point, she told me, [using a tablet] works for you because you do exercises. I told her, [the tablet] works for you as well, because you have a picture, you can zoom in and draw over the picture. And she said... ‘of course!’, and she bought a tablet last weekend.”

He also mentioned that people who are not motivated to change are not interested in seeking out or participating in the pedagogical training activities offered by the university:

“I have perceived in other professors a disinterest in changing. I have seen it in many things. First, they don’t care that they have bad evaluations from students. There are people that, semester after semester, with bad evaluations, don’t make any changes in their instructional practices... some are good teachers, they really are very good in the scenario, talking, explaining their topics, they know their content very well, but their classes are essentially the same... they don’t participate in the [pedagogical training offered by the university]. With one of them [another assistant professor] I have had many talks about it, but the only one he wants to use that I used... is the type of assessments that I conduct to make grading faster, but besides that, his class is essentially the same.”

Nonetheless, as one associate professor commented, professors recognize the value that more pedagogical knowledge provides to the class; thus, students are more likely to learn the concepts:

“There are professors in our department who have a lot of knowledge about learning and education. So, they teach their courses applying known theories... I believe they prepare their classes much better. I believe they could obtain better results [in their classes].”

The adaptation of RBIS oriented to increase students’ academic motivation also leads to another dynamic that impacts faculty motivation to adopt RBIS in their classes.
**Students evaluation of teaching (R11):** Professors acknowledge that an increase in students’ academic motivation and learning is reflected in more positive evaluation of teaching. Students learn more as a consequence of being more motivated and engaged in learning activities. Such engagement, complemented by deep explanations of the theory behind the activities provided by the professors, make it more likely that students show appreciation for their professor by increasing the positive results of students’ evaluation of teaching (SET). Such appreciation has a positive effect on faculty motivation not only as a consequence of formal means such as SET scores but as a consequence of other non-formal means that show gratitude for the way the class was taught.

An associate professor provided an example of how former students of his course recognize his teaching positively, besides formal SETs, and how that motivates him:

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“My students finish the course very happy, they appreciate it, they keep writing to me in the following semesters. Sometimes when it’s time to write a letter to their teachers, some of them have written to me saying thank you. I see they liked my teaching... that motivates me too because recognition comes from students rather than from my department colleagues.”
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**Permissiveness (B8):** As a consequence of better learning, it is expected that students will increase their academic quality, obtain better grades, and professors obtain better SETs, which in turn increases their motivation to adopt RBIS. However, results of the data collection showed a collective belief that good grades and good SETs could be attributed to how permissive the professors were with their students and not necessarily attributed to an increase in students’ learning.

Such belief on the permissiveness in grading is reinforced by the combination of a perceived reduction in students’ academic quality and the acknowledgment that other professors, who apply RBIS and whose students have good grades, receive positive SET scores. A professor who is used to traditional instruction and shared this belief is less motivated to adopt RBIS because he or she tends to associate the adoption of RBIS with being more permissive. To many professors, being perceived as permissive is against the cultural value of being a highly demanding teacher because that perception questions their overall quality of teaching.
<table>
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<td>Students' recognition of teaching</td>
<td>Pedagogical training</td>
<td>R11</td>
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</tbody>
</table>

**Figure 23 Students evaluation of teaching (R11)**
Three professors from different categories acknowledged that they underestimate the SET scores because they are highly related to students’ performance and subjectivity:

“Other professors believe that those professors have good SETs because the students pass their courses, whereas the professors who have bad SET is because students fail the course.”

“I believe certain professors have the mindset of doing whatever is possible to make students learn. I believe that not everybody is on that mindset because
students evaluate you, then if students have a good performance they say ‘that professor is wonderful’.\(^{36}\)

“Those SETs have to be cautiously understood because students don’t really know what the professor has to teach. Students only have a perception from their viewpoint that is not the whole reality.”\(^{37}\)

Conversely, professors who share a belief that good grades and good SETs are the result of an increase in the students’ academic quality (R12) are less likely to associate positive SETs with permissiveness in grading.

In this regard, a professor who sometimes uses RBIS in his courses and receives good SETs commented on the strategy he used; he needed to acknowledge that his good SETs were not a product of being permissive and he emphasized his thoroughness in his students’ grades, thus he was more confident about the positive comments of his students.

“Students make positive comments about their experience in the classes I taught... even though I’m not, let’s say, I’m not determined to fail everybody but I do maintain rigorosity in their grading. I haven’t noticed comments from the students like what I’ve heard about other professors, who are either not demanding enough and every student passes, or professors are too demanding and don’t deliver what is expected from them in the classroom.”\(^{38}\)

In the same regard, another professor who has adopted RBIS felt the social pressure to use direct instruction from professors who share the belief that using RBIS implies permissiveness:

“Many [professors] don’t validate [my strategies], it is like they think what I do is meaningless... that I spoil [the students] too much, that they are not learning... They feel that traditional practices must persist in engineering. I believe [my students] learn, I have numbers that demonstrate it, the same final exam made in two different courses with old methods and new methods, and you can see the difference, I even wrote an article about this two years ago that was recognized as the best paper at a conference... but here [in my department], since there is not much interest, I don’t discuss [my strategies] either.”\(^{39}\)
Pressure to reduce attrition (B9): Other circumstances reinforce the belief that relates good grades and SETs with permissiveness. First, is the perception that the overall students’ academic quality is reduced and that such quality is also reduced due to a decreased *selectivity in admissions*. Second, the reduction in students’ academic quality increases the pressure felt by the professors to reduce attrition. Third, depending on the professors’ perceptions of job security, such pressure increases the likelihood of being permissive with their students, which in turn increases students’ grades.

Two quotes from an assistant professor and an administrator emphasized the perceived reduction in the first-year students’ quality:

“I have talked to many senior professors, and they believe that it is the students who don’t ‘function’. That is the difference... Everybody perceives it! They say that students come ill-prepared from high school, that every year they’re coming worse... Everybody recognizes this, but everybody knows that we need to teach to these students, who are not the same as ten years ago.”

Figure 25 Pressure to reduce attrition (B9) Balancing Loop
“There are [professors] who say that [students] should know this and that, and they don’t know it, so they ask who are we admitting? We should admit only the best, but we are not in a time of high demand… here, the selection is reduced, and we can’t make a long face over it.”41

Second, such perception of reduced quality combined with a sub-par applicant pool from which to select prospective students has increased the pressure felt by professors to increase students’ results, as an associate professor described:

“My responsibility as an institution is to elevate [the students] to the point of excellence that I want, at the expense of what? At the expense of whatever is necessary, because it is the university’s pledge… which is telling us to admit 40 or 80 students with a profile that is not as superior as we were used to 20 years ago. That is why there is so much investment in students support… this is the person who entered [the program], our responsibility is to take them to the point of excellence, if we have to push them, then we have to push them… our responsibility is to graduate them with excellence, not only graduate the best we receive.”42

In this regard, an assistant professor, with some frustration, noted how this pressure was related to an increase in permissiveness:

“We have to reduce attrition, so what is the solution? To facilitate students passing the course. It is not easy… in a talk we had with [the program chair], a collaborator told us that: ‘we have to take care of the kids…’, [to which I say:] But they are not kids! they are 20 years old; they are young adults now, we need to be demanding of them if we want them to become professionals”43

Third, depending on professors’ perceptions of job security and experience, the pressure felt by the professors to reduce attrition increases the likelihood of being permissive with their students. In particular, this pressure could be higher on adjunct faculty, whose contract renewal is partially tied to the SETs.

“A professor like [a tenured senior professor] has well-defined concepts, and when he teaches a class, he could change the strategy, but he makes sure students are learning what they need to learn, and he is not going to lose his job. If that happens to a professor like [an adjunct professor]… his students complained that the professor was very tough, or something like that. What was the solution? That he will not teach that course anymore. Next semester, another professor is teaching the class… his students told me that he does not have any clue [about the topics]. Students have such power that they could even get a professor fired.”44
In summary, professors noted that in many cases the more *permissiveness* that exists in the classroom, the better the students’ grades and the better the SETs. Therefore, if professors believe that RBIS are associated with more permissiveness, they will be less inclined to adopt such strategies in their classroom. Such permissiveness is reinforced by the overall perception of a reduction in the academic quality of students caused, in part, by the reduction in the selectivity in the program admission process.

At the beginning of this chapter, I explained that the implementation of the adjustments at the program level has enormous delays before the actual effects of the adjustments are perceived because of the complexities of the dynamics in the adjustments at the course level and at the class level that were explained in loops B2 and B3. Nonetheless, there are additional loops that introduce other delays and difficulties to stabilize the change process and ultimately impact faculty motivation to adopt RBIS. Those loops are related to the quality of the adjustments and the institutional policies for tenure, promotion, and continuity of an academic career in a university.

**Quality of the adjustments (B10):** The quality of adjustments necessitates changes in the curriculum design at the program, course, and class levels. A proper change management process will require *credible assessments* to inform the decision-making process (Abbas & Howard, 2015). That is, the more credible the assessment, the better the quality of the decisions that lead to the adjustments in the curriculum, course, and class designs. The *credibility of the assessment* is a direct consequence of the *quality of the assessment*, and such quality depends on the value that professors give to the change process, their knowledge about how to conduct the assessment, the *available time* to conduct the assessments (which can be reduced because of the adoption of RBIS as I will explain later), and the *institutional policies* that affect the objectivity of the assessment methods.
Related to the institutional policies that could affect the assessment process, an associate professor expressed his fears about what professors, who do not highly value the change process, would report when instructed to provide the assessment:

“People will fill out anything they feel like [in the assessment report] because when one is reviewing it, one finds those contradictions between course sections that we would expect to be correlated... so, I don’t know how much information an assessment done in 15 minutes would give me when the professor already...
Another professor commented on this idea and shared that other colleagues put it more bluntly:

“We will need to define which strategies to use to assure that everyone is working in the same way... because some professors have told me ‘one thing is what is in the reports and another one is what I do in my class.’”

In these remarks, professors confirmed that other colleagues may not conduct the assessment conscientiously, therefore questioning the quality of such assessment. The same associate professor enunciated the negative effects (e.g., deviations from the expected results) that a low-quality assessment would have on the overall change process:

“If the professor does not conduct [the assessment] conscientiously, the professor introduces a lot of noise in the assessment... [because] I do not measure what I should measure and I make decisions about something that is not properly measured... [therefore] I deviate from the baseline point, I make decisions that instead of getting me closer to the baseline point, they will make me divert.”

The empirical model contains five additional balancing loops that hinder faculty motivation to adopt RBIS related to the institutional policies for tenure and promotion on the academic career in a university. To facilitate the description of these loops, I will describe them as if they were independent of the previously described loops. Nonetheless, they are integrated into the whole empirical model, which can be seen in Figure 30.

These five loops start by acknowledging that periodically professors are subject to evaluation to determine their promotion, tenure, or continuity in their jobs; thus, they tend to invest their time on activities that will likely increase their positive evaluations and move them toward the desired promotion. This creates a balancing loop.

**Time on activities required for promotion (B11):** The increase in activities required for promotion controls the available time professors have for all their activities. In general, professors manage their available time by balancing their teaching, research, and service activities that increase their positive evaluations. This management is mediated by institutional policies and their personal decisions. Data suggest that the time on teaching, research, and
service activities had two different dynamics that affect faculty motivation. These dynamics are described in the two following loops.

![Diagram](image)

**Figure 27 Time on activities required for promotion (B11) Balancing Loop**

**Teaching recognition (B11.1):** Depending on institutional policies, the *available time* could reinforce the motivation to adopt RBIS. If the institutional policies recognize the *positive evaluations of teaching* as part of the professors’ promotion, professors will be more motivated to expend time on activities that lead to the adoption of RBIS. Conversely, if policies for promotion and continuity are not leaning toward teaching, professors will not likely invest more time to innovate in their teaching, therefore reducing their motivation to adopt RBIS.
**Figure 28 Teaching recognition (B11.1) and Research recognition Balancing Loops (B11.2)**

**Research Recognition (B11.2):** Similarly, depending on institutional policies, professors will likely increase their time invested in new research or service activities because an increase in funding and publications would increase their recognition and their positive evaluations to satisfy the promotion and continuity requirements.

To illustrate in more depth the influence of time on activities required for tenure and promotion on the motivation to adopt RBIS, I briefly describe one of the policies specific to the site studied. This policy impacts all full-time faculty in the college of engineering.

Full-time professors from all ranks (i.e., instructor, assistant, associate, and tenure) are classified in three different profiles depending on their research involvement and the number and quality of their publications: 1) High research profile: professors who are actively engaged in research and have a higher number of publications or intellectual products (e.g., patents, designs). On average, these professors teach at least 8 hours per semester (i.e., four to five courses per year). 2) Medium research profile: professors who are actively engaged in research and have a moderate number of publications or intellectual products. On average, these professors teach at least 12 hours per semester (i.e., six to seven courses per year). 3) High teaching profile: professors who
are actively engaged in teaching and have few publications. On average, these professors teach at least 16 hours per semester (i.e., eight to ten courses per year).

Independent of these profiles, professors of all ranks are evaluated with the same criteria that include recognition of teaching, research, and service in the form of points. Points are recognized by peer evaluations of teaching (informed by the students’ evaluations of teaching, and research and service involvement) and quality of publications (recognized by an independent committee associated with the provost’s office). Except for instructor, each rank (assistant, associate, and tenure) have three different salary scales. To advance in each rank (or its subscales), professors have to accumulate a specific number of total points (including a specific minimum number of points resultant of publications). As an example, promotion to associate professor requires 300 points and 5 years in the assistant professor rank. A paper in a high impact journal is worth up to 100 points, a conference paper up to 20 points, and the peer evaluation of teaching up to 15 points per semester. Every year, the professor’s profile could change according to the publications or intellectual products of the last 3 years.

Data suggest that this policy hinders faculty motivation to adopt RBIS because it relies heavily on research criterion. An associate professor summarizes the effect of this policy on faculty motivation by stating that faculty who want to advance on their career ladder prefer to invest their time on publishing rather than teaching:

“There is a very clear faculty career ladder: you have to publish, or you will not advance in your career. Even if you teach in some focused and effective way, in the end, it is worth much less than publishing an article, so you say ‘I cannot keep doing this because I also need to advance in my professional career’.”

Even professors who adopted RBIS previously have decided to invest less time on teaching because it does not help them achieve promotion. As perceived by an assistant professor who was recently profiled due to high teaching and has adopted PBL, this policy does not recognize adopting RBIS as a way to advance in their promotion and tenure:

“When I am with my students in the class, showing and doing some type of experiment, it is highly exciting to see their faces [showing interest], I believe I am doing the right thing, I feel very proud of my courses, just because I have changed. Now, that has taken more time. Hence when I started in the high teaching [profile], it affected me. So, I stopped using projects in my class
because that wasn’t giving me anything. Even though these experiences are rewarding, it is my time to be promoted and to get out of the high teaching profile; I reduced a lot of activities that took more time. But that greatly reduces [the students’] experience. That has been reflected in the fact that I currently do not have students in the final capstone project because the students are less interested in my area.”

In his comments, this professor recognizes that not adopting PBL in his course had a negative effect on students’ motivation and learning. However, he reduced the use of PBL in his courses because he considers that the required time to adopt PBL was better spent in activities that helped him with his promotion.

Another professor supported this idea by suggesting that reducing the quality of his teaching does not necessarily have a negative effect on his promotion and prefers to invest the available time on activities that offer more recognition and promotion:

“To be evaluated as an excellent teacher I had to make decisions to reduce interaction with students. I believe that my SETs have gradually decreased. That is, I don’t believe I have had major flaws as a teacher... but I know that my classes are not the best because I’m not delivering them in the best way. I accepted that it was going to happen. Before, I had SETs of about 5.5/6 which was a very good rating; now I’m between 4.9 and 5; as long as it doesn’t fall below 4, it’s fine. Nobody here will be bothered because of that; they’re not going to say anything to me. There is no difference between 4 and 6 in terms of recognition; there is not a really well-defined teacher recognition. I know I can deliver my classes better, but I do just enough to be ok with what they demand from me, and I dedicate more time to what gives me more benefits and more recognition, especially to advance in the rank and the profile.”

In his comments, the professor illustrates that this policy reduces the likelihood of teaching innovations because professors see the time invested in teaching as less effective to their promotion. Even professors that have reduced their SET average are not perceiving the effects of this reduction on their overall evaluation and promotion. They tend, then, to be more pragmatic and do what works well enough to prevent negative SETs that could affect their promotion.

Teaching Workload (B12): In addition, a balancing loop that hinders faculty motivation occurs because the adoption of RBIS is typically associated with an increase in the teaching workload due to the increase in preparation, assessment, and feedback activities. This increase in teaching workload adds to the general workload dictated by the institutional policies. More workload
implies less time available to innovate in their teaching, therefore reducing faculty motivation to adopt RBIS.

An assistant professor who used to adopt RBIS in his courses commented on the increasing time demands for professors and how such demands have reduced the use of RBIS in class:

“I understand that the university must maintain a balance to lowering expenses and raising revenue that is directly reflected on faculty. Therefore, faculty have to increase their teaching hours to maintain that balance, right? But when you lose perspective, it is more difficult for a professor and more demotivating. I think that’s happening. We are forced to return to our traditions, what we have been doing historically... there are some teachers who simply decide ‘I teach my classes as I used to [lecturing], because [my peers] will still give me a positive evaluation’.” 51
In his comments, the professor suggests that increasing the teaching workload hinders faculty motivation to implement RBIS because of the combination of two reasons: professors have less time available, thus they will not likely invest the additional time that RBIS would require, and even if they do, such additional time will not increase their positive evaluations.

Similarly, another assistant professor suggested that by having more time available (as a consequence of being categorized in the medium research profile), he was more willing to integrate PBL:

“"I feel that with more time I will always be able to give more, I will always be able to explain better what I like, I will be able to look for more examples, I will be able to find other books, I will be able to do more simulations, I will be able to propose better teaching strategies. Because that takes time. I know I did it at some point, when I was in medium research [profile], I prepared very well my courses; that allowed me to propose courses based on projects."”

Having more time available also helped the professor learn more about the content that he is teaching and find ways to make it simpler and easier for students to learn. Conversely, he considers that not having enough time to add depth to the content is limiting the quality of his classes.

