On Self Regulation in College-Level Mathematics Classes

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Abstract

This paper looks into need for improvement in mathematics education at the college level in the US regarding equitable practices in instruction. In particular, this paper focuses on understanding the role self-regulation can play in the classroom dynamics, and how self-paced assessment can be a way to empower students. Also included is a case study in an introductory linear algebra class at a liberal arts college and is meant to provide a investigation into self-regulation in this context. The appendix includes an annotated bibliography comprised of the most relevant studies in self-regulation conducted in the last two decades or so. An index of keywords and pertinent quotes are highlighted for the ease of the reader.

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Chapter 1

Introduction

1.1 Motivation

Before I begin, I ask you, reader, to consider my abbreviated description of my experience of mathematics education: a typical child sits in a classroom full of students, all who are told to practice and memorize the materials presented by the teacher; there are no stupid questions as long as they are relevant to the material at hand. As she attends her first classes in college, she again finds herself sitting in a classroom full of students, questions left unanswered "in the interest of time." She wonders whether the lecturer knows her name or even cares if she shows up at all.

Mathematics has always been a difficult subject for me. In large part, it is difficult because of how difficult it is to stay awake during lectures. Perhaps laughable, but it's true; I often joke that had it not been for my persistent parents' efforts and lifelong interest in the subject, I would have easily been an art major, which requires a lot more moving of body parts and far fewer listening to lectures. I am therefore not surprised when many of my peers express distress or dislike of math of any kind, or when in turn they express surprise to my liking of it. It is, in my experience, a difficult subject to learn to enjoy in the classroom.

I am therefore as baffled as I am frustrated with institutional traditions that exist as obstructions to effective learning, both of mine and my peers'. Forgetting for a moment that lectures are simply difficult to be interesting for over an hour, I, a female student of color, rarely see a figure for me to look up to or relate to. I have sat in numerous math lectures being the sole female student in the room, questioning where all of my fellow female math majors could have gone. I have shuffled through mathematics texts wondering when the last time I read a textbook from a female author of color was, never mind see a theorem named after one. Being Asian-American, I constantly question and face biases and stereotypes of Asian-Americans, many which make me take a second glance my pride and love for my ethnical identity.

This list can go on, and I'm not happy. I find that this system of learning which disregards the students in the picture is highly ineffective; the context in which mathematics lives in for people like myself is simply non-negligible in fostering a good learning environment.

This thesis is my attempt to bring some of the problems I see into light, as a way to expose the flaws and changes necessary in mathematics pedagogy, particularly in postsecondary education. Afterwards, I propose a question that takes into consideration a way that may solve a subset of these problems using a small case study at my own institution.

1.2 Background

1.2.1 The status quo.

The classroom setting that I described in the very beginning is an example of the "banking model" of education, named by Paulo Freire in *Pedagogy of the Oppressed* in 1968. Freire draws a metaphor between this style of education to a bank, where the teacher is the depositor and the students are depositories (Friere, 1968). The teacher's tasks are to "fill" the students of information, and the student's role is to simply accept this information, with no particular requirement to digest its contents further or apply additional context. Thus, under this model, a good teacher is one who can give as much as they can to as many students, and a good student is one who receives and regurgitates the most with precision.

Of the various problems Freire points out about this model, he particularly hammers down the notion that the banking model transforms students into objects that merely act as containers, devoid of critical or creative thought.

Friere is certainly not the only individual questioning the method of education utilized in classrooms. Educator and psychologist Donald Bligh presents in his book, *What's the Use of Lectures?*, rationale for why traditional lecture style classrooms are ineffective and outdated, supported by an exhaustive collection of studies (Bligh, 1998). His ideas are not new either, compiling hundreds of studies conducted on this topic and relating theories from many other educators. Most notably, he cites the work of Benjamin

Bloom, also a professor known for proposing and driving experiments on mastery-based learning (Bligh, 1998).

Despite the existing literature about the flaws of the traditional system, there has been little action and large resistance towards change, in large part due to the impracticality and difficulty of bringing changes into fruition. Take for instance educator Bob Moses, who saw struggling students in mathematics and created a nontraditional way of teaching algebra, called the Algebra Project. In his book, he describes the experience in spreading this idea across middle schools in Boston as an "uphill slough" (Moses, Cobb, 2001). He was turned down by principals for reasons ranging from teachers claiming that student skills not being up to par to stating that it would be too difficult to transition from the traditional approach.