“"I am no longer teaching my classes as before. Before, I taught them more in-depth... the different ways that I can deal with abstract concepts help the students a lot... the way you add depth to your knowledge is year after year, semester after semester. To teach the best I can implies that I can build the content in the most structured way. It seems to me that I have succeeded to some extent in simplifying topics that have traditionally been supremely complex for students. That takes time, and I would like to have a little more time to reach an even greater depth. I think that’s what professors of the best universities in the world do."”

In this same area, an adjunct professor highlighted another effect that institutional policies have on faculty willingness to adopt RBIS. As an adjunct professor, his main income comes from outside the university. Therefore, he is more careful with the time invested in teaching. Acknowledging that innovations in class require additional time, he suggested that knowing that he will teach the same courses in the future motivates him to invest time applying innovations in his current courses because he could use those innovations in his future courses.
“Another factor that motivates me is the continuity in the classes they assigned me. For example, I only have one class that I know I will teach every year. In that class, I put the effort to apply innovations. Not so much in the other classes, because of my time and salary... because I don’t know if I will be able to use those innovations later. If they assure me continuity, I will invest time, because I invest in what benefits me in the long term. Otherwise, I will use that time in other things that I need for my income.”54

Research Workload (B13): An increase in research activities will lead to increments in workload, which in turn hinders faculty motivation to adopt RBIS. Time invested in new research or service activities will likely be used to develop project proposals. In time, these proposals will result in more funding to develop the proposed projects. With more funding, more projects could be implemented and, later, will prompt an increase in publications. Activities associated with developing proposals, implementing the projects, and publishing increase the overall workload that professors have. An increased workload reduces the time available, leaving less time to invest in activities associated with their teaching. Especially for junior professors, it is expected that the workload gradually increases because of the delay between proposals, funding responses, project implementation, and publishing activities. This means that at the beginning of their career, professors would have more time available for teaching, but such availability would be reduced over time due to the gradual increase in their research workload. It is likely, then, that faculty motivation to adopt RBIS will decrease gradually as the junior professors’ careers advance. For readability of the diagram, some links in this loop (R13) shown in Figure 29 are thicker than the others.

An assistant professor who is in the high teaching profile and adopted RBIS in the past highlighted that the activities to conduct research take time.

“I have a publication, but that took me years. That is, I require time to obtain results and publish them, or even submit [for review].”55

Also, there is a delay between the proposed projects and the publications, which are the primary requirements to change the professors’ profiles:

“Bringing in a project does not reduce my teaching workload. University policies are clear, reductions in workload only occur when one’s profile changes, and I only change profiles when I have more publications. However, to
Noting such increase in the time commitments, he mentioned that the effort professors invest in proposing a new project increases workload but is not recognized as part of their evaluation.

“It seems to me that proposing a large research project is not valued, nor does it receive the importance it deserves. I don’t know if it is a matter of visibility, public recognition, or promotion of what we do, our research centers, or the projects that are funded by [a government foundation]. Here, there is no model in which they recognize what we do, which is very valuable, in let’s say, more time available, or visibility, and that [the recognition] would help to bring more projects. Everyone talks about entrepreneurship but the conditions don’t exist.”

In his remarks, the professor suggests that a policy heavily focused on publications disregards the effort to propose and implement the projects that lead to those publications. That is, proposing and implementing a project increased the workload and reduced the time available but did not increase their recognition. Therefore, it will not help them to advance in their career nor reduce their workload in the short term.

As such, professors are more inclined to invest their time on activities that lead them to more publications. Particularly, professors in the high teaching profile had more difficulty in fulfilling the requirements for promotion. This leads to exhaustion and frustration, as another assistant professor in the high teaching profile commented:

“I feel that my research lacks depth and it is not a matter of resources, because the resources can be obtained. It is a matter of time and fatigue... these last two years, I feel that I am worn out a lot and it frustrates me. I feel that this is happening because of the high teaching policies. I think that at some point we are losing some perspective on what it means to be a teacher.”

In summary, the combination of the increases in teaching workload that adopting RBIS entails, the gradual increase in workload of conducting research, the long delays between initiating research and producing publications, and the promotion policies heavily focused on publications creates a loop that gradually reduces the available time and makes career advancement very difficult for professors in the high teaching profile. Professors in this profile, then, are less
inclined to adopt RBIS in their courses because, ultimately, additional time invested in teaching will not help them with their promotion.

**Figure 30 Empirical CLD**
5.3 Summary of the CLD

Table 7 offers a summary and a brief description of the causal loops in the empirical CLD. In this table, I offer a classification of the feedback loops based on the five categories described in the theoretical model. Therefore, the loops described in this table do not necessarily follow the order I presented in the previous section. This classification would facilitate the comparison between the empirical and theoretical CLD.

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5.4 Policy Implications

As mentioned, the purpose of this CLD is to describe the structure of the academic system that affects faculty motivation to adopt RBIS based on empirical evidence. From this structure, we can better understand the behaviors of the factors involved and their implications on faculty motivation. The complexity of the system is modeled in the 10 reinforcing loops and the 13 balancing loops in the CLD; however, to predict the behavior of the factors over time, the model would need to be formulated in every academic context using quantitative descriptions. Despite these limitations and based on the described structure, I can infer key factors that could potentially become leverage points (Senge, 1990). That is, factors that, based on the dynamics of the system, will have a higher impact with lesser effort. In this section, I provide insights of such leverage points.

5.4.1 Leverages in Change Management

Managing a curriculum implies that administrators and professors adjust the curriculum to increase students’ achievement of defined program outcomes. This basic statement brings two big questions from a change management perspective: 1) When to introduce those adjustments? and 2) Which data should inform those adjustments? Inevitably, every change in the curriculum at the program level has delayed effects both at the program and course levels. Therefore, it is difficult to know if the curriculum design was appropriate because its real effects cannot be seen until several iterations or program cycles have passed. That is, at the moment of the assessment it is extremely difficult to know if the results are caused by the recent adjustments in the
curriculum or caused by delayed effects of past adjustments a long time ago. I explain the implications of these two questions and suggest some ways to reduce their difficulty.

The dynamics that explain the question of when to introduce the adjustments are described in the loop (B1) (see Figure 31). Because of the delayed effects of the academic system, making adjustments sooner than appropriate increases the probability of oscillations, overshoots, or collapses in the system (Senge, 1990). Similarly, making adjustments later than appropriate either will not produce the desired results or their effects will take even longer intervals of time. The latter would increase the possibility of great disruption in the system by unexpected external variables like sudden changes in technology, demographics, or accreditation (Kezar, 2014).

The empirical CLD showed how the dynamics of the implementation of the adjustments could lead to a reduction in the perceived validity of the learning objectives (see Figure 14). The validity of the learning objectives is a central part of the dynamic that affects faculty motivation to adopt RBIS. Such a reduction could also be a natural consequence of the change process itself, regardless of how thoughtful and careful the changes were designed. The model suggests that the delayed effects of the curriculum adjustments could last several curriculum cycles (i.e., more than 10 years). Thus, it is understandable that professors would have concerns about the
trustworthiness of the adjustments, especially if they expect the adjustments to have short-term or immediate results. In other words, the model also shows that it is very unlikely that the implementation of the changes work on the first attempt. The effects of change, therefore, can be observed only after a long lead time (i.e., a time where the results are not affected by the adjustments). However, it is doubtful that professors and administrators will be willing to wait for several program cycles to adjust the process. As the data suggests, the perceived risk is enormous, and such risk increases the resistance of some faculty members to change. In turn, this will increase the delay in the process, therefore reducing the quality of the adjustments in the curriculum and the courses.

On the other hand, waiting for the long lead-time to implement adjustments opens the door to any other factors affecting the results of the process. For example, new faculty, retiring faculty, professors changing the courses they teach before the course stabilizes, modifications in student characteristics, changes in administration personnel, or sudden changes in the external forces that affect the academic systems like technology, politics, budgets, or demographics. All of these factors could be confounding variables threatening the validity of the assessment. That is, it would be very difficult to attribute the level of achievement of the program outcomes to the adjustments made to the curriculum because of the influence of all these confounding factors.

A step to solve this problem could be extracted from the lessons of systems engineering. Experts suggest that one of the biggest leverage points to improve systems performance is to minimize system delays (Schwaninger & Groesser, 2011; Senge, 1990). That means reducing the rippled effect or the propagation of the delays in the courses, shown in Figure 31. Knowing that each course adjustment could add a delay, it would be imperative to implement characteristics in the courses that allow corrections within the course without impacting its effects on other courses. In short, it means reducing the content to cover and leaving enough room in the course schedule so professors could make the adjustments that help students achieve the course objectives without having to sacrifice other topics that were expected to be covered. For example, if a professor notices at the beginning of the course that her students do not know a required topic, she would have room in the schedule to add activities that reinforce those topics without having to reduce time for other topics in the syllabus.
Similarly, if she notices that her students are not achieving one of the course objectives, she would have room in the syllabus to implement additional learning activities related to those course objectives. Another alternative is to intentionally create overlaps in the topics covered in each course. Understanding that learning does not necessarily occur at the same time as the instruction (Ambrose et al., 2010), it would be expected that students do not master all the concepts in each course by the time the course ends; therefore, including content that was covered in previous courses would give students the opportunity to hear another perspective, synthesize what they know, integrate other connections, or clarify misconceptions without disrupting the flow of the course.

To answer the second question (which data to use to make the adjustments), I suggest that there are two leverage points: 1) increasing the quality of the assessment and 2) create or clarify a reference model. The dynamics of these two potential leverage points have been described in the Quality of the adjustments (B10) loop (see Figure 31).

The first leverage point implies the need to put in place proper measurements of the course objectives along the course and not only at the end, but without increasing the time commitments of the professors. That is, the assessment of the learning outcomes should not be an additional task, and it would have to be embedded in the learning activities of the course. Data suggest that if the assessments are not embedded in the course activities, they would likely be flawed because they would not be the result of a conscious process. For example, asking for assessment reports whose only objective is to satisfy an accreditation requirement is likely to be seen as an activity of reduced value (Spurlin et al., 2008). Similarly, the assessment should not be tied to processes that affect faculty who report it because it could be biased (Spurlin et al., 2008). There are alternatives that increase the value of the assessment and reduce bias, such as including independent standardized measurements, having independent teams to analyze the assessment, or linking the rubrics of specific learning activities to the reports prepared for accreditation purposes.

The second leverage point to answer the question implies creating or clarifying a reference model. A reference model would provide a working definition of how the change should occur.
An interviewed associate professor who is an expert in control systems defined a reference model:

“When we make the control system, we design it to behave as a reference model...., the reference model is what [the designers] have in mind for how the curriculum should work, this is what I will compare to... [what we have now is] the baseline point, the curriculum, with the outcomes embedded in each course, but why we have to do [the changes]? Are we doing them ok? Is that what we wanted? Is [the system] behaving the way we wanted? without the reference model, there is no one who gives us that feedback.”59

In other words, this reference model provides a way for decision-makers or change agents to control or regulate the system. That is, they need a regulatory process that could predict the behavior of the outcomes to make proper decisions in the adjustments. Likewise, this regulatory process would give feedback to professors about the effects of the decisions in their courses. Having a clear reference model will, in turn, increase the quality of the adjustments made at the program and course levels.

Conversely, without a proper reference model, the implementation of RBIS could not lead to achieving the expected program outcomes. A proper reference model should acknowledge the delays inherent to a curricular change process. Hence, it should show a pace that accommodates the time required to achieve the outcomes (Spurlin et al., 2008). This allows avoidance of the pressure of hasty changes that could create overcorrections. Also, it allows assessing the change process by comparing the trends of the actual outcomes versus the expected trends defined in the reference model. This could mean that someone or some group should oversee the curriculum change and avoid a fast response, slowing it down to allow for the delayed effects to occur.

5.4.2 Leverages in the Culture

As previously mentioned, the perceived validity of the learning objectives is a potential leverage point of the dynamics that influence faculty motivation. It not only affects change management but also the culture, particularly the beliefs professors have in regard to the change process. Data suggest that the perceived validity of the learning objectives is reduced because of five reasons: 1) professors do not see the objectives as useful because they do not understand them, 2) the
objectives do not reflect what students know, 3) professors do not know how to assess the objectives, 4) the objectives are not stable, and 5) achieving the objectives is not feasible.

First, professors do not perceive the usefulness of the learning objectives because they do not completely understand them. For example, a professor who regularly uses RBIS in his classes questions the validity of the learning objectives. He based his critique on the lack of clarity of both the objectives and the provided assessment tools (i.e., rubrics).

“I still don’t know what to expect of my students, I have some learning goals, and I have rubrics that supposedly must give me an idea of what is expected that students learn. Now, I have studied those CDIO rubrics… but in the end, I don’t understand them. I don’t understand the logic behind them; I compare them to what I know… I say, ‘ok, I have done this, I have done digital designs, what do I need to know about this? And the rubrics don’t tell it to me’, that is, if I evaluated myself with those rubrics, I would not understand what do I need to know. If I evaluate myself with the rubrics they gave me, I don’t know if I would pass the course I’m teaching.”  

Second, professors could perceive a lack of validity of the learning objectives if they do not reflect what students know. To illustrate this, another professor, who does not use RBIS, puts it bluntly:

“I don’t trust the level of knowledge I presume [the students] came with [to my class]”

He explained how even the good students did not know some previous basic topics that he expected them to know according to the syllabus of the previous course. He also questioned the depth of coverage of these topics.

“I assumed that they have seen [a specific topic] because I saw it on the syllabus [of the preceding class], but they have not seen anything. They saw only an example.”

As a consequence, the lack of students’ knowledge of what he considers important topics restrains him from changing his instructional approach:

“If they have such flaws and I make experiments [in my class] like asking [the students] to read a paper, even simple application notes, and they don’t have the basic concepts…[they will be in big trouble], I have seen terrible flaws in them,
I fear to start doing those experiments, maybe when the course is consolidated, but I see it difficult right now. ”

Third, the difficulty of assessing the objectives increases the discrepancy between expected knowledge and what students actually know. A professor illustrates the discrepancies between students’ knowledge at the end of a course and other professors’ beliefs of what students should know at the beginning of the next course.

“The problems I propose on an exam are really difficult and complex, but students solve them. So, I am somehow very satisfied that [the students] accomplish good things, but then, in the next class, the professors are complaining that students don’t know anything. So, I don’t know, I question myself, but finally, that is the problem of the assessment. However, up to what point I am not assessing correctly? and up to what point are other professors assuming things that they should not assume?”

He gave an example of the different assumptions that professors have about what students should know:

“There is a quiz that [an associate professor] makes at the beginning of his class, ‘the diagnostic quiz,’ and he complains every semester, he says that [the students] are not capable of solving it. Although it is very easy, it is a velocity quiz. So, they would be able to solve it but not in the time that [the associate professor] expect they solve it, they don’t have the math agility. ”

Fourth, the learning objectives are not as stable as a consequence of the changes in the curriculum. This dynamic was illustrated in Figure 14 (for readability I also copied it into the following Figure 32).

As two assistant professors expressed, the ongoing curriculum change process does not prompt professors to make decisions in their courses of which topics to cover and which topics to avoid. Such decisions, in consequence, increase the discrepancy between the expected and achieved outcomes of the subsequent courses, which in turn will reduce the validity of the learning objectives:

“I will have to make recommendations to previous courses’ professors, if they have the time because possibly they have the same problem I have: what they covered in three courses they have to cover it in two courses now, so they say ‘I am going to give the most important topics and sacrifice these [other topics]’,
but with such curricular transition I am not sure of what they know and don’t know.”

To professors, such changes in the objectives make their expectations of students more uncertain at the beginning and at the end of the course.

“The course designs and implementations are made in real time. We don’t know how these courses work in practice; we don’t know if we can achieve [the objectives], everybody is new in designing the courses.”

Fifth, in concordance with the latter, the learning objectives of the course could not be achieved because of the reduced time available to cover the content.

“Even if [the learning objectives] are very well done... I don’t have the time to accomplish them.”

The time available and the deep learning of the course content is reduced as a consequence of discovering that students do not have an expected previous knowledge:
“When I realize that [students] did not see [an expected topic], then I reduced the rigor of the course..., that is, topics that we expect [students] to learn, when you discover that there are more [topics], you have to reduce the quality of the course somehow. In some cases, even adding more topics [to the course]; more topics imply increasing the content to cover.”

If achieving the objectives is not feasible, the discrepancy between what it is expected and what students know increases, which in turn reinforces the dynamic that reduces the validity of the learning objectives. One of the administrators recognized this problem and emphasized the necessity of better coordination of activities related to the new curriculum to try to reduce this discrepancy.

“The department sections and the course leaders have to work to try to be very consistent and that everything [the courses’ content] is covered. Hopefully, in the way, it was designed. Do it as you want, use the strategy and didactic that you want, but follow the syllabus! That is very difficult, very difficult!”

In his comments, the administrator recognized that the discrepancy prompts professors to demand changes in the objectives of the prerequisites and current courses. Attending to those demands would require additional adjustments that, as it was described in the policy implications for change management, introduce other delays in the system response and, therefore, more resistance to implementing the expected changes in the curriculum.

Another potential leverage point in culture is to reduce the association of the adoption of RBIS with an increase in permissiveness. In Figure 24, I described the negative effect on faculty motivation of an increased belief that adopting RBIS implies permissiveness of a professor. One suggestion is to increase the awareness that good SETs not solely depend on the students’ grades. Research suggests that in engineering, SETs correlate not only with higher grades but smaller class size, course levels (Narayanan et al., 2014), or higher students motivation (Jones, 2010; Laird et al., 2008; Narayanan et al., 2014).

Another suggestion is to open the conversation to questions about the cultural value of being a highly demanding teacher and its impact on the SET scores. As one assistant professor acknowledged and critiqued:

“As an institution, we should encourage that the big achievement, beyond a good SET, is that such SET be a reflection of a good performance, not that
everybody failed ‘but look!, I have a perfect SET’, or ‘he is the best teacher I have had in my whole life, but I failed!’. There is something wrong, something very wrong… It can’t be that the stereotype of a good teacher is the one who fails people. We need to change that in the students, they get used to an educational system that filters them, instead of one that builds them.»

In these remarks, the professor questions that people, including students, tend to value the SET scores if the professor is a highly demanding teacher, and not if many students pass the course. The professor questions this value by stating that it encourages a system focused on controlling and filtering, rather than on making every student having a good performance.

5.4.3 Leverages in the Institutional Support

Another potential leverage point to faculty motivation is to control the class size. Research indicates that large class sizes are often reported as barriers to change for professors from different departments (Henderson et al., 2012; Pagnucci et al., 2015). Specifically, larger class sizes often motivate professors to use direct instruction (Prosser & Trigwell, 1997) because of the difficulty of maintaining effective interactions and engagement with students. Nonetheless, research also reports that class size is not an isolated factor but often it is accompanied by other variables like increased workload (Pagnucci et al., 2015), curriculum flexibility (Finelli et al., 2014), or departmental support (Prosser & Trigwell, 1997).

The loops described in Figure 21 (and reproduced in Figure 33) suggest the idea that changes in class size reinforce the increase on the teaching workload, the increase in difficulty to apply RBIS, and the decrease in the quality of feedback provided when professors engage with students. All of these reinforcing effects affect faculty motivation negatively and it appears that none of the factors derived by the increase in class size would potentially reinforce positively the motivation to adopt RBIS. However, other powerful factors apply pressure to increase class size like university growth, increases in enrollment (Zaini et al., 2017), or financial restrictions (Borrego et al., 2010). In short, universities have pressure to increase class size, which in turn negatively reinforces faculty motivation to adopt RBIS. Efforts from the department to control the class size growth are needed to stop this negative effect. It is worth noting that reducing the class size would not enact changes in instruction by itself, but it would control the negative reinforcing effect that hinders faculty motivation.
Figure 33 Class Size (B7) Balancing Loop
CHAPTER 6. DISCUSSION AND CONCLUSIONS: A CONCEPTUAL SYSTEM DYNAMICS MODEL OF ADOPTION OF RBIS IN THE CLASSROOM

6.1 Introduction

The purpose of this study was to better understand how the academic system affects instructional change in engineering education. I addressed this purpose by creating a conceptual System Dynamics Model (SDM) that illustrates how the factors influencing instructional change in academia interact dynamically to drive or hinder faculty motivation to adopt RBIS in their courses. Through this in-depth qualitative inquiry, I was able to contribute to our understanding of the complexity of instructional change by providing a theoretical Causal Loop Diagram (CLD), described in Chapter 4, and an empirical CLD, described in Chapter 5. In this chapter, I present an integration of both CLDs in relation to the literature about motivation. In previous chapters I have proposed and detailed policy implications as products of the causal loops found in each CLD. Those implications are summarized in this chapter as well as the implications to research. I then provide recommendations for future work that will allow us to continue advancing instructional change initiatives using a systems perspective. Finally, I present concluding remarks from this research concerning the dynamics of the academic system that affects faculty motivation to adopt RBIS.

6.2 Integration of the Theoretical CLD and the Empirical CLD

The theoretical CLD shows the interaction of the academic system components influencing instructional change in the form of 8 reinforcing and 6 balancing causal loops; likewise, the empirical CLD shows such interactions in the form of 10 reinforcing and 13 balancing loops. All of these interactions drive or hinder faculty motivation to adopt RBIS in their courses.

This section shows the integration of the theoretical and empirical CLDs. It includes all the reinforcing and balancing loops in both CLDs classified by the five categories defined in the literature review. As a summary, Table 8 shows the overall integration of the theoretical and empirical CLDs.
<table>
<thead>
<tr>
<th>Categories</th>
<th>Theoretical CLD</th>
<th>Empirical CLD</th>
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<tbody>
<tr>
<td></td>
<td>Causal Loop Name</td>
<td>Description of Causal Loop</td>
</tr>
<tr>
<td><strong>Change Management</strong></td>
<td>Sense of Urgency to Change (B6) Balancing Loop</td>
<td>Balancing effect on the sense of urgency to change caused by the difference between the actual and expected effectiveness of the teaching practices.</td>
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<tr>
<td>Student’s Learning</td>
<td>Reinforcing effect on faculty motivation driven by the identification that students learn better with RBIS than with traditional teaching strategies.</td>
<td>Adjustments in the implementation of RBIS Balancing Loop (B5, B5.1)</td>
</tr>
<tr>
<td>(R5)</td>
<td>Quality of the Adjustments (B10) Balancing Loop</td>
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<tr>
<td>Categories</td>
<td>Theoretical CLD</td>
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<td></td>
<td>Causal Loop Name</td>
<td>Description of Causal Loop</td>
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<tr>
<td>Culture</td>
<td>Collective Value on Teaching Innovations (R7)</td>
<td>Reinforcing effect on faculty motivation driven by the value that faculty as a whole give to the adoption of RBIS.</td>
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<td></td>
<td></td>
<td>Permissiveness (B8) Balancing Loop</td>
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<tr>
<td></td>
<td></td>
<td>Balancing effect that hinders faculty motivation to adopt RBIS because students’ grades and SETs can be attributed to how permissive professors are.</td>
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<td>Students’ academic quality (R12) Reinforcing Loop</td>
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<td></td>
<td></td>
<td>Reinforcing effect that reduces the sense of permissiveness when students’ academic quality increases.</td>
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<td></td>
<td></td>
<td>Pressure to reduce attrition (B9) Balancing Loop</td>
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<td></td>
<td></td>
<td>Balancing effect that increases the sense of permissiveness caused by the pressure to reduce attrition.</td>
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<td></td>
<td>Faculty Collaboration (R8)</td>
<td>Perceived validity of the learning objectives Reinforcing Loop (R1)</td>
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<td></td>
<td></td>
<td>Reinforcing effect on faculty motivation caused by the credibility on the assessment of the learning objectives of previous courses.</td>
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<tr>
<td>Categories</td>
<td>Theoretical CLD</td>
<td>Empirical CLD</td>
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<td></td>
<td>Causal Loop Name</td>
<td>Description of Causal Loop</td>
</tr>
<tr>
<td>Institutional Support</td>
<td>Content Coverage (B3)</td>
<td>Balancing effect on faculty motivation caused by the reduction of the content that can be covered when adopting RBIS.</td>
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<tr>
<td></td>
<td>Class Size (B4)</td>
<td>Balancing effect on motivation caused by how faculty perceive the feasibility of adopting RBIS in courses of larger class sizes.</td>
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<tr>
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<td>Faculty Workload (B1)</td>
<td>Balancing effect on motivation caused by the increase in teaching workload attributed to the adoption of RBIS.</td>
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<td></td>
<td>Workload of Larger Classes (B5)</td>
<td>Balancing effect on motivation caused by the increase in teaching workload attributed to the growth of class size.</td>
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<td></td>
<td>Practical Teaching Experience (R4)</td>
<td>Reinforcing effect that reduces teaching workload when faculty gain more experience implementing RBIS.</td>
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<tr>
<td>Categories</td>
<td>Theoretical CLD</td>
<td>Empirical CLD</td>
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<td></td>
<td>Causal Loop Name</td>
<td>Description of Causal Loop</td>
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<tr>
<td>Student Experience</td>
<td>Students’ Learning (R5)</td>
<td>Reinforcing effect on faculty motivation driven by the identification that students learn better with RBIS than with traditional teaching strategies.</td>
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<td>Students’ Resistance (B2)</td>
<td>Balancing effect on faculty motivation caused by students’ resistance to RBIS implementation. Such resistance is manifested in reduction of the students’ engagement.</td>
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<tr>
<td></td>
<td>Students’ Resistance (B2)</td>
<td>Balancing effect on faculty motivation caused by students’ resistance to RBIS implementation. Such resistance is manifested in reduction of the students’ engagement.</td>
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<tr>
<td></td>
<td>Student Evaluation of Teaching (R6)</td>
<td>Reinforcing effect on faculty motivation caused by the positive evaluations of teaching.</td>
</tr>
<tr>
<td>Pedagogical Knowledge</td>
<td>Practical Teaching Knowledge (R3)</td>
<td>Reinforcing effect on faculty motivation caused by an increase in knowledge product of the experience gained by implementing RBIS.</td>
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<tr>
<td>Informal Training (R2)</td>
<td>Reinforcing effect on faculty motivation caused by increase in pedagogical training resultant from an emergent collaboration between faculty.</td>
<td>Number and extent of feasible learning activities (R9)</td>
</tr>
<tr>
<td>Formal Training (R1)</td>
<td>Reinforcing effect on faculty motivation caused by increase in pedagogical training offered by institutions, organizations, and established networks.</td>
<td>Pedagogical training (R10) Reinforcing Loops</td>
</tr>
</tbody>
</table>
In Table 8 the loops in the theoretical CLD that are related to the loops in the empirical CLD are in the same row. For example, in Table 9 the balancing loop B6 (sense of urgency to change) in the theoretical CLD is related to three loops in the empirical CLD (i.e., Implementation and adjustments in the curriculum design at the program level (B1), Adjustments in the curriculum at the course level (B2), and Adjustments in the curriculum at the class level (B3)). Also, each loop is briefly described in the table. To increase readability of the table, I colored some cells to differentiate which loops do not have a counterpart in the other CLD. For example, in Table 12 the reinforcing loop R1 in the empirical CLD (Perceived validity of the learning objectives) does not have a directly related related loop in the theoretical CLD.

In this section, I will discuss which motivation concepts explain the differences and similarities between the related loops in each CLD. Suggestions on how to reduce the negative effects of the loops or improve their positive effects are detailed in the policy implications of each CLD and summarized in the next section. Although the MUSIC model of motivation was the best fit to classify the factors that influence instructional change in the literature review, it does not necessarily provide enough detail to better help describe the differences and similarities in the loops. Therefore, I used concepts and constructs from other theories like Expectancy-Value Theory (Eccles & Wigfield, 2002), Self-Determination Theory (Deci & Ryan, 2000), or Self Efficacy theory (Bandura, 1997). Nonetheless, such theories are also related to the MUSIC model as described by Jones (2018).

Before getting into details of the integration, it is noteworthy to remember that to minimize researcher bias the construction of the empirical CLD followed a reflexive bracketing procedure (Gearing, 2004); thus, I temporarily set aside the theoretical CLD and approached data collection as an exploratory inquiry. This bracketing procedure was not intended to validate or test the theoretical model, instead, it was intended to create a CLD based entirely on the experiences and beliefs of the study participants. Furthermore, the interview and GMB protocols were designed purposefully to elicit dynamics that included the factors affecting change found in the literature review but not including findings of the theoretical CLD.
This bracketing process, in addition to other validity procedures described in Chapter 3 (research methods), allows me to argue that the high relationship between the CLDs is not a product of confirmation bias, but instead is likely due to the notion of isomorphism that explains why academic institutions tend to be very similar even in different countries and educational systems (Kezar, 2014). However, such a claim warrants further investigation.

As mentioned, both CLDs are highly related. Few variables and dynamics existent in the empirical CLD are not explained in the theoretical CLD, and all loops but one in the theoretical CLD are directly related to the loops in the empirical CLD. Specifically, the biggest differences occurred in the cultural loops (see table 10). The theoretical CLD in loop R8 shows a way for individual faculty motivation to reinforce the institutional culture toward increasing the collective value of adopting RBIS. There is not correspondent loop found in the empirical CLD. Similarly, loop R1 in the empirical CLD does not have a correspondent loop in the theoretical CLD. Loop R1 shows how the credibility of the assessment of learning objectives influences faculty motivation to adopt RBIS and that an increase in the validity of the learning objectives reduces the collective resistance to the curriculum change initiatives. Despite these differences, the similarities between the CLDs suggest that some modifications in the theoretical model with the inclusion of few additional loops would likely be a comprehensive model useful in understanding different academic systems and their influence in faculty motivation to adopt RBIS. However, such inclusion is beyond the extent of this research and it will constitute a further step in the construction of a comprehensive theory of transferring research to practice.

### 6.2.1 Change Management Loops

In essence, the change management loops are oriented to understand the design and management of the processes associated with adopting RBIS in the classroom. The integration between theoretical and empirical CLDs is shown in Table 9 and Table 10.

Table 9 illustrates loop B6 in the theoretical CLD as related to loops B1, B2, and B3 in the empirical CLD. All these loops show that there is a possible first step to enact change, this step consists of recognizing that there is a discrepancy between what students are achieving and what professors or administrators desire of that achievement; in other words, that
something is not working as expected or desired. This step is shown in the theoretical CLD as the discrepancy between the expected and perceived effectiveness of teaching practices mostly at the class level, whereas in the empirical CLD, this step is shown in the discrepancy in the actual and expected achievement of program outcomes, course objectives, and class objectives at the program, course, and class levels, respectively. Also, the empirical CLD details the delayed and ripple effect of the implementation of changes and how decisions at the program level have an impact on faculty motivation to change.

Table 9 Comparison between change management loops in the theoretical and empirical CLDs (1)

<table>
<thead>
<tr>
<th>Theoretical CLD</th>
<th>Causal Loop Name</th>
<th>Description of Causal Loop</th>
<th>Empirical CLD</th>
<th>Causal Loop Name</th>
<th>Description of Causal Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense of Urgency to Change (B6) Balancing Loop</td>
<td>Sense of Urgency to Change (B6) Balancing Loop</td>
<td>Balancing effect on the sense of urgency to change caused by the difference between the actual and expected effectiveness of the teaching practices.</td>
<td>Implementation and adjustments in the curriculum design at the program level (B1) Balancing Loop</td>
<td>Balancing effect that prompts adjustments in the curriculum aimed to reduce the difference between the expected and the actual level of achievement of program outcomes.</td>
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<td></td>
<td>Adjustments in the curriculum at the course level (B2) Balancing Loop</td>
<td>Balancing effect that prompts the adjustments in the courses aimed to reduce the difference between the expected and the actual level of achievement of the course objectives.</td>
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<tr>
<td></td>
<td>Adjustments in the curriculum at the class level (B3) Balancing Loop</td>
<td>Balancing effect that prompts the adjustments in the classes aimed to reduce the difference between the expected and the actual level of achievement of the class objectives.</td>
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</table>

The theoretical CLD suggests that faculty motivation is reinforced by the sense of urgency to change and it is consistent with the findings of the empirical CLD. Motivation theory suggests that the sense of urgency is a powerful motivator to enact action if people consider they have the ability to make changes (Weiner, 2001). In other words, faculty would be motivated to take actions if they believed they can succeed in completing those actions (Jones, 2018). The empirical CLD suggests that because of the delayed effects of the adjustments to the curriculum and courses, faculty’s sense of success could decrease as well.
as their motivation to change. In other words, if professors believe they can succeed in increasing the students’ achievement, they are more inclined to act; conversely, if they cannot attribute the achievement of students to professors’ actions, they will be less inclined to act.

Motivation theory also suggests that if faculty perceive that their actions are useful or fit into their future plans, they are more motivated to take those actions (Eccles & Wigfield, 2002). This sense of usefulness (Jones, 2016) is reduced when faculty believe they have to wait too long to perceive the impact of their actions. The delayed effect of the implementation of changes reduces the likelihood of faculty putting in the effort to change because they cannot perceive that such effort is useful (Knight, 2009).

Table 10 Comparison between change management loops in the theoretical and empirical CLDs (2)

<table>
<thead>
<tr>
<th>Theoretical CLD</th>
<th>Description of Causal Loop</th>
<th>Empirical CLD</th>
<th>Description of Causal Loop</th>
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<tbody>
<tr>
<td>Causal Loop Name</td>
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<td>Causal Loop Name</td>
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</tr>
<tr>
<td>Students’ Learning (R5)</td>
<td>Reinforcing effect on faculty motivation driven by the identification that students learn better with RBIS than with traditional teaching strategies.</td>
<td>Adjustments in the implementation of RBIS Balancing Loop (B5, B5.1)</td>
<td>Balancing effect that controls the adjustments in the instructional strategies aimed to increase the students’ learning and engagement.</td>
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<td></td>
<td>Quality of the Adjustments (B10) Balancing Loop</td>
<td>Balancing effect that mediates the quality of the adjustments made at the program, course, and class levels.</td>
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</tbody>
</table>

Also, the sense of usefulness is reinforced by the effect that adopting RBIS has on their students’ learning and engagement. The loops shown in Table 10 (R5 in the theoretical CLD and B5, B5.1 in the empirical CLD) suggest that faculty are motivated to adopt RBIS if they perceive these strategies are useful to increase students’ engagement and learning. Moreover, the empirical CLD (B10) highlights that when the learning assessment has higher quality, the adjustments have more quality. Therefore, it increases both the credibility to the effects of adopting RBIS and their usefulness to increase students’ learning.
6.2.2 Cultural Loops

In essence, the cultural loops represent the dynamics between the collective values, beliefs, assumptions, symbols, or attitudes held by faculty that affect RBIS implementation in the classroom. Table 11 shows the cultural loops of the theoretical and empirical CLDs that have direct relationship or similarities to each other, and Table 12 shows the loops in both CLDs that are not directly related or do not have an equivalent in the corresponding CLD.

*Table 11 Comparison between cultural loops in the theoretical and empirical CLDs*

<table>
<thead>
<tr>
<th>Theoretical CLD</th>
<th>Empirical CLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causal Loop Name</td>
<td>Description of Causal Loop</td>
</tr>
<tr>
<td>Collective value on teaching innovations (R7)</td>
<td>Reinforcing effect on faculty motivation driven by the value that faculty as a whole give to the adoption of RBIS.</td>
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</tbody>
</table>

*Table 12 Cultural loops in the theoretical and empirical CLDs that do not have corresponding loops*

<table>
<thead>
<tr>
<th>Theoretical CLD</th>
<th>Empirical CLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causal Loop Name</td>
<td>Description of Causal Loop</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Faculty Collaboration (R8)</td>
<td>Reinforcing effect on the collective value on teaching innovations driven by the growth and participation in communities of practice.</td>
</tr>
</tbody>
</table>
If the sense of urgency to change is the first step to enact adoption of RBIS, the second step is the perceived value to enacting and sustaining that change. Motivation theory defines the values of the activities (e.g., utility, cost, attainment, interest) as the reasons or incentives to do such activities (Eccles & Wigfield, 2002). Therefore, if faculty perceived an increase in value of adopting RBIS, they would be more motivated to adopt such strategies.

In this sense, Matusovich et al. (2014) concluded that it is possible that individual faculty motivation to change is also influenced by the collective value to change, and that individual faculty have the power to shift the value system of the departments’ culture. This conclusion fits with the observations illustrated in the theoretical and empirical CLD. The loops shown in Table 11 (R7 in the theoretical CLD, and B8, R12, and B9 in the empirical CLD) suggest that a professor’s individual value on adopting RBIS is reinforced by how their peers collectively value the adoption of teaching innovations.