Moses' experience goes to show that there exists resistance towards change, and isn't uncommon in middle school classrooms. Thus it is unlikely that postsecondary mathematics in America has changed since a century ago. In fact, I claim this lecture-based, transmissive style of education still dominates mathematics classrooms today. A Google search for "changing higher education" returns a plethora of articles responding to recent student strikes advocating for change in policies regarding finances and other economic concerns. In contrast, a search for "changing K-12 education" returns a 20-page ERIC (Education Resources Information Center) document on curriculum reform and effect on entering post-secondary institutions. It was only in 2014 when an official committee by the name of Transforming Post Secondary Education Math was formed to in part discuss using a variety of instructive methods in the classroom (Holm, 2016).

In some ways, the formation and existence of this committee reflects the persistent push for change and experimentation of different methods of instruction.

1.2.2 Pedagogical methods

Throughout the 20th century, a variety of pedagogical methods came into trial across subject areas and institutions. Specifically in regards to postsecondary mathematics education, methods that have been explored include the following.

Flipped classrooms

This method of instruction involving an inversion or a "flip" in the classroom is best described as placing the students in a setting where the lectures are given outside of the classroom, and activities meant to be more meaningful for the learning experience take place inside the classroom (Zappe, et al., 2009). These activities, ranging from group work to solving tutorials to leading workshops, are often described as active learning and have been shown to significantly improve student performance in science and mathematics (Freeman, et al., 2014). There are ongoing studies on the effects of flipped classroom being done in undergraduate engineering and mathematics settings (Yong, et al., 2015).

Inquiry-based learning

The Moore Method of teaching, which departs entirely from lectures and turns to having student-led classes that required the work in proving theorems and concepts be done by the students, was both hailed for its innovative ways to foster learning and criticized for unaccounted fallbacks and impracticalities with broader audiences (Parker, 1992).

Seeing ways he could improve the method, David Cohen introduced and experimented with the Modified Moore Method within mathematics classrooms, where he looked to reduce the downsides of the Moore Method while maintaining its intentions and benefits (Cohen 1982). Inquiry-based learning (IBL) stems here, particularly relating how students can learn actively through questioning and creating arguments independently (Yoshinobu, 2013).

IBL in postsecondary mathematics have recently received attention as they appeared in discussions and examples presented in an issue of *Problems, Resources, and Issues in Mathematics undergraduate Studies* (Katz, 2017). Various examples that appear in this issue of IBL studies, which were run on various student bodies and subjects, bring up notable questions and results.

A focus on self-regulation

Educator and psychologist Benjamin Bloom developed mastery-based learning, which expects students to have complete or near-complete mastery of concepts before proceeding further into the material (Bloom, 1968). Over the years mastery learning has taken on many variations, some more successful than others, but all focus on individual pacing and developing autonomy in a student's ability to learn. The biggest takeaway from studies done in mastery learning is the positive impact it has on students despite how much it differs from traditional methods of teaching (Zollinger, 2017, Bradley, 2017).

Self-regulation is not a method but a vital piece of mastery-based learning that asks students to identify and understand their own progression in learning. A focus that requires and trains meta-cognitive skills in learning mathematics can be useful in enabling students to grow independence and attain ownership of their own learning. Furthermore, rather than introducing large stylistic changes to the classroom, bringing in a focus of self-regulation can be relatively easily accomplished compared to flipped classrooms or IBL (Montague, 2007). In mathematics, self-regulation has not been explored as explicitly as the other two methods, but

Incorporating the ideas of self-regulation, detailed further in a later chapter, this paper proposes a possible way to change classroom dynamics using self-paced assessments.

1.2.3 Inequity and Underrepresentation

Postsecondary mathematics also faces issues of underrepresentation in gender and race, in particular shown by the percentage of degrees awarded in mathematics. Below are tables (1.1, 1.2) with data from the most recent 2015 survey conducted by the Conference Board of Mathematical Sciences (Blair, Kirkman, Maxwell, 2018).

Department	Men	Women	Total
University (PhD)	3431 (68%)	1645 (32%)	5076
University (MA)	1436 (51%)	1365 (49%)	2801
College (BA)	2529 (51%)	2388 (49%)	4917

Table 1.1 Number of degrees awarded in all mathematics majors, categorized by gender and department during July of 2014 to June of 2015.