The theoretical CLD shows in detail (in loop R7) that the collective values reinforce individual faculty values, whereas the empirical CLD details three dynamics of these collective values. The first dynamic illustrates that if faculty attribute the adoption of RBIS to how permissive the professors were with their students instead of to an increase in students’ learning (i.e., sense of permissiveness), they are less motivated to adopt these strategies. In this case, because faculty consider it very important to be recognized as highly demanding teachers, adopting RBIS would go against their identity as academic professors (Osborne & Jones, 2011).

Second, the sense of permissiveness decreases when faculty perceive an increase in the overall academic quality of students. Collectively, faculty consider teaching as a useful way to increase students’ learning (Ambrose et al., 2010), and therefore their overall academic quality. Loop B8 in the empirical CLD describes that one indicator of learning gains is the rise of students’ grades if such a rise is not associated to professors being permissive with students. Thus, the utility value of adopting RBIS increases when faculty associate the increase in students’ grades to be a result of an increase in the overall academic quality. Similarly, the utility value of adopting RBIS increases when faculty collectively believe that better SET scores are not the result of professors accommodating students’ preferences.
that have very little to do with the process of learning (Tolman, Kremling, & Tagg, 2016). In short, the usefulness of RBIS increases when better SET scores do not imply that professors are more permissive or that students are giving ratings to professors based mostly on first impressions or personality (Titus, 2008).

Third, the sense of permissiveness increases when faculty feel the pressure to reduce students’ attrition. Research on students’ resistance suggests that students, through the SETs, have the chance to express which professors they prefer to be retained and promoted which sets a pressure for faculty, specially untenured and adjunct faculty, to cede to students’ request to avoid negative ratings or complains (Tolman et al., 2016). Such conclusions fit the findings in the empirical CLD. Loop B9 in the empirical CLD describes how the pressure to reduce attrition influences faculty to be more permissive by predisposing them to increase retention and graduation rates.

In general, the institutional culture may either reinforce individual faculty beliefs and values, strengthening the status quo, or may be reinforced by individual faculty motivation. Loop R8 in the theoretical CLD (see Table 12) shows a way for individual faculty motivation to reinforce the institutional culture toward increasing the collective value of adopting RBIS: allowing and encouraging professors to participate in local communities of practice (Cox, 2004; Finelli et al., 2014; Matusovich et al., 2014). Similarly, loop R1 in the empirical CLD shows how the credibility of the assessment of learning objectives influences faculty motivation to adopt RBIS. Motivation theory (Eccles & Wigfield, 2002) explains that an increased belief in the positive results of RBIS increases its utility value to professors, and therefore their motivation to adopt such strategies. Furthermore, loop R1 also suggests that such an increase in the validity of the learning objectives reduces the collective resistance to the curriculum change initiatives; however, such a claim warrants further investigation.

### 6.2.3 Institutional Support Loops

The institutional structures, including policies and practices of faculty and administrators, shape the environment in which faculty work and in which faculty resistance to change emerges. Institutions also create the climate in which faculty make decisions about
instructional strategies, research, and their priorities in general. The institutional support loops are related to the cultural loops in the sense that the structures, policies, and practices are also manifestations of the cultural values. Table 13, Table 14, and Table 15 show the institutional support loops of the theoretical and empirical CLDs that have direct relationship or similarities to each other.

Table 13 Institutional support loops in the theoretical and empirical CLDs (1)

<table>
<thead>
<tr>
<th>Theoretical CLD</th>
<th>Empirical CLD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Causal Loop Name</strong></td>
<td><strong>Description of Causal Loop</strong></td>
</tr>
<tr>
<td>Content Coverage (B3)</td>
<td>Balancing effect on faculty motivation caused by the reduction of the content that can be covered when adopting RBIS.</td>
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</tbody>
</table>

Table 14 Institutional support loops in the theoretical and empirical CLDs (2)

<table>
<thead>
<tr>
<th>Theoretical CLD</th>
<th>Empirical CLD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Causal Loop Name</strong></td>
<td><strong>Description of Causal Loop</strong></td>
</tr>
<tr>
<td>Class Size (B4)</td>
<td>Balancing effect on motivation caused by how faculty perceive the feasibility of adopting RBIS in courses of larger class sizes.</td>
</tr>
</tbody>
</table>

Table 15 Institutional support loops in the theoretical and empirical CLDs (3)
Another step to the adoption of RBIS is the institutional support that sustains such adoption. A comparison of the CLDs reveals the dynamics of three general policies or practices that support or hinder the adoption of RBIS: 1) the content to cover in each class, 2) the class size, 3) and the faculty workload.

First, although literature suggested that instead of covering content, instructors should use content to teach important or core principles within the discipline (Weimer, 2002). The institutional support loops highlight that professors feel a high pressure to cover the content, and sometimes that pressure makes professors decide that it is more important to cover the content than if students learn it in depth. In this case, the cost value (Wigfield & Eccles, 2000) of not covering all the content surpasses the utility value (Wigfield & Eccles, 2000) that professors put on students’ learning.

In this sense, loops B3 in the theoretical CLD and B6 in the empirical CLD (see Table 13) show that faculty could perceive that adopting RBIS reduces the content that can be covered, thus reducing the feasibility of adopting such strategies (Froyd et al., 2013; Henderson et al., 2012). In other words, if faculty believe that adopting RBIS is less useful to cover the content, they will be less motivated to innovate in their classroom (Jones, 2018). In addition, loop R2 in the empirical CLD suggests that such reduction in usefulness is also reinforced when professors include more content in the course because they observe that students have not achieved the learning objectives established in previous courses.

<table>
<thead>
<tr>
<th>Faculty Workload (B1)</th>
<th>Balancing effect on motivation caused by the increase in teaching workload attributed to the adoption of RBIS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larger Classes Workload (B5)</td>
<td>Balancing effect on motivation caused by the increase in teaching workload attributed to the growth of class size.</td>
</tr>
<tr>
<td>Practical Teaching Experience (R4)</td>
<td>Reinforcing effect that reduces teaching workload when faculty gain more experience implementing RBIS.</td>
</tr>
<tr>
<td>Teaching Workload (B12)</td>
<td>Balancing effect on motivation to adopt RBIS caused by an increase in teaching workload.</td>
</tr>
<tr>
<td>Research workload (B13) Balancing Loops</td>
<td>Balancing effect on motivation to adopt RBIS caused by an increase in research workload.</td>
</tr>
<tr>
<td>Time on activities required for promotion (B11) Balancing Loop</td>
<td>Balancing effect on faculty motivation caused by the time invested on activities required for promotion that are not aligned with the adoption of RBIS.</td>
</tr>
</tbody>
</table>
Second, loop B4 in the theoretical CLD and loop B7 in the empirical CLD (see Table 14) show that larger class sizes increase the difficulty of implementing RBIS, reduce the enjoyment that professors feel about implementing such strategies, and decrease the sense of usefulness of these strategies. Motivation theory explains that the difficulty of a task affects people’s self-concept or their ability to succeed on a task (Bong & Skaalvik, 2003), and therefore their motivation. A larger class size hinders faculty self-efficacy because it is more difficult to implement RBIS in such classes (Finelli et al., 2014; Henderson & Dancy, 2007; Prosser & Trigwell, 1997). Also, motivation theory explains that the enjoyment of doing a task increases the interest value of doing such a task (Eccles & Wigfield, 2002); therefore, professors that enjoy the experience of implementing RBIS in smaller classes are more likely to adopt these strategies (Finelli et al., 2014). Lastly, loop B7 in the empirical CLD also highlights that smaller class sizes increase the sense of usefulness of adopting RBIS because it facilitates professors’ ability to provide timely and quality feedback to students, and thus improve students’ learning (Ambrose et al., 2010).

Third, motivation theory explains that people invest time and energy in a task if they are convinced that the task deserves such time and effort because its benefits outweigh the costs (Eccles & Wigfield, 2002) and that they would be successful in that task (Bandura, 1997). Loop B1 in the theoretical CLD and Loop B12 in the empirical CLD (see Table 15) suggest that adopting RBIS has the potential cost of increasing the teaching workload. Such costs increase when faculty face larger class sizes, as described in loop B5 of the theoretical CLD. Similarly, loop B13 of the empirical CLD shows how the research workload increases, gradually reducing the available time faculty have and thus making even more costly the potential increase on the teaching workload when implementing RBIS. On the other hand, loop B11 in the empirical CLD shows that faculty perceive bigger benefits of engaging in an activity if such activity is aligned with the policies for tenure and promotion (Finelli et al., 2014); in this sense, the usefulness of adopting RBIS increases if the collective faculty value innovations in teaching and such value is reflected in the tenure and promotion process (Matusovich et al., 2014).

In essence, faculty have some degree of autonomy on making decisions about the time they invest in academic activities. Faculty will likely spend that time on activities they consider
useful and that they will be successful at. Because policies for tenure and promotion tend to err on the side of research (Feldman & Paulsen, 1999), faculty would likely increase their attention to research and grants and would likely decrease the time for teaching (Froyd et al., 2013; Litzinger & Lattuca, 2014; Matusovich et al., 2014). This may not be a fully conscious behavior but is an adaptive response to changing requirements for tenure and promotion by the institution (Tolman et al., 2016).

Nonetheless, loop R4 in the theoretical CLD suggests that the teaching workload caused by the adoption of RBIS could decrease over time. Professors gain more practical experience when adopting RBIS, thus reducing the effort to adopt such strategies (Bandura, 1997). In this sense, loop B12 of the empirical CLD indicates that professors would take advantage of this practical experience in future iterations of the same course. Thus, professors would be more motivated to adopt RBIS if their time invested in adopting RBIS is useful for reducing the workload in future courses. Conversely, if RBIS is perceived as an additional workload that would not decrease over the time, faculty would be less inclined to adopt these strategies because it would reduce the available time for the activities that move forward their promotion and tenure.

6.2.4 Student Experience Loops

The students’ experience loops illustrate the dynamics between faculty motivation and the perception that students have about their academic experience in classrooms where RBIS are implemented. Table 16, Table 17, and Table 17 show the students’ experience loops of the theoretical and empirical CLD. Comparing the student experience loops reveals three dynamics that reinforce or hinder faculty motivation: 1) students’ learning, 2) students’ resistance, and 3) students’ evaluation of teaching. First, as noted previously, the change management loops shown in Table 10 suggest that faculty motivation increases if they perceive the RBIS are useful to increase students’ engagement and learning. One particularity that make these strategies more useful is that RBIS help faculty to provide quality and timely feedback to students (see loop R8 of the empirical CLD in Table 16).

Research suggests that such feedback supports students’ motivation and learning (Ambrose et al., 2010) because it could help students early in the semester to adjust to the reality of
difficult coursework (Tolman et al., 2016), to be successful individually and at group work (Pfaff & Huddleston, 2003), and to encourage students’ positive interdependence (Johnson, Johnson, & Stanne, 2000). Motivation theory (Jones, 2009) also permits to explain that providing timely feedback in class is useful for professors because it could reduce the teaching workload of providing feedback after class (Angelo & Cross, 1993).

**Table 16 Students’ experience loops in the theoretical and empirical CLDs (1)**

<table>
<thead>
<tr>
<th>Theoretical CLD</th>
<th>Description of Causal Loop</th>
<th>Empirical CLD</th>
<th>Description of Causal Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causal Loop Name</td>
<td></td>
<td>Causal Loop Name</td>
<td></td>
</tr>
<tr>
<td>Students Learning (R5)</td>
<td>Reinforcing effect on faculty motivation driven by the identification that students learn better with RBIS than with traditional teaching strategies.</td>
<td>Quality of timely feedback (R8) Reinforcing Loop</td>
<td>Reinforcing effect on motivation to adopt RBIS caused by the possibility of providing quality and timely feedback to students.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Students’ ability to succeed in the learning activities (R3) Reinforcing Loop</td>
<td>Reinforcing effect on faculty motivation caused by the perceived ability of students to succeed in the learning activities occurring during the RBIS implementation.</td>
</tr>
<tr>
<td></td>
<td>Use of direct instruction Balancing Loop (B4)</td>
<td></td>
<td>Balancing effect on motivation to adopt RBIS caused by a misconception that direct instruction is a better alternative than RBIS.</td>
</tr>
</tbody>
</table>

**Table 17 Students’ experience loops in the theoretical and empirical CLDs (2)**

<table>
<thead>
<tr>
<th>Theoretical CLD</th>
<th>Description of Causal Loop</th>
<th>Empirical CLD</th>
<th>Description of Causal Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causal Loop Name</td>
<td></td>
<td>Causal Loop Name</td>
<td></td>
</tr>
<tr>
<td>Students’ Resistance (B2)</td>
<td>Balancing effect on faculty motivation caused by students’ resistance to RBIS implementation. Such resistance is manifested in reduction of the students’ engagement.</td>
<td>Students’ motivation and engagement in class (R4) Reinforcing Loop</td>
<td>Reinforcing effect on motivation to adopt RBIS caused by increases in students’ motivation and engagement.</td>
</tr>
</tbody>
</table>
Table 18 Students’ experience loops in the theoretical and empirical CLDs (3)

<table>
<thead>
<tr>
<th>Theoretical CLD</th>
<th>Description of Causal Loop</th>
<th>Empirical CLD</th>
<th>Description of Causal Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causal Loop Name</td>
<td></td>
<td>Causal Loop Name</td>
<td></td>
</tr>
<tr>
<td>Students’ Resistance (B2)</td>
<td>Balancing effect on faculty motivation caused by students’ resistance to RBIS implementation. Such resistance is manifested in reduction of the SET scores.</td>
<td>Figure 13 Students evaluation of teaching (R11)</td>
<td>Reinforcing effect on motivation to adopt RBIS caused by the positive evaluations of teaching.</td>
</tr>
<tr>
<td>Student Evaluation of Teaching (R6)</td>
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</tbody>
</table>

Also, loop R3 of the empirical CLD highlights that professors are more motivated to adopt RBIS if their students are able to succeed in the learning activities occurring during the RBIS implementation. Motivation theory explains that the attainment value, or the personal importance of doing well on an activity, is a factor that affects motivation (Eccles, 1983). Students’ success motivates both students and professors. Professors’ caring about students’ learning and success is a powerful factor that influences students’ academic motivation (Jones, 2009), but also such caring indicates that they are good professors. Conversely, students succeeding in the learning activities influences the cost value; if students are not succeeding in the learning activities, it means they are not learning the content, and professors would then have to invest more time to teach the content once again. The latter, as described in loop B4 in the empirical CLD, could prompt some professors to use direct instruction to cope for the lack of students’ ability even if such instruction is less effective to increase students’ non-technical skills (Prince, 2004).

Nonetheless, the dynamics in loop R3 of the empirical CLD have an underlying assumption of what professors understand as success in the learning activities. To some professors it could mean that students are able to solve the problem or make the project work. To other professors, success in the activity could mean that students are engaged with the activity and struggle with a project regardless of its outcome. These differences occur because
solving a problem does not necessarily imply that learning occurred, but students putting
the effort toward understanding or solving the problem does (Smith et al., 2005). Likewise,
students tend to perceive that success in the activity always means that they are able to
complete it (Jones, 2018). In that case, professors’ understanding of success could be
misaligned with what students perceived as success, thus reducing the students’ motivation
(Jones, 2016; Tolman et al., 2016) and ultimately reducing the faculty’s perceived
usefulness of the RBIS.

Second, faculty are more motivated to adopt RBIS if these strategies prompt students to
lower their resistance to learn. Tolman et al. (2016) defines student resistance as a
motivational state in which students reject learning opportunities caused by multiple
systemic factors. One way that students passively manifest their resistance is by
disengaging in the class. Loop B2 (see Table 17) in the theoretical model explains that such
resistance could occur because students are not familiar with the strategies, have to do more
work (Henderson et al., 2012; Seymour & De Welde, 2015), or feel less successful (Finelli
et al., 2013). Loop R4 in the empirical CLD, however, illustrates how this resistance to
learn is lowered when students are motivated and engaged because they will learn better
and enjoy the class more; this observation is consistent with the reasons why professors
would want to increase students’ academic motivation (Jones, 2016). Moreover, motivation
theory (Eccles & Wigfield, 2002) allows to suggest that professors would want students to
be engaged because it provides utility and interest value to professors. If adopting RBIS
increases students’ engagement, these strategies would provide utility value because it is
important to professors that students learn, and thus, professors would not have to re-
explain the material later because students were not paying attention. Also, they provide
utility value because by engaging students in class, professors would require less work to
help students learn. RBIS would also provide interest value because the class is more
enjoyable when students are engaged.

Third, loops B2 and R6 of the theoretical CLD and R11 of the empirical CLD (see Table
17) show that students could actively resist the adoption of RBIS by punishing professors
with lesser SET scores (Jones, 2010; Laird et al., 2008; Narayanan et al., 2014; Tolman et
al., 2016). Research on motivation (Deci & Ryan, 2000) permits us to explain that
professors would want students to be engaged and give better SET scores because they are useful and help to satisfy professors’ psychological need for competence and relatedness. If adopting RBIS is reflected in better SET scores, these strategies will be useful because they would help professors’ promotion. Also, if students are more engaged, they will perceive the professor in a more positive way and they will be more inclined to appreciate (i.e., satisfying the need for relatedness) and recognize explicitly the quality of the professor (i.e., satisfying the need for competence). Loop R11 of the empirical CLD also highlights that other informal ways for students to manifest recognition of teaching beyond the SET also reinforce the need for competence and relatedness.

6.2.5 Pedagogical Knowledge Loops

In essence, the pedagogical knowledge loops represent the dynamics between the different levels of knowledge or skills that faculty have about RBIS implementation in the classroom. Table 19 shows the loops related to experience and Table 20 shows the loops related to training.

Table 19 Pedagogical knowledge loops in the theoretical and empirical CLDs (1)

<table>
<thead>
<tr>
<th>Theoretical CLD</th>
<th>Empirical CLD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Causal Loop</strong></td>
<td><strong>Description of Causal Loop</strong></td>
</tr>
<tr>
<td>Name</td>
<td></td>
</tr>
<tr>
<td>Practical Teaching Knowledge (R3)</td>
<td>Reinforcing effect on faculty motivation caused by an increase in knowledge product of the experience gained by implementing RBIS.</td>
</tr>
</tbody>
</table>
Table 20 Pedagogical knowledge loops in the theoretical and empirical CLDs (2)

<table>
<thead>
<tr>
<th>Theoretical CLD</th>
<th>Empirical CLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causal Loop Name</td>
<td>Description of Causal Loop</td>
</tr>
<tr>
<td>Formal Training (R1)</td>
<td>Reinforcing effect on faculty motivation caused by increase in pedagogical training offered by institutions, organizations, and established networks.</td>
</tr>
<tr>
<td>Informal Training (R2)</td>
<td>Reinforcing effect on faculty motivation caused by increase in pedagogical training resultant from an emergent collaboration between faculty.</td>
</tr>
</tbody>
</table>

Loop R3 in the theoretical CLD (see Table 19) illustrates how the pedagogical knowledge increases as a result of gaining experience with the RBIS, whereas loop R5 of the empirical CLD shows how the overall experience of implementing RBIS reinforces or hinders faculty motivation. Based on motivation theory (Eccles & Wigfield, 2002), we could predict that increasing professors’ pedagogical knowledge about RBIS provides them with bigger expectancy of success when implementing these strategies, and professors would feel more confident about adopting RBIS because the more they use these strategies the more opportunities they have to build knowledge of what is effective for professors and students (Butler & Schnellert, 2012; Pascarella & Terenzini, 2005). Also, if professors have a positive experience when adopting RBIS, they would feel more confident about being successful at these strategies (Ormrod & Jones, 2015). Conversely, if they had a bad experience, their perception of themselves as a good professor (i.e., self-concept (Bong & Skaalvik, 2003)) could be affected, thus hindering their motivation to adopt RBIS.

The overall experience of implementing RBIS also impacts the trade-off between the cost and utility value (Eccles & Wigfield, 2002). As described in R5 of the empirical CLD, faculty balance the students’ learning, engagement, and content covered when designing and implementing activities in their classrooms. Faculty beliefs shape their perception if the
effort put into the adoption of RBIS (cost value) overcomes its benefits to students and professors (utility value), therefore reinforcing or hindering faculty motivation.

Another cost involved in implementing RBIS is the risk of losing self-worth (Covington, 1992) by decreasing their students’ approval or their sense of being competent. Implementing RBIS usually involves losing control over the activities (Seymour & De Welde, 2015) and raises the possibility that professors do not know the answers to the questions and queries from students (Ambrose et al., 2010). If professors often do not know the answers, students could consider the professors less competent and complain about the class. Again, when professors have more experience in these classes, they would be more comfortable acknowledging that they do not know the answers (Seymour & De Welde, 2015). Also, with more experience, professors discover similarities in the questions that students have asked, therefore lowering the risk of not knowing the answers to the questions. The risk of losing self-worth is shaped by professors’ beliefs about teaching; if they believe that a good professor is someone who should know the answers, they will fear losing control of the activities. Conversely, if they believe that a good professor is someone who provides the proper environment for students to be engaged in solving the problems or the activities, they will be more inclined to adopt RBIS.

Beliefs and knowledge about teaching could be shaped by the pedagogical training offered by institutions (Coburn, 2003; Lattuca et al., 2014). Loops R1 and R2 in the theoretical CLD and loops R9 and R10 in the empirical CLD (see Table 20) highlight that an increase in pedagogical knowledge increases the sense of self-efficacy (Bandura, 1997; Felder et al., 2011). Particularly, loop R9 in the empirical CLD emphasizes that such sense of self-efficacy increases when faculty consider it less difficult to implement RBIS (Litzinger & Lattuca, 2014; Matthew-Maich et al., 2007; Matusovich et al., 2014). Motivation theory (Deci & Ryan, 2000) also allows to infer that pedagogical training helps to satisfy professors’ psychological need for autonomy when professors voluntarily seek such training. Pedagogical training also impacts professors’ cost and utility value (Eccles & Wigfield, 2002) because they would need to invest time in learning about RBIS, time that could be more useful in activities required for their promotion and tenure.
6.3 Implications

The results of my study have implications both for research and educational practice. Implications for research involve the use of system thinking for further study of educational systems and problems. Implications for practice include leverages resulting from the creation and analysis of the theoretical and empirical CLD.

6.3.1 Implications for Research

The research presented in my dissertation has general implications for research on education. Particularly, but not exclusively, research on issues germane to change in academia. I argue that a great direction for future research in engineering and higher education is to understand from a systems thinking perspective the problems traditionally addressed in our field. Systems thinking understands two types of complexity: detail complexity referring to the existence of many elements in the system, and dynamic complexity referring to the existence of feedback mechanisms, interdependence of elements, nonlinearities, and delays between causes and effects (Sterman, 2000). Most social and human systems, and thus their problems, are typically complex, not only because of their massive number of details but for their extreme dynamic complexity (Senge, 1990). Therefore, using techniques that deal with complexity can be an improvement for education management, practice, and research.

This dissertation is an example of how we can understand an education problem using one such technique (i.e., SDM) created in the industrial and systems engineering field. Although studies of systems and complexity are not exclusive to engineering disciplines, engineering has fully developed tools, techniques, and technologies to design and manage complex systems (Senge, 1990). I argue that using such techniques and technologies will allow us to understand and solve more complex social problems like students’ resistance to learning (Tolman et al., 2016).

My argument of the need for using systems thinking in education research does not try to discredit the deep research that has been done in education and social sciences. On the contrary, we can enhance such research by going beyond the single or linear cause-and-
effect relationships of the problems by understanding better the underlying structures of educational systems, and most importantly, by providing alternative explanations to why conventional solutions have failed before. There are multiple education problems for which a linear perspective is perfectly adequate, but many of these problems have not been solved. Similarly to instructional change in engineering education, which has been needed since the beginning of the last century, many old traditional problems could benefit from a systems perspective to find new solutions.

Using systems thinking (or SDM) in education research can seem overwhelming and may be impractical because humans have cognitive limitations and human systems seem tremendously complex. However, even a thorough process of finding causal loops in a complex system will be inherently incomplete to describe all the relevant dynamics. My experience in this dissertation allows me to postulate that using a systems perspective is a way of thinking rather than a problem-solving methodology. It was hard to start thinking about complex systems and create a whole research process about them; but as with many automated actions, we deal with multiple details and dynamic complexities in our daily life and work (e.g., going through graduate school, managing the household, or teaching to a diverse group of kids). We would not be using systems engineering in our research from scratch, as exemplified in this dissertation; using a systems perspective could involve the use of qualitative, quantitative, and mixed methods that have a detailed complexity as its nature. Changing our mindset toward systems thinking will take time, but it will get increasingly easier.

6.3.2 Implications for Practice

The research presented in my dissertation also has general implications for practice in the area of instructional change. In particular, this research is another step toward building a unifying theory of transfer research in education into actual instructional practices because it describes a structure of the academic system that affects faculty motivation to adopt RBIS. From this structure, we can better understand the behaviors of the factors involved and their policy implications on faculty motivation.
Such behaviors are shown in the feedback loops on each CLD. The analysis of the CLDs can explain potential unintended consequences of decisions and policies, possible sources of resistance to instructional change initiatives in academia, and, most importantly, how to improve the behavior of the academic system by small actions (called “leverages” or “leverage points” (Senge, 1990)) that have high impacts on enhancing the loops that reinforce faculty motivation and reducing the impact of loops that hinder it. In Chapter 4, I detailed policy implications that emerged from the analysis of the theoretical CLD, whereas in Chapter 5, I detailed the implications that emerged from the analysis of the empirical CLD. In these chapters, the policy implications suggested were potential leverages that could create significant improvements in the adoption of RBIS. These leverages were not exhaustive and were suggested as starting points. In this section, I summarize such leverages per each category of factors that affect change.

**Pedagogical knowledge factors:** The first leverage is the implementation of formal pedagogical training focused on two aspects: 1) the pedagogical tenets that explain why RBIS work. It will reduce the difficulty to access and discern the research that validates such strategies, and will reduce the apprehension that faculty could have about learning new instructional approaches; and 2) the quality of the adaptation of the RBIS to the individual faculty context by supporting the transition to RBIS and understanding that to stabilize such a transition it would take more than one iteration of the course.

**Cultural factors:** The second leverage is the department head commitment to teaching innovations and her support for building and sustaining local communities of practice. Such actions will encourage faculty to put a higher value on teaching. Therefore, proper RBIS adoption would be reflected positively during the peer review process for tenure and promotion.

The third leverage is to increase the awareness that good SETs not only depend on the students’ grades and performance but on a smaller class size, a difference in course levels, and higher students’ motivation. Increasing this awareness will reduce the association of the adoption of RBIS with an increase in permissiveness.
The fourth leverage is to increase the perceived validity of the learning objectives. Such perception directly affects the beliefs professors have in regard to the change process. To increase this validity, we need to 1) ensure that professors understand and recognize the objectives’ usefulness; 2) ensure the objectives reflect what students know at the beginning and at the end of the courses; 3) ensure professors know how to assess the objectives; and 4) coordinate constructive discussion between faculty related to the objectives, because during the change process the objectives are not stable and some of them might not be feasible.

**Institutional support factors:** The fifth leverage is to set a limit on class size and favor faculty autonomy in their teaching practice to facilitate maintaining effective interactions and engagement with students, and to reduce teaching workload.

**Change management factors:** The sixth leverage is to manage the sense of urgency by establishing and constantly assessing and communicating the vision and goals of the change initiative. Such vision and goals should be shared by the community and advocate for multiple instructional strategies.

The seventh leverage is to put in place proper measurements of the course objectives without increasing the time commitments of the professors by embedding the measurements in the learning activities or having independent teams to analyze the assessment.

The eighth leverage is to create a reference model that regulates the change process. This model would give feedback to professors about the effects of the decisions in their courses, increase the quality of the adjustments at the program and course levels, and avoid adjustments that are made sooner or later than appropriate.

The last leverage is to minimize the delays and the propagation of effects to improve the systems’ performance. This can be done by reducing the content to cover in the courses and leave enough room in the syllabus to adjust the content as required by the particular circumstances of the course, or intentionally create overlaps in the topics covered in each course.
6.3.3 Summary of Implications

In summary, the results of my dissertation have implications in the areas of research and practice. The implications for research are products of the system dynamics method used in this investigation and the implications for practice are the leverages resulting from the creation and interpretation of the theoretical and empirical CLDs.

6.4 Future Work

From the current study, I suggest three areas of future work: 1) Enhance the theoretical model with the loops found in the empirical CLD, 2) Provide support for the implementation of a faculty development program at the site where I built the empirical CLD, 3) modelling other possible sources of resistance to change, 4) simulating the effect of instructional change policies in the short and long term, and 5) applying the results of such models to faculty development programs. These areas are iterative processes of creating a System Dynamics Model for simulation and implementation. I discuss each of these suggestions in the following paragraphs.

First, as noted, the similarities between the CLDs suggest that some modifications in the theoretical model with the inclusion of few additional loops would likely be a comprehensive model useful in understanding different academic systems and their influence in faculty motivation to adopt RBIS. This will constitute a further step in the construction of a comprehensive theory of transferring research to practice.

Second, the empirical CLD showed some leverages that could be implemented in the site where the CLD was built. Such site needs a faculty development program that help them to sustain the change efforts and tackle the new challenges they are facing. I am able to provide support to design and evaluate such program. I started to disseminate the results of this research with faculty and administrators of the site and we can work on a proposal to adopt the conclusions of this study. It is worth noting that a proper faculty development program is not focused only on increasing the faculty pedagogical knowledge but also on other factors of the academic system.
Third, other possible sources of resistance can be obtained by developing CLDs from other engineering departments. This would increase the validity and would add depth to the theoretical CLD. The proposed method is similar to the one followed here for the construction of the empirical CLD. Some of these CLDs could be exploratory, that is, they could be created without using the theoretical CLD. Others could be explanatory, that is, using the theoretical CLD as a base to discuss and add depth to the feedback loops.

Fourth, to simulate the effect of instructional change policies, this research can be expanded to produce a simulation SDM that includes quantitative data collection and analysis from stakeholders of different institutions. A simulation SDM requires proper definition and assessment of each of the variables of some of the loops, gathers historical data from the institutions, elicits behaviors of the variables from the experiences of faculty and administrators, and follows validation procedures of the dynamics in the simulation model.

Finally, applying the results of the SDM to faculty development programs requires a discussion and implementation of some of the leverages described in this dissertation. The first step to this idea is to disseminate the results of this study with faculty and administrators of the center of teaching and learning from the institution where I will be working in the near future. I am committed to studying and promoting favorable systemic conditions for faculty to adopt changes in their instruction.

6.5 Concluding Remarks

I developed this research study with the aspiration of better understanding why the typical strategy used in engineering classes is still lecture despite the multiple calls for instructional change since the beginning of the last century, the overwhelming results of research on education that states that RBIS are better for students’ learning, and the multiple external factors that demand change in engineering education. My biggest argument is that although there have been multiple initiatives in engineering schools to change instructional strategies, the low success of these initiatives can be explained by our underestimation of the complex nature of academia and its effect on faculty motivation. Faculty ultimately are the people who would be enacting and sustaining that change.
The study I completed found what many already know intuitively: that instructional change is more likely to occur and be sustainable when professors are willing to make that change, and academic units are consistently supporting it. However, what many do not know is that encouraging change entails systemically understanding how the system itself promotes or hinders such change. There are no rules of thumb or standard policies that motivate faculty to change. Motivating faculty is not a problem that can be solved only with development programs that externally encourage faculty to experiment with new techniques and to take risks on their instruction. Instead, such development programs have to take into account the dynamic complexity of academia. Instructional change will not likely occur if we do not modify internal factors of the system that interact dynamically and ultimately present barriers to professors to sustain that change. The System Dynamics Model I offered in this dissertation explains the interactions of the factors in the academic system that influence faculty motivation to adopt RBIS.

I offered several options, in the form of *leverages*, that can potentially lower the resistance to change in instruction and reinforce the motivation to adopt and sustain RBIS. Many of these leverages are related to the success and value beliefs of faculty. Any factor that diminishes faculty success and value beliefs will tend to be avoided. As humans, we tend to be persistent with what we are familiar with, what we value, and what we are comfortable doing, and we are naturally reluctant to try something new. To avoid this reluctance, faculty need to perceive personal benefits when implementing RBIS because it will ultimately have costs in time, in effort, in recognition, in students’ resistance, or in workload. While changing the “reward system” is not a sufficient condition for faculty motivation, it is certainly a necessary one because such costs could be invested in activities that provide benefits to faculty that are not aligned with the adoption of RBIS. In the end, thousands of other students have done just fine in traditional courses. So, why change? In short, the answer to this question is that the system will ultimately motivate them to change, or not.

I intended to answer this question in depth. I am confident that the conceptual System Dynamics Model of adoption of RBIS in the classroom effectively captures the multiple dynamics that affect faculty motivation to change. While I cannot prove that all the important dynamics are captured in the model due to the exploratory nature of my study, I
developed the model in a way that advances our understanding of our academic systems and how they could promote change. I plan to evolve this work and to continue advancing the scholarship of instructional change. I hope that other researchers and practitioners will join me on this journey.
REFERENCES


Mehra, B. (2002). Bias in qualitative research: Voices from an online classroom. The qualitative report, 7(1), 1-19.


Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). Qualitative data analysis: a methods sourcebook: Los Angeles, CA,[etc]: SAGE.


# APPENDIX A. CATEGORIES OF FACTORS THAT AFFECT INSTRUCTIONAL CHANGE

<table>
<thead>
<tr>
<th>Categories and Definition</th>
<th>Subcategories</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Culture:</strong> Related to the cultural elements that give meaning and drives to take actions. Those elements are shared among members of a culture and transmitted to new members.</td>
<td>Symbols &amp; artifacts</td>
<td>Heavy workload (Finelli et al., 2014; Pembridge &amp; Jordan, 2016)</td>
</tr>
<tr>
<td></td>
<td>Attitudes</td>
<td>Ignoring reality of the environment of the instructors (Finelli et al., 2014; Litzinger &amp; Lattuca, 2014) (inner) Resistance to change (Finelli et al., 2014) Collegial trust (Matthew-Maich et al., 2007)</td>
</tr>
<tr>
<td></td>
<td>Beliefs</td>
<td>Faculty beliefs (mental models) (Matusovich et al., 2014) (Cooper et al., 2000) Feelings of incompetence because traditional practices are challenged (Litzinger &amp; Lattuca, 2014)</td>
</tr>
<tr>
<td></td>
<td>Assumptions</td>
<td>Faculty trust on educational data (Finelli et al., 2014) (Handelsman et al., 2004) Assumption that traditional teaching is meeting the goals (Dancy &amp; Henderson, 2010) (Cooper et al., 2000; Kezar, 2014)</td>
</tr>
<tr>
<td></td>
<td>Values</td>
<td>Lesser importance on students’ deep approach to learning (Litzinger &amp; Lattuca, 2014) More value to create new pedagogical methods vs transfer to practice (Litzinger &amp; Lattuca, 2014) Value placed on innovation by administrators (Matusovich et al., 2014) Pressure to fulfill expectations of publishing and gain funding (Matusovich et al., 2014)</td>
</tr>
<tr>
<td><strong>Process Management:</strong> Factors related to the management of the change process.</td>
<td>Vision</td>
<td>Common vision of change (Litzinger &amp; Lattuca, 2014)</td>
</tr>
<tr>
<td></td>
<td>Goals</td>
<td>Advocacy for only a single practice instead of multiple practices (Litzinger &amp; Lattuca, 2014) Goals of the change process (Henderson &amp; Dancy, 2007; Kezar, 2014; Pembridge &amp; Jordan, 2016)</td>
</tr>
<tr>
<td>(Research Based) Process Design</td>
<td>Research methods of change needed for adoption (Litzinger &amp; Lattuca, 2014) Sustainability of implementation (Kezar et al., 2015) Articulation or coordination (Dancy &amp; Henderson, 2010) Implicit views of change (Kezar et al., 2015), Explicit views of change (Kezar et al., 2015)</td>
<td></td>
</tr>
<tr>
<td><strong>Student Experience:</strong> Factors associated with the student’s experience in classrooms where RBIS are implemented.</td>
<td>Students’ Resistance</td>
<td>Student resistance (Dancy &amp; Henderson, 2010; Henderson &amp; Dancy, 2007; Kezar et al., 2015) (Cooper et al., 2000)</td>
</tr>
<tr>
<td></td>
<td>Students’ Evaluation of teaching</td>
<td>Student perceptions of the class (Ambrose et al., 2010; Finelli et al., 2014; Henderson &amp; Dancy, 2007) Students’ evaluation of teaching (Cooper et al., 2000)</td>
</tr>
<tr>
<td></td>
<td>Improvement on students’ learning</td>
<td>Improvements in student learning (Finelli et al., 2014; Kezar et al., 2015) Ambrose et al. (2010)</td>
</tr>
<tr>
<td></td>
<td>Evaluation of students’ learning</td>
<td>Students’ learning evaluation (Cooper et al., 2000)</td>
</tr>
<tr>
<td>Categories and Definition</td>
<td>Subcategories</td>
<td>Factors</td>
</tr>
<tr>
<td>--------------------------</td>
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</tr>
</tbody>
</table>
| Faculty Motivation: Factors directly associated with the faculty motivation to adopt RBIS. | Empowerment | Faculty Rank (Cross et al., 2016; Dancy & Henderson, 2010; Matusovich et al., 2014)  
Autonomy (Bouwma-Gearhart et al., 2016; Cross et al., 2016; Fowler et al., 2016)  
Self-Regulation (Feldman & Paulsen, 1999)  
Novice faculty’s experience (Dancy & Henderson, 2010; Kezar et al., 2015)  
Faculty integration of service, teaching, and research (Bouwma-Gearhart et al., 2016) |
| | Value | Perception that RBIS increases value in students (Abrami et al., 2004; Ambrose et al., 2010; Cooper et al., 2000; Cross et al., 2016; Dancy & Henderson, 2010; Kezar et al., 2015)  
Certainty of the benefit of RBIS (Ambrose et al., 2010; Dancy & Henderson, 2010; Matthew-Maich et al., 2007) |
| | External Motivation | Reward systems (Feldman & Paulsen, 1999; Finelli et al., 2014; Kezar, 2014)  
Financial incentives (Finelli et al., 2014; Kezar et al., 2015)  
External Value (Kezar et al., 2015) |
| | Cost Benefit Balance | Cost to implement (Abrami et al., 2004; Dancy & Henderson, 2010)  
Uncertainty of the benefits of the change process (Cross et al., 2016; Fowler et al., 2016)  
Potential time savings when adopting RBIS (Finelli et al., 2014; Pembridge & Jordan, 2016)  
Increasing time commitments when adopting RBIS (Cooper et al., 2000) |
| | Success | Evidence of the practice’s effectiveness (Ambrose et al., 2010; Cross et al., 2016)  
Teaching evaluations (Finelli et al., 2014),  
Performance evaluation and feedback (Borrego & Henderson, 2014; Feldman & Paulsen, 1999) |
| | Self-Efficacy | Competence beliefs (Litzinger & Lattuca, 2014; Matthew-Maich et al., 2007; Matusovich et al., 2014)  
Self-confidence to effectively use RBIS (Abrami et al., 2004; Ambrose et al., 2010; Pembridge & Jordan, 2016)  
Self-confidence in faculty’s abilities (Finelli et al., 2014)  
Perceived success of innovation (Abrami et al., 2004; Matusovich et al., 2014)  
Apprehension for drastic change (Fowler et al., 2016) |
| | Interest | Believe that faculty can make an impact (Finelli et al., 2014)  
Compatibility with past experiences and faculty needs (Litzinger & Lattuca, 2014)  
Interest in their own abilities (Finelli et al., 2014),  
Creating awareness and interest (Borrego & Henderson, 2014; Matusovich et al., 2014)  
Compatibility and personal connection with the RBIS (Litzinger & Lattuca, 2014; Matusovich et al., 2014) |
| Pedagogical Knowledge and Skills: Factors related to the | Awareness | Understanding of educational concepts (Ambrose et al., 2010; Fowler et al., 2016)  
Sheer number of RBIS (Ambrose et al., 2010; Litzinger & Lattuca, 2014) |
<table>
<thead>
<tr>
<th>Level of knowledge or skills that faculty has about RBIS.</th>
<th>Awareness about RBIS (Dancy &amp; Henderson, 2010; Finelli et al., 2014), (lack of) (Handelsman et al., 2004) Access to RBIS (Ambrose et al., 2010; Dancy &amp; Henderson, 2010) Apprehension about learning new approaches (Finelli et al., 2014) (Handelsman et al., 2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Familiarity</td>
<td>Adapting the practice (Litzinger &amp; Lattuca, 2014) Familiarity with research-based teaching practices (Ambrose et al., 2010; Finelli et al., 2014)</td>
</tr>
<tr>
<td>Expertise</td>
<td>Adopting the strategy (Ambrose et al., 2010; Dancy &amp; Henderson, 2010) Understanding why RBIS works (Ambrose et al., 2010; Litzinger &amp; Lattuca, 2014) Expertise to develop improved teaching methods (Borrego &amp; Henderson, 2014)</td>
</tr>
<tr>
<td>Institutional Support: Factors associated with the institutional support to adopt RBIS.</td>
<td>Institutional Policies</td>
</tr>
<tr>
<td></td>
<td>Available Resources and Infrastructure</td>
</tr>
<tr>
<td>Structures and Procedures</td>
<td>Instructional Training</td>
</tr>
<tr>
<td></td>
<td>Flexibility of Curriculum</td>
</tr>
<tr>
<td>Network</td>
<td>Emergent</td>
</tr>
</tbody>
</table>
The opportunity to engage with others (Cross et al., 2016; Finelli et al., 2014)

| Coordination of activities | Collegial and administrative support (Feldman & Paulsen, 1999; Finelli et al., 2014)  
Coordination of change with colleagues (Dancy & Henderson, 2010)  
Support during trial stage (Borrego & Henderson, 2014; Cooper et al., 2000)  
Mentoring from senior colleagues (Austin, 2011; Henderson et al., 2011; Matthew-Maich et al., 2007) |
| Prescribed | Highly structured and specific interventions developed by change agents to be used by others (Borrego & Henderson, 2014),  
Support from institutional leadership (Feldman & Paulsen, 1999)  
Educational developer consultant that helps to develop the process (Fowler et al., 2016)  
Department leadership role (Kezar et al., 2015; Matusovich et al., 2014)  
Community leaders (Borrego & Henderson, 2014) |
APPENDIX B. INTERVIEW PROTOCOL

Date: _______________________ Hour: ________________ Location: ______________

Roles: Interviewer: ________________

Interviewee: _________________________________________

First Section

This section will consist of open-ended questions related to identifying the factors and reasons that positively and negatively affect their motivation to adopt RBIS.

The interviewer will introduce the objective of the project, the interview process, and the expected outcome of the interview. The interviewer will emphasize that several questions might prove difficult and that it is expected that he or she may not have all the answers.

First, a discussion about RBIS and what they represent to the interviewee. A familiar term identifiable to RBIS will be used for this interview (e.g., active learning, PBL, student centered approach, group work collaborations, teaching innovations).

From your own experience or perspective, we are going to list and discuss the academic system’s factors that are promoting or hindering your willingness to implement RBIS in your courses.

Typically, RBIS are not commonly used in engineering, or the most common teaching practice is traditional lecturing. Why do you think this situation persists?

Faculty pedagogical knowledge.

Do you implement RBIS? Never, sometimes, often, Always.

Do you think faculty implement RBIS? Never, sometimes, often, Always

Which percentage of your class time is used in RBIS?

What is your level of expertise about RBIS? Aware, familiar, expert? Please explain.

What is the faculty level of expertise about RBIS? Aware, familiar, expert? Please explain.

Have you participated in activities intended to increase your knowledge or skills about RBIS? Please describe them.

Do you think they favor RBIS implementation in your case? Why?

Have faculty participated in these activities? Never, sometimes, often, regularly?

Do you think the activities favor RBIS implementation for all faculty? Why?
Institutional support

Please describe the support provided from your institution to implement or adopt RBIS.

In terms of structures:

What structures are in place to support RBIS adoption?

What are the resources or infrastructure related to RBIS implementation?

What are the policies for training related to RBIS implementation?

Does the content favor the RBIS implementation? Why?

Does the timing and sequence of the instruction favor the RBIS implementation? Why?

Does the time allowed favor the RBIS implementation? Why?

In terms of networking and community:

Are there activities intended to create community of practices (working collaboratively around teaching)? are these activities coordinated?

How consistent is this support? Please explain

Is it effective, accessible or enough? Please explain

Cultural:

Do faculty value RBIS adoption? Why?

What is faculty or the institution assuming about RBIS? Are they favorable to RBIS adoption? Why?

What are the collective beliefs, symbols or attitudes of your academic institution regarding RBIS? Are they favoring RBIS adoption? Why?

Students experience:

How students perceive their academic experience in classrooms where RBIS are implemented?

Do you think they favored it? Resist it? Why?

Do you think implementation RBIS improves their learning? Please explain
Change management:
How is the institution managing the RBIS adoption?
Do you think there is a vision or mission for the RBIS adoption? Please explain
Do you think there are goals for the RBIS adoption? Please explain
Do you think the RBIS adoption is assessed? Please explain

Faculty motivation: based on Jones (2009)

Empowerment
Do you feel that you have control over some aspects of the RBIS adoption?
Do you feel that faculty have control over some aspects of their RBIS adoption?
Do you have choices about what you can do?
Do faculty have choices about what they can do?
Do you believe that faculty is empowered to adopt RBIS? Are they obligated or manipulated to do so?

Usefulness
Do you believe that adopting RBIS is useful? To whom? In which sense?

Success
Do you believe that the expectations of adopting RBIS are clear? Why?
Is RBIS adoption challenging to faculty? Are these challenges too easy or too difficult? Why?
Do you receive any type of feedback about the success of your teaching? Please elaborate.

Do you believe that you can succeed implementing RBIS? Why?
Do you believe that faculty can succeed implementing RBIS? Why?

Interest
Do you feel interested in adopting RBIS?
Do you feel faculty is interested in adopting RBIS?

Caring
Does the institution care about whether you implement RBIS or not? Why?

Does the institution care about faculty success at implement RBIS? Why?

Does the institution care about your teaching? Why?

**Second Section**

*This section will focus on building a CLD with the interviewee. The interviewer will briefly explain the process of constructing a causal loop and the basic notation.*

What, in your opinion, constitutes the most important aspects with regard to RBIS adoption?

*From the previous responses, the interviewer will select a factor for the next questions. The factor selected must be in a way that can be explained as a variable that increases or decreases.*

Assuming that all other variables in the system are static:

which do you think are the direct causes for the increase of such variable? Why?

Or which other variables will increase such variable?

Which do you think are the direct consequences for the increase of such variable? Why?

*For each new variable, the questions will be repeated until a loop is found.*

Does this loop make sense to you? Why, or what needs to change in this loop to make sense to you?

Does it explain a clear story that relates to a personal experience? Please elaborate

What aspects can be distinguished about the increase or decrease in motivation to adopt RBIS?

This section will be repeated to elicit at least three causal loops.
APPENDIX C. GMB PROTOCOL

Date: _______________________ Hour: ________________ Location: ______________

Number of participants: __________

Roles: Facilitator and modeler: ________________

Process and content coach: ________________________________

Recorder: ________________________________

Gatekeeper: ________________________________

Notes: This protocol is Based on Luna-Reyes et al. (2006).

The modeler should be knowledgeable of the subject matter and will focus on drawing the model and aid in preventing the group from developing a one-sided view of the problem.

The facilitator will ask the questions, guide the group discussion, maintain the flow of the conversations, and take notes on the white board to keep track of the so-called group memory.

The content and process coach will focus on the group process and dynamics, he or she will observe the group and help the facilitator to identify strategies to keep the group effective.

The recorder should take notes that can be used to keep discussion on track and make the final report.

The gatekeeper will be one of the Department’s administrators interested in solving the problem focused on motivating the participants to engage in the group activity.

First section

1. The facilitator introduces the concepts of system dynamics and causal loops with a simple and known example.

2. The facilitator presents the problem to model (to increase the faculty motivation to adopt RBIS).

3. The facilitator asks the group to identify (individually and then collectively) as many problem-related variables (factors) as possible. The facilitator will show the categories of factors that affect instructional change to help them generate ideas and to focus the conversation. The question to motivate the activity is: What are the key variables affecting faculty motivation to adopt RBIS?

4. The facilitator will ask the group to discuss why these variables are important.

5. The facilitator will prioritize and organize the variables according to group consensus. Then the variables will be organized around the 5 categories of factors. The facilitator will make sure that the definition of each variable is clear to the group.

Second Section
6. For each category of loops, the facilitator will present the different causal loops on the CLD created in the interviews. These loops will be previously organized using the categories of the theoretical model.

The group will be asked to discuss and critic the presented causal loops.

Do they make sense to the group?

Do they explain a clear story that relates to a personal experience?

Are there other variables that they consider better explained these loops or extend their narrative?

The recorder will keep track of the group suggestions, discussions, other variables mentioned, and critics of the loops.

If the loops elicited in the interviews have contradicting narratives, the facilitator will prompt the participants to reach an initial consensus of which narrative makes more sense to the group.

The purpose of this step is not to reach consensus of the final causal loop yet, but to brainstorm ideas.

7. Each member of the group will be asked to relate the key variables of each category within the presented causal loops. This activity is individual. These relations will be aimed to find causal relationships.

From the list of variables, which one do they think causes any of the variables in the loop?

Which one do they think is caused by any of the variables in the loop?

What are the explanations for each link?

8. After each individual draw the relationships or links, the modeler will combine each response into one diagram which will be presented to the group. The facilitator will ask the group to discuss, explain, critic and agree with each new connection. The recorder will make sure that the comments, suggestions and critics that were discussed in step 6 are included. When the group reach a consensus (Do they explain a clear story that relates to the group experience?), the facilitator will present the next group of causal loops found in the interviews and repeat steps 6 to 8.

This second section ends when the group agrees that the model “tells a complete story”.

7. Summary and reflection

a. The facilitator and recorder will present a structured reflection of the group thinking process, show the loops, and a summary of the stories told by the group.

b. The group gives permission to use this new model as the basis for theory development.

c. The facilitator will ask the participants perceptions of the validity of the current CLD. can the model be used to identify new policies? can it be used to capture new conditions, such as different causes of the problem, or unexpected consequences? Has this model enriched the participants’ knowledge of the system?
# APPENDIX D. CODE BOOK

<table>
<thead>
<tr>
<th>Categories</th>
<th>Code</th>
<th>Description</th>
<th>includes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symbols and artifacts</td>
<td>The rituals, traditions, events or historical representations of the organizational culture.</td>
<td>Heavy workload</td>
<td>The curriculum or instructional change initiative as a symbol(^7)</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Attitudes</td>
<td>The perceived institutional attitudes towards faculty and the faculty attitudes toward change.</td>
<td>Ignoring reality of the environment of the instructors (inner) Resistance to change</td>
<td>Colleagual trust</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Risk attitudes (aversion, neutral, seeking) *</td>
</tr>
<tr>
<td>Beliefs</td>
<td>The mental models that faculty share about teaching.</td>
<td>Faculty beliefs (mental models)</td>
<td>Feelings of incompetence because traditional practices are challenged</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Beliefs on what is considered good teaching*</td>
</tr>
<tr>
<td>Assumptions</td>
<td>The predefined interpretations or meanings towards academic activities.</td>
<td>Faculty trust on educational data</td>
<td></td>
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<td>Assumption that traditional teaching is meeting the goals</td>
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<td>Assumption that a particular RBIS does not work</td>
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<td>Assumptions that traditional methods are not working</td>
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<td></td>
<td></td>
<td>Generational gap*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The assumption that how faculty learned is how students learn</td>
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<td>Previous learning experiences (how they were taught)</td>
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<td>(Dis)trust on what is in the syllabus is actually taught or learned*</td>
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<td>(Dis)trust on the rubrics*</td>
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<td>Values</td>
<td>The different collective importance or reputation that faculty and administrators attribute to the academic activities.</td>
<td>Lesser importance on students´ deep approach to learning</td>
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<td>More value to create new pedagogical methods vs transfer to practice</td>
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<td>Value placed on innovation by administrators</td>
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<td>Pressure to fulfill expectations of publishing and gain funding</td>
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<td>Balance between value given to teaching and scholarship</td>
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<td>Value on traditional practices*</td>
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<td>Value that other colleagues put on the professors´ teaching or vice versa*</td>
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<td>Social pressure or colleagues’ feedback*</td>
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<td>Value on developing non-technical skills*</td>
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</table>

\(^7\) Added during analysis of the empirical CLD
<table>
<thead>
<tr>
<th><strong>Change Management:</strong></th>
<th><strong>Vision</strong></th>
<th>A picture of the future communicated to stakeholders that helps clarify the direction in which an organization wants to move.</th>
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</thead>
<tbody>
<tr>
<td>Factors related to the design and management of the change process itself.</td>
<td>Common vision of change</td>
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<tr>
<td><strong>Goals</strong></td>
<td>The milestones to fulfill the vision.</td>
<td>Advocacy for only a single practice instead of multiple practices</td>
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<td></td>
<td>Goals of the change process</td>
<td>Clarity of the short-term goals, like clarity of the learning outcomes*</td>
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<tr>
<td><strong>Evaluation</strong></td>
<td>The assessment and interpretations of the instructional change process.</td>
<td>Evaluation and assessment</td>
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<td>Collection of evidence of success</td>
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<td>Documentation of evaluation of practices</td>
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<td>Evaluation of implementation</td>
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<td>Comprehensiveness of the rubrics*</td>
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<td>Indications of How to use the rubrics and its purpose.</td>
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<tr>
<td><strong>Institutional Support:</strong></td>
<td><strong>Institutional Policies</strong></td>
<td>The norms and rules of the institution about tenure, promotion, service and teaching.</td>
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<tr>
<td>Factors related to the formal institutional support to the change initiative.</td>
<td>Institution type and research emphasis</td>
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<td>Departmental norms</td>
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<td>Direct command of use of instructional strategies*</td>
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<td>Institutional policies about tenure and promotion</td>
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<td>Weight put on teaching evaluations for tenure and promotion*</td>
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<td>Weight put on teaching performance for tenure and promotion*</td>
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<td>Alignment of the reward structures</td>
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<td>Consistency: Nominal but not real support from the department</td>
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<td>Communication with the supervisor*</td>
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<td>Teaching load*</td>
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<tr>
<td><strong>Structures and Procedures</strong></td>
<td><strong>Available Resources and infrastructure</strong></td>
<td>The Institutional resources, the allocation of those resources and the physical infrastructure.</td>
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<tr>
<td></td>
<td>Availability of physical resources, Teaching assistant’s requirements</td>
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<td>Physical classroom</td>
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<td>Resource allocation, logistics</td>
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<td>Class size</td>
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<td><strong>Instructional training</strong></td>
<td>The support resources directed to enhance the faculty’s pedagogical knowledge.</td>
<td>Implementation procedures</td>
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<td>Faculty development programs</td>
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<td>Simulation of activities</td>
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<td>Description of innovation</td>
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</table>
| ****Open Codes
| **Content training** | The acquisition of more disciplinary knowledge by research or formal and informal training in the technical content of the course. This includes training in professional skills like communication, teamwork, negotiation and project management | Knowledge about the curriculum, pre-requirements, objectives of other courses* Time for research*
| **Flexibility of Curriculum** | The flexibility of timing, content and sequence of the instruction. | Expectations of content coverage Requirements for teaching, expected strategies*
| **Content structure** | The type of content and structure of the course | Course syllabi and content structure Type of concepts (threshold concepts, abstract concepts)*
| **Time Dedication** | The time allotted and dedicated to adopting the change initiative. | Time for implementation Difficulty to cover content when using RBIS Time for preparation Time for learning RBIS
| **Emergent** | Conditions for networking and community development which naturally arise from faculty. | Community of practice Self-organizing groups Participation in faculty learning community The opportunity to engage with others
| **Prescribed** | Conditions for networking and community development which are designated by administrators and leaders. | Highly structured and specific interventions developed by change agents to be used by others Support from institutional leadership Educational developer consultant that helps to develop the process Department leadership role Community leaders
| **Coordination of activities** | The coordination of change initiative activities among change agents, faculty, administrators and staff. | Collegial and administrative support Coordination of change with colleagues Support during trial stage Mentoring from senior colleagues

** Open Codes
<table>
<thead>
<tr>
<th>Pedagogical Knowledge and Skills: Factors related to the level of knowledge or skills that faculty have about RBIS.</th>
<th>Awareness</th>
<th>The consciousness that faculty have about the existence and characteristics of different RBIS. (but don’t apply it)</th>
<th>Sheer number of RBIS Awareness about RBIS, (lack of) Access to RBIS Apprehension about learning new approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Familiarity</td>
<td>The understanding of the educational concepts behind RBIS and those concepts’ effect on students’ learning. (is trying to apply it, experiment with the RBIS, trial and error, unsure of its functionality or why it works or if it works better)</td>
<td>Understanding of educational concepts Adapting the practice Familiarity with research-based teaching practices</td>
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<tr>
<td></td>
<td>Expertise</td>
<td>The accumulated knowledge of the RBIS that effectively improves faculty teaching methods. (intentional application with clarity of the pedagogical tenets of the RBIS)</td>
<td>Adopting the strategy Understanding why RBIS works Expertise to develop improved teaching methods</td>
</tr>
<tr>
<td>Students’ Experience: Factors related to how students perceive their academic experience in classrooms where RBIS are implemented.</td>
<td>Improvement on students’ learning</td>
<td>The perception of the improvement that RBIS has on student’s learning.</td>
<td>Improvements in student learning</td>
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<tr>
<td></td>
<td>Evaluation of student’s learning</td>
<td>The assessment of the students’ performance.</td>
<td>Students´ learning evaluation Discrepancy between the expected results and the actual results* Rubrics (instruments) employed Comprehensiveness of the rubrics Quality of feedback</td>
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<td>Students´ resistance</td>
<td>The students´ resistance to engage in classrooms where RBIS are implemented.</td>
<td>Student resistance</td>
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<td>Students´ evaluation of teaching</td>
<td>The feedback and evaluation that students provide to the instructors and their instruction.</td>
<td>Students´ perceptions of the class students´ evaluation of teaching</td>
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<td></td>
<td>Students´ quality**</td>
<td>The students´ characteristics like previous concepts learned, academic preparation, positive attitude to learn.</td>
<td>possibilities of what students can do*</td>
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<td></td>
<td>Improvement on students´ motivation and engagement**</td>
<td>The students’ motivation and engagement in class</td>
<td>Academic Motivation* Students´ Engagement*</td>
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<tr>
<td>Faculty motivation: Factors related to the faculty’s willingness to adopt RBIS in their classes</td>
<td>Empowerment</td>
<td>Usefulness</td>
<td>Success</td>
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<tr>
<td><strong>Empowerment</strong></td>
<td>The perception that faculty have some control over their change in teaching and a sense of autonomy to make their own choices</td>
<td><strong>Value</strong></td>
<td>The perception that adopting RBIS is useful or beneficial for faculty’s short or long-term goals</td>
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<td></td>
<td>Faculty Rank</td>
<td><strong>External motivation</strong></td>
<td>The external incentives, rewards, recognition or benefits of implementing RBIS.</td>
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<td></td>
<td>Autonomy</td>
<td><strong>Cost Benefit Balance</strong></td>
<td>The perception that the benefits of adopting RBIS outweigh its costs or risks.</td>
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<td>Self-Regulation</td>
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<td>Novice faculty’s experience</td>
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<td>Faculty integration of service, teaching, and research</td>
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<td><strong>Perception that RBIS increases value in students</strong></td>
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<td>Certainty of the benefit of RBIS</td>
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<td>Reward Systems</td>
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<td>External Value</td>
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<td><strong>Cost to implement</strong></td>
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<td>Uncertainty of the benefits of the change process</td>
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<td>Potential time savings when adopting RBIS</td>
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<td>Increasing time commitments when adopting RBIS</td>
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<td>Evidence of the practice’s effectiveness</td>
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<td>Teaching evaluations</td>
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<td>Competence beliefs</td>
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<td>Self-confidence to effectively use RBIS</td>
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<td>Self-confidence in faculty’s abilities</td>
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<td>Perceived success of innovation</td>
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<td>Apprehension for drastic change</td>
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<td>Feasibility of the strategy*</td>
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<td><strong>Interest</strong></td>
<td>The value or importance that faculty put on their teaching.</td>
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<td>Believe that Faculty can make an impact</td>
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<td>Compatibility with past experiences and faculty needs</td>
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<td>Interest in their own abilities</td>
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<td>Creating awareness and interest</td>
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<td>Compatibility and personal connection to the RBIS</td>
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APPENDIX E. QUOTES IN SPANISH

1 “Si tomamos una decisión [acerca del plan de estudios] no podemos cambiarla antes de que el tiempo muerto me permita ver los resultados reales; por ejemplo, si aplico un estímulo hoy tengo que esperarme a que se establezca el efecto varios muestreos. Por tanto reduzco ancho banda [rapidez de la respuesta a los cambios]. No puedo inmediatamente 6 meses después corregir porque todavía el efecto [del estímulo] no se ha visto”.

2 “lo mínimo [que tenemos que esperar] es 6 meses, que es un muestreo, pero seguramente en 6 meses no he visto el cambio..., yo debería esperar dos o tres ediciones del curso para que el profesor se establezca en dictar ese nuevo curso... Este es un proceso lento, voy a cambiar mi curso, Lo preparo para el siguiente semestre, lo ejecué y me doy cuenta de que no lo hice como quería. Entonces después de dos tres tiempos de muestreo es que uno tiene el curso como lo quiere”.

3 “digamos que hacemos experimentos [adoptar RBIS] y esperamos varios ciclos para obtener resultados; pero y si entonces nos damos cuenta dentro de 5 años de que toda la generación que salió tuvo tales fallas?, no!, la realimentación tiene que ser a mucho más corto plazo y yo creo que las rúbricas (más allá de cumplir [con los reportes para ABET y CDIO] que dan alguna información...) no dan suficiente información para hacer realimentación a corto plazo”.

4 “Esta discrepancia va a tener un impacto en la motivación o desmotivación dependiendo de la experiencia que tuvo el estudiante. Si uno le coloca algo fuera de su alcance, el estudiante no va llegar a una solución y va a sentir que no aprendió nada”.

5 “Para [Otro profesor asistente veterano] hay una diferencia muy grande [entre la habilidad de solución de problemas esperada y la real] y muchas veces regañaba, porque él ve frustración en él y ve que los chicos como que no le responden y él reacciona. Y eso produce a veces problemas en los chicos. Entonces ya el chico no aprende, le coge pereza a la materia, o al profesor y así va a ser una cosa negativa”.

6 “Les he visto [a los estudiantes] una cantidad de falencias tremendas, me da miedo comenzar a hacer esas pruebas [de PBL], si tienen estas falencias y no tienen los conceptos básicos y me pongo hacer experimentos... entonces no hay garantía [de que ellos aprendan]”.

7 “yo creo que lo que más me motiva es que los estudiantes aprendan y que desarrollen competencias”.

8 “En mi experiencia personal para mí siempre ha sido un motivo de mucha alegría ver que las cosas funcionan, es decir que [el contenido de la clase] no se quede únicamente en teoría... cuando las cosas funcionan eso para mí es algo realmente bueno. Y pues yo creería que para los demás puede ser bueno también. De pronto para todas las personas no será lo mismo pero para muchos sí y yo he visto que muchos de los estudiantes tienen la misma respuesta”.

9 “Pero el hecho de que [los estudiantes] lo pudieran ver [las cosas funcionando] y pudieran experimentar, ... ¡O sea, la cara de asombro que tenían era absolutamente gratificante!”.

10 “A los estudiantes yo les propuse cambiar el examen final por participar en el concurso [de recepción de imágenes satelitales], si?, fue una experiencia muy chévere porque el curso se transformó completamente, osea el curso dejó de ser en el cual, magistral, yo daba todo, comenzamos a plantear el proyecto, a leerlo... a entender diferentes tipos de soluciones..., entonces entendieron con una cosa muy simple, nunca se imaginaron en la vida una recepción de una imagen satelital, porque para ellos satélites es ciencia ficción, eso es completamente Star trek, pero es algo tan simple cuando lo ven que también [ayuda a] aterrizarlos a una cosa que pueden hacer ellos mismos. Eso fue súper motivante, osea, los chicos comenzaron a participar, comenzaron a hacer sus diseños, hicieron cosas espectaculares, la simulación, el modelo, todo!... un grupo ganó el concurso”.

11 “Cuando estamos en el laboratorio... donde hay también un discurso teórico y verificación de manera inmediata [de los problemas de laboratorio] y no al semestre siguiente cuando los conocimientos han
perdido vigencia o se han olvidado un poco... me ha gustado mucho [PBL], sobre todo veo que a los estudiantes les ha gustado mucho y muchos de ellos toman el énfasis que es electrónica de potencia en la maestría”.

12 “Cuando yo veo que a nivel profesional [los estudiantes] ya se han graduado y están trabajando en ese tema y le dicen a uno, estoy trabajando en esto y uno ve que siguieron por el área... de alguna manera eso lo hace sentir a uno feliz.”

13 “Si veo que no están funcionando, yo personalmente las cambio, me invento otra estrategia distinta o le hago ajustes y vuelvo y la uso con la intención de aumentar el nivel de atención de los estudiantes... o sea, ya le toca a una inventarse estrategias para volver la clase dinámica, porque si no, la gente se desespera”.

14 “los resultados de los parciales digamos que pueden ser un reflejo del aprendizaje del estudiante... pero yo sí necesito sentir que ellos están aprendiendo, ¿Cómo es fácil saber que están aprendiendo? Con la calidad las preguntas... Osea, si creó que la calidad de la preguntas disminuye, entonces ellos están aprendiendo menos... ya los cambios vienen siendo ensayo y error. [Me doy cuenta si funcionan] por los resultados de los estudiantes o por feedback de ellos y ahí refinamos... yo suelo preguntarles mucho a ellos, cómo les pareció esto que hicimos en esta clase, [y ellos responden:] ‘no profe no entendimos nada’, o ‘sí funcionó, qué nota’”.

15 [soy muy reflexiva, se me ocurrían [las actividades de clase] cuando al preguntarme yo cómo aprendo, cómo soluciono el problema mejor en la vida diaria. Ahí mismo yo decía, ‘vayamos ensayando esto, digamos, ya no hagamos tanto los laboratorios de esta forma, sino de esta otra. Entonces fui cogiendo cancha como profesora porque, ¡imagínate!, yo recién me gradúo, y en la primera semana de clase les estoy enseñando a estudiantes que eran compañeros míos. A medida que fui avanzando, fui cogiendo como esa experiencia que me hacía quitar el miedo, porque uno también ya empieza a dominar el público. Es esa experiencia práctica de cómo tratar a la gente. Eso me fue ayudando a que se me fueran ocurriendo otro tipo de cosas [en la clase]”.

16 “Estas prácticas [RBIS] no funcionan porque uno busca en Google o mira un video, hay que hacerlas, hay que irlas puliendo. Uno aprende así, ajusta el siguiente semestre. ¿esto no me funcionó?; uno vuelva y haga, vuelva y haga, púlalo; y aún así uno tiene sus dudas y a veces uno sale del salón de clase y uno dice: “¿Será que sí logré que esto quedara claro?; o, ¿se logró este otro [objetivo]? Pero si no tenemos un proceso a conciencia con los profesores [para aprender a adaptar RBIS] pues no lo van a hacer y pues uno hace lo que siempre ha hecho: enseñar a la antigua. Ellos dicen, hay que dar la clase, para eso me contrataron, yo lo hago como pueda, y a ver qué resulta…”.

17 “un curso como el mío que está en construcción, no es un curso predeterminado en el que tú digas todas las clases llegó con este tema, sino que son cursos que tienen que poderse mover en el tiempo según los que [los estudiantes] están haciendo, eso implica cambios. Busco alternativas para mis clases, porque por defecto mi política es no dictar clase magistral, o sea, a menos que sean temáticas puntuales hago exposiciones de no más de 20 minutos”.

18 “… A veces mis ajustes son clases adicionales, si una clase fue muy de descubrimiento, hago una clase mucho más teórica. Vuelvo a una enseñanza un poquito tradicional porque finalmente hay que reconocer que explicar funciona... no la vamos a descartar, sólo que ese componente [enseñanza tradicional] yo lo he venido reduciendo, porque también sé que uno aprende más cuando uno mismo encuentra los propios patrones, si?, cuando uno hace el ‘click’ interno”.

19 “[Usar PBL en grupos colaborativos pequeños] es más efectivo y eficiente; al final de la clase [los estudiantes] lograban manejar el software de simulación y llegar a buenos resultados. Cuando ellos desarrollan los problemas en la clase, se reduce la posibilidad de errores, que se llevan imaginarios falsos, que “cacharreros” [i.e., ensayo o error], o de que el amigo les diga que [la simulación] funcionaba así [de una manera específica]. Cuando puedo asesorar a cada grupo en la clase se evita ese tipo de problemas o errores y es mejor para el aprendizaje de ellos... Solos en la casa [sin quien los supervise] hay riesgos, se generan mitos, mitos de que [los problemas] se solucionan de una única manera”.

200
“[No uso PBL en algunos cursos] por escasos recursos y tiempo. Guiar a pocos estudiantes es posible, puedo corregir cuando uno se equivocó, o 2 se equivocaron, pero con 24 o 30 estudiantes sería muy complicado aplicar esa metodología, la he usado en cursos de 20 estudiantes o hasta 24. Logré que hicieran una buena simulación trabajando en parejas, pero igual se me iban las 3 horas de clase haciendo un ejercicio [que debería durar] una hora porque tenía que estar ahí asesorando a cada uno... es difícil”.

“Uno siente la diferencia cuando son grupos más pequeños: fluye la clase, fluyen los diseños, fluyen las actividades, se pueden hacer actividades como compartir, que todos expongan y aprendamos todos de todos, cuando un estudiante tiene que oír 7 exposiciones de los compañeros, nadie pone atención”.

“Profesores que no han dictado un curso con estas estrategias [RBIS] no se dan cuenta lo que implica tener a 24 estudiantes en un salón, pues en la clase no se puede llegar a aprovechar lo que uno quisiera. Ellos siguen con la clase magistral... por eso ellos dicen "¿Cuál es el lio [de tener grupos más grandes]". No!, créame, cuando usted está parado allá y tiene que hacer esas actividades, esas dinámicas no se pueden con la cantidad de estudiantes”.

“Yo sigo todos los semestres pidiendo que los grupos sean más pequeños y así lo seguiré haciendo hasta cuando lo logre. Incluso mis estudiantes escribieron una carta a las directivas diciendo que los grupos son tan grandes que no podemos hacer la clase como queremos. He pedido cambios de salón o extensión de horarios justamente porque el grupo es tan grande que una hora de clase no da el tiempo para aplicar una estrategia [PBL] bien”.

“ese es uno de mis más grandes miedos, con grupos de 36 personas dar un curso por proyectos no es posible. Tengo un curso de 24 personas en las que hacemos proyectos pequeños y y a veces siento que tengo que tener el don de la abstracción! Este tamaño de grupos solo permite hacer proyectos pequeños, no los proyectos de diseño que queremos que los estudiantes desarrollen”.

“En electrónica para llegar a un producto hay que conocer de muchas cosas. Con circuitos básicos, ¿qué producto puede uno hacer? No sé, como que no es fácil ... ¿cómo integro pbl [con el curso de circuitos básicos] ... Uno necesita la idea de qué proyecto se puede plantear, o con qué especificaciones [los estudiantes] están en capacidad de realizarlo”.

“¿Hasta qué conoce una persona de segundo semestre? están los proyectos que están haciendo en primer semestre... yo veo que hacen cosas, pero no tienen ni idea de electrónica. Saben que si ponen una pila el motor se mueve... que sea más rápido o más lento, es más como a punta de “músculo” [ensayo y error]. Pero ya cuando uno se pone como en otro nivel, a veces no me es fácil llegar a esas ideas y concluir qué tipo de proyectos pueden realizarse]”.

“no es que pbl no les genera aprendizaje, sino es que es más difícil utilizar pbl en este tipo de cursos que tienen más conceptos teóricos abstractos”.

“yo podría dictar una clase de análisis de señales que requiere mucha matemática. Puede ser un curso netamente teórico o yo podría tratar de mostrar alguna de esas teorías haciendo el análisis de alguna señal predeterminada... puedo hacerlo muy fácil con un computador... puedo mostrarles en Matlab el análisis de una imagen”.

“Aunque mi formación académica no fue asociada a pbl, por el tipo de actividad profesional uno se encuentra con pbl. Como he estado siempre en investigación y desarrollo, entonces, para mí esa es la forma de aplicar la electrónica: siempre algo práctico... no es que no tenga la familiaridad con pbl, sino que ¿cómo yo hago esto para llevarlo a un circuito para que [los estudiantes] lo puedan ver?”.

“Si conociera bien [pbl] estaría interesado en utilizarla, pero solamente en momentos en que realmente eso sea lo que se necesita, ... para introducir el concepto de qué es un voltaje, de qué es una corriente, una malla, etcétera, prefiero presentarlo todo inicialmente... de pronto para anclarlo mejor, ya se puede pasar a una parte enfocada en un proyecto... No sabría en este momento si definitivamente es mejor usar pbl en todo instante como para explicar esos conceptos”.

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“[para tener ideas de asequibles actividades de aprendizaje] leo pedagogía, y encontrar ‘insumos’. Yo no lo veo de otra manera, siempre hay ideas que están ahí rondando, es oír gente que ha tenido experiencias interesantes, conocer gente... conversar con profesores, del mismo networking. Hay gente [otra profesora de un departamento diferente] que ha ido a mi clase..., en algún punto me decía, es que [usar una tableta en clase] le funciona a usted, porque usted hace ejercicios. Yo le dije, a usted [la tableta] le funciona igual, porque usted tiene una foto, ¿puede hacerle zoom y pintar sobre su foto y señaló...ah claro!, y se compró una tableta este fin de semana”.

“He percibido en otros profesores desinterés en cambiar. Lo he visto en varias cosas, primero, que no les importa que les vaya mal en la calificación de los estudiantes, hay gente que, semestre tras semestre mal evaluada, no hace absolutamente ningún cambio en su práctica docente... algunos son buenos profesores, de verdad son muy buenos en escenario, hablando, planteando su tema, conocen muy bien su tema, pero su clase es esencialmente igual... ellos no participan [del entrenamiento en pedagogía ofrecido por la universidad] Con uno de ellos [otro profesor asistente] tengo bastante charlas al respecto, pero lo único que quiere utilizar de lo que yo uso... es el tipo de evaluación que yo hago para que sea rápido de calificar, pero más allá de eso, su clase es esencialmente la misma”.

“hay profesores que sí tienen, en nuestro departamento, mucho conocimiento de lo que es aprendizaje y educación. Entonces ellos dictan sus cursos aplicando teorías conocidas... yo creo que preparan su clase mucho mejor, yo creo que ellos podrían obtener resultados mucho mejores [en sus clases]”.

“Los estudiantes que están en mi curso teórico-práctico salen muy contentos, me agradecen, me siguen escribiendo semestres después. A veces cuando hacen la carta a los profesores algunos me han escrito por allí, que muchas gracias. Uno sí ve como que a ellos les gusta... eso también lo motiva uno pues el reconocimiento es más que todo por parte de los estudiantes que de parte de los colegas del departamento”.

“otros profesores piensan que los profesores que son bien evaluados es porque los estudiantes pasan, mientras que los profesores que son mal evaluados es porque los estudiantes pierden”.

“Yo creo que ciertos profesores tienen la mentalidad de hacer lo posible porque el estudiante aprenda. Yo creo que no todo el mundo está en ese plan porque el estudiante lo evalúa a usted y, entonces, si el estudiante le va bien, dicen ese profesor es una maravilla”.

“esas evaluaciones de los estudiantes también hay que tomarlas con precaución porque el estudiante en realidad no sabe qué es lo que le tiene que enseñar el profesor. Ellos tienen sólo una percepción desde su punto de vista que no es la realidad completa”.

“Los estudiantes hacen comentarios positivos sobre la experiencia de los cursos que tomaron conmigo..., aun siendo, digamos, no estricto a rajar a todos, manteniendo el rigor de las calificaciones, no he percibido de los estudiantes comentarios que sí escucha uno de otros profesores, o porque exigen muy poco y todos pasan, o porque exigen demasiado y no dan lo que se espera de ellos en las clases”.

“Muchos [profesores] no lo validan, como que les parece una tontería lo que yo hago... que los consiento mucho, que no están aprendiendo... ellos sienten que la práctica tradicional debe persistir en ingeniería. Yo siento que [mis estudiantes] aprenden, ¿tengo números que lo muestran, sí? el mismo parcial hecho en dos momentos diferentes con nuevas metodologías, con viejas metodologías y se nota la diferencia, escribió un artículo sobre eso hace 2 años reconocido como mejor artículo en una conferencia... pero aquí [en el departamento] como tampoco hay mucho interés, pues yo tampoco lo discuto”.

“Yo he hablado con otros profesores ya veteranos y consideran que los estudiantes son los que no “funcionan”. ¿Esa es la diferencia... todos lo perciben?, ellos dicen que los estudiantes vienen del colegio mal, que cada vez vienen peores... todos reconocemos eso, pero todos sabemos que hay que hablarle a este estudiante, que no es el mismo de hace 10 años”.

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“Hay [profesores] que dicen que [los estudiantes] deberían saber esto o esto, y no lo saben, entonces preguntan ¿a quién estamos recibiendo? ¿es que deberíamos recibir a los mejores?, pero nosotros no estamos en un tiempo de alta demanda... aquí la selección es reducida y no hay que poner cara larga por ello”.

“Mi responsabilidad como institución es ponerlos [a los estudiantes] en el punto de excelencia al que yo quiero, ¿a costa de qué?, a costa de lo que toque, porque es la apuesta de la Universidad... que nos está diciendo que recibamos a 40 u 80 con un perfil que no es el superior como el que veníamos acostumbrados hace 20 años. Por eso hay tanta inversión en acompañamiento [de los estudiantes]... Esa es la persona que entró [al programa], tu responsabilidad es llevarla al punto de excelencia, si toca estar detrás de ellos, ¡pues tocó estar detrás de ellos!... nuestra responsabilidad es graduarlos con excelencia, no graduar solo a los mejores que entraron”.

“Como la deserción toca bajarla, entonces ¿cuál es la solución? facilitarles que pasen. No es fácil..., en una charla que tuvimos con [director de carrera], [una colaboradora] decía: ‘es que los niños toca tratarlos como...' [a lo que yo digo] Pero es que no son niños!; son personas de 20 años, son unos jóvenes ya, que toca exigirles si yo quiero sacar un profesional”.

“Una persona como [profesor de planta veterano] tiene sus conceptos muy definidos y al dictar una clase puede que cambie de método, pero se preocupa de que la gente aprenda lo que tiene que aprender y a él no lo van a cambiar. Si le pasa lo mismo a alguien como [un profesor de cátedra joven]... la gente se quejó de que el profesor era muy brusco o algo así. ¿Cuál fue la solución? Que [un profesor de cátedra joven] no vuelve a dictar esa materia. El siguiente semestre pusieron a otro profesor a dictar la materia... cuando los mismos estudiantes me comentaban que el tipo no tiene ni idea [sobre el tema]... los estudiantes tienen tanto poder que pueden sacar a profesores”.

“la gente va a llenar cualquier cosa [en el reporte de assessment], porque cuando uno va a revisar encuentra esas contradicciones entre grupos que esperaría correlacionados... entonces no sé qué tanta información me va a dar esa medición que el profesor hizo en 15 minutos cuando ya entregó notas, no quiere saber nada más y llena cualquier evaluación [en el reporte de evaluación]”.

“Nos va a tocar ver ahora qué estrategias usamos para poder asegurar que todos estemos trabajando de la misma forma... pues algunos profesores me han dicho ‘Una cosa es el papel y lo que yo hago dentro del aula de clase es otra’”.

“si [la evaluación] el profesor no lo hace a conciencia, se suma un montón de ruido que el profesor le mete a su evaluación... [porque] no estoy midiendo lo que debo medir y tomo decisiones sobre algo que no está bien medido ... [por tanto] me desvio de la referencia, tomo decisiones que en lugar de acercarme a la referencia me van a hacer alejar”.

“hay un escalafón profesoral muy claro, tienes que publicar, o no vas a avanzar en tu escalafón profesoral. Aunque hagas docencia de alguna manera enfocada, puntualizada, efectiva, al fin y al cabo, te vale mucho menos que publicar un artículo, entonces pues dices ‘no puedo seguir haciendo esto porque yo también necesito ascender’.

“cuando estoy con los estudiantes en clase, presentando y haciendo algún tipo de experimento me resulta súper estimulante ver sus caras [mostrando interés], ¿sí?, ¡Siento que estoy haciendo lo correcto!. Me siento muy orgulloso de mis cursos, sólo por el motivo de que he logrado cambiar. Ahora, eso me ha implicado más tiempo, y por eso cuando comencé en alta docencia me vi afectado, entonces dejé de hacer proyectos porque esto no me está valiendo nada. Aunque estas experiencias sean gratificantes, es mi hora de subir de categoría, y para salir de alta docencia redujo mucho lo que implicaba tiempo y eso reduce mucho la experiencia de ellos [los estudiantes], y eso se ha reflejado en que actualmente no tengo estudiantes de trabajos de grado, pues los estudiantes están menos interesados en mi área”.

“Para llegar a ser calificado excelente tuve que tomar decisiones como reducir contacto con estudiantes. Yo siento que mis calificaciones como profesor han bajado gradualmente, O sea, no siento que haya tenido grandes falencias como profesor... pero sé que mis clases no son las mejores porque no las estoy dando de la mejor forma. Yo acepté que eso iba a pasar. Antes obtenía un puntaje sobre 5,5/6 que era una muy buena calificación, ahora estoy entre 4.9 y 5; mientras no baje de 4 entonces está bien, acá no me molestan por eso, acá no me van a decir absolutamente nada. No hay una diferencia entre 4 y 6 en cuanto a lo que me
reconocen aquí, no hay un reconocimiento realmente docente bien hecho. Yo sé que puedo dar mejor mi clase, pero doy lo suficiente para estar sobre lo que me exigen acá y dedicó más tiempo a lo otro que me genera más beneficios, y más reconocimiento a mí, sobre todo para avanzar en el escalafón y el perfil”.

51 “Entiendo que la universidad debe mantener un balance de bajar gastos y subir ingresos que se ve directamente reflejado en los profesores. Entonces los profesores tienen que intensificar las horas de clase para mantener ese balance, Sí?, pero cuando se pierde perspectiva de eso, es más difícil para un profesor y más desmotivante. Creo que eso está sucediendo, que nos veamos obligados a volvernos a lo clásico, lo que históricamente se venia haciendo… hay algunos profesores que sencillamente toman la decisión de ‘yo doy mis clases como siempre [clase magistral], pues igual [los pares] me van a calificar bien”.

52 “yo siento que con más tiempo siempre voy a poder dar más, siempre voy a poder explicar mejor lo que me gusta, voy a poder buscar más ejemplos, voy a poder buscar otros libros, voy a poder hacer más simulaciones, voy a poder plantear mejores estrategias de enseñanza. Porque para eso se requiere tiempo. Sé que lo hice en algún punto, cuando estaba en media investigación dejé mis cursos muy bien preparados, eso me permitió plantear cursos basados en proyectos”.

53 “ya no estoy dictando mis clases como antes. Antes yo las daba de una forma mucho más profunda... las diferentes formas como abordo los temas abstractos ayudan mucho al estudiante... la forma como uno profundiza sus conocimientos es año a año, semestre a semestre, la mejor manera de enseñar las cosas implica que yo pueda construirlas de la forma más estructurada posible. Me parece que he logrado en cierta medida simplificar algo que para la gente ha sido tradicionalmente algo supremamente complejo. Para eso se necesita tiempo y yo quisiera tener un poco más de tiempo para llegar a una profundidad aún mayor. Me parece que eso es lo que hacen los profesoress de las mejores universidades del mundo”.

54 “Otro factor que me motiva es la continuidad en las clases que a uno le asignan. Por ejemplo, sólo tengo una clase fija cada año. A esa le meto las ganas en aplicar innovaciones. En las otras no tanto, por tiempo y salario... porque no sé si voy a utilizar esas innovaciones después. Si me aseguran continuidad le invertiré tiempo, pues uno invierte en lo que a largo plazo puede sacar provecho. De otra forma uso ese tiempo en otras cosas que necesito para obtener remuneración”.

55 “Saqué una publicación, ¡pero eso me llevo años!, o sea llegar a los resultados para poder publicar algo, o para poder someterlo [a revisión] requiero tiempo”.

56 “Traer un proyecto no me descarga en docencia, porque las políticas de la universidad son claras, sólo hay descarga si cambio de perfil y solo cambio de perfil cuando tenga más publicaciones, pero para publicar se necesita tiempo trabajar en esos proyectos, para proponerlos y realizarlos, y después esperar el tiempo que dure en salir la publicación”.

57 “me parece que el hecho de plantear un proyecto de investigación grande no se valora, ni se le da la importancia que merece. No sé si es una cuestión de visibilidad, de reconocer públicamente, de promocionar más lo que hacemos, de nuestros centros de investigación, de los proyectos que nos ganamos en Colciencias. Aquí no hay modelo en el cual a nosotros nos den un reconocimiento por lo que hacemos, que es muy valioso, digamos, en descarga de tiempo, o en visibilidad, Sí?, y que eso [el reconocimiento] sirva para catalizar el seguir trayendo más proyectos. Todo el mundo habla de emprendimiento, pero no se dan las condiciones”.

58 “yo siento que a mi investigación le falta profundidad y no es un tema de recursos, porque pues los recursos se pueden conseguir, es un tema directamente de tiempo y de desgaste... estos últimos dos años, yo siento que me he desgastado un montón y me da un poco de frustración eso. Siento que eso está sucediendo con estas políticas de alta docencia, me parece que en algún punto se está perdiendo algo de perspectiva sobre lo que es ser profesor”.

59 “cuando uno hace el sistema de control Lo diseña para que se comporta como un modelo de referencia... el modelo de referencia es lo que [los diseñadores] tenían en la cabeza de cómo debería funcionar este plan de estudios, que es contra lo que me voy a comparar luego... [lo que ahora tenemos es] esa referencia, está este plan de estudios, con estas competencias embebidas en cada curso, pero ¿hay que hacer [los cambios]
por qué? ¿lo estamos haciendo bien?, ¿es eso lo que se quería?... ¿el sistema] se comporta como lo esperábamos?, [sin el modelo de referencia] no está quién nos da ese feedback”.

“todavía no sé qué es lo que espero de mis alumnos, yo tengo unos objetivos de formación y tengo unas rúbricas que supuestamente deben darme una idea de lo que ellos esperan que aprendan, Ahora, yo me siento a mirar esas rúbricas de CDIO... pero finalmente no las entiendo. Yo no entiendo su lógica, porque las comparo con lo que sé... yo digo ‘bueno yo he hecho esto, he diseñado digital, ¿qué necesito saber de esto?’; pero la rúbrica no me lo dice, es decir si yo me evaluara a mí mismo con esas rúbricas, yo no entendería qué es lo que yo necesito saber. Yo no sé si pasaría un curso que estoy dictando, si me evalúo a mí mismo con las rúbricas que me dieron”.

“no confío en el nivel de conocimiento con el que yo presumo que [los estudiantes] llegan [a mi clase]”.

“yo presumía que sí habían visto [un tema específico] porque lo vi en el syllabus [del curso prerrequisito], pero no han visto nada, solo les hicieron un ejemplo!”.

“si tienen estas falencias y me pongo hacer experimentos [en mi clase] de que [los estudiantes] lean este paper, así sean notas de aplicación sencillas, y no tienen los conceptos básicos... [tendrán serios problemas], les he visto una cantidad de falencias tremendas, me da miedo comenzar a hacer esas pruebas, cuando esté consolidado el curso de pronto, lo veo difícil ahorita”.

“los problemas que les pongo en un parcial son de verdad difíciles y complejos pero los resuelven, Entonces yo me voy de cierta manera como muy satisfecho de que [los estudiantes] logran cosas interesantes, pero después llegan a la clase siguiente y los profesores se están quejando de que los [estudiantes] no saben nada, entonces ahí ya no sé, me lo cuestiono, pero Bueno, finalmente es el tema de la evaluación, hasta donde yo estoy evaluando bien y hasta qué punto los profesores están asumiendo cosas que no deben asumir”.

“hay un quiz que hace [otro profesor asociado] de entrada, el quiz de diagnóstico, y se queja todos los semestres, dice que [los estudiantes] no son capaces de resolverlo, pero es un quiz que a pesar de que es muy fácil, es un quiz de velocidad; entonces ellos serían capaces de resolverlo, pero no en el tiempo que [otro profesor asociado] espera que lo resuelvan, no tienen la agilidad matemática”.

“me va a tocar hacerle recomendaciones a los profesores de atrás, si es que ellos tienen tiempo, porque posiblemente les pase lo mismo que a mí, que lo que veían en tres cursos lo tienen que dar en dos y ellos dicen, Pues voy a ver lo más más importante y sacrificó estos [otros temas], pero entonces con esta transición curricular, yo no estoy muy seguro de qué saben y qué no saben”.

“El diseño de los cursos y la ejecución se hace en tiempo real. No sabemos en la práctica cómo funcionan los cursos, no sabemos si se logra el cumplimiento [de los objetivos de aprendizaje], todos somos nuevos en la elaboración de las asignaturas”.

“Incluso si [los objetivos de aprendizaje] se hacen muy bien... no tengo el tiempo para llevarlos a cabo”.

“Cuando descubro que ellos no vieron [un contenido esperado], por tanto, le bajo la calidad, ..., O sea, temas esperados que [los estudiantes] aprendan, cuando descubres que son más, te toca disminuir la calidad del curso de alguna manera. En algunos casos hasta agregar más temas [al curso], entre más temas te implica aumentar los contenidos por cubrir”.

“Tiene que haber un trabajo entre las secciones y los líderes de curso para tratar de ser muy coherentes y que todo [el tema] se cubra. Ojalá de la forma en que fue diseñado... Hazlo como quieras, utiliza la técnica y la didáctica que te inventes, ¡pero sigue el programa! Eso sí que es difícil, esa sí que es difícil”.

“como institución uno debería fomentar que el gran logro más allá de una buena evaluación de los estudiantes es que esa evaluación sea consecuencia de un muy buen desempeño, no que se rajó todo el mundo ‘pero mira que me evaluaron perfecto’ o ‘es el mejor profesor que he tenido en toda la vida, pero perdí’. Hay algo que no funciona, hay algo que no funciona... No puede ser que el estereotipo del buen profesor es el que
raja... eso también hay que cambiarlo en el estudiante, porque están acostumbrados a un sistema educativo en el que se filtra, no en el que se construye.”