What is most notable from the number of degrees awarded is the sharp decline in the percentage of women receiving PhDs than men compared to the percentage of MAs and BAs awarded. Table 1.2 further shows there exist fewer women, regardless of ethnicity, in tenured faculty positions overall which diverge even more from the numbers of PhDs awarded. Exploring the reasons behind why such may be the case calls for a paper of its own. The

Department	Asian	Black	Hispanic	White	AIAN/ NHPI*	Unknown
University (PhD)						
Men	15	1	3	55	0	2
Women	5	0	1	16	0	1
University (MA)						
Men	11	2	3	46	0	2
Women	6	1	1	26	0	1
University (BA)						
Men	6	2	1	53	0	2
Women	4	1	1	30	0	1

*American Indians and Alaskan Natives / Native Hawaiians and other Pacific Islanders

Table 1.2 Percentages of full time faculty members belonging to various ethnic groups by gender and by department as of fall 2015.

facts here show underrepresentation of women in mathematics is certain.

Looking specifically at ethnic groups, the numbers show an overall evidence of minoritization of non-white faculty for both genders. We explore how this could potentially impact mathematics education in the next chapter where I discuss inequitable practices in mathematics education.

1.3 Self-paced assessment

There is no concrete, definite way or solution to the problem I and many others see in how mathematics education has been unfair and ineffective in serving all students. Yet, it is important to try to attempt and propose possible ways to alleviate and work towards what could better serve the current student population.

To do so, I propose what I call self-paced assessment, a method that takes from self-regulation and self-regulatory methods, which I contend stems from various non-traditional yet frequently tried methods in postsecondary mathematics education. Such include but aren't limited to mastery-based learning, flipped classrooms, and inquiry-based learning.

In describing this method, I also present a case study conducted on a group of first year students taking an introductory linear algebra course at a liberal arts college. The results of the study, though small and rather unique, propose a possible question of using self-paced assessments to shift the locus of control to students and enhance their experiences, thereby introducing more equity in practice and reducing negative sentiments towards mathematics.

Chapter 2

In context, math is not fair.

The title of this chapter may be confusing. What do I mean when I discuss fairness in mathematics?

Far too often, I grew up hearing and thinking that math was neutral; that unlike in literature or social studies, the instructions told you 1 + 1 was always 2, no matter who you were or what you believed in.

As Friere discusses, the role a student typically takes in a traditional classroom is to act as a container that simply accepts information and regurgitates out appropriately (Friere, 1968). The system disregards fostering the capabilities of a student to process and apply independent thought, and the instructor is not expected to have their students be able to do so, either.

A student, however, is not a memorizing machine. There is always context outside of the paper that definitely affects the way a student perceives and performs in mathematics, particularly in the college or university level. With biases and implicit obstructions that exist in ways to curb student achievement, mathematics education is not fair in various ways that I'd like to look at different levels of society.

2.1 Implicit Biases by Instructors

If there is one individual that interacts and directly impacts a student, it is the instructor of a class. Hence, if an instructor were to hold preemptive opinions or biases that pertain to particular students, no matter how subconsciously, this may impact their preferences for or against certain students and their performances. Specifically, this proposition comes from the Harvard implicit association study, which essentially showed how people could hold biases or preferences without explicitly portraying them using a test that detected differences in reaction speeds to making adjective-subject associations.

Using this test, a study done in 2015 showed that male scientists had a tendency to associate science with males more than female scientists (Smyth and Nosek, 2015). In fact, this discrepancy was the greatest with associating males with engineering and mathematics, exceeding 0.8 standard deviations. This then possibly implies that male professors are likely to hold a stronger association between male students and mathematics. Referring back to Table 1.1, where the percentage of full time female faculty members was less than that of male members, this further suggests bias that a female student may be subjected to during her career.

In fact, a study conducted in 2012 showed that science faculty, regardless of gender and race, preferred male students over female students (Moss-Racusin, et al., 2015). The study involved using two nearly identical fictional individuals and seeing who was more likely to be hired as a laboratory manager. The only difference was their implied gender, deduced by the names "John" and "Jennifer." Despite all other attributes being identical, there was significant preference for hiring John; participants scored him higher than Jennifer on all marks on average.

These studies present a strong case for how instructors may hold presumed assumptions towards certain students in mathematics. Certainly what this implies is that if this were true, students subject to negative biases must work harder than their counterparts to impress or succeed and must have more discipline to remain in the field despite possible opinions being held against them.

Furthermore, if female students are already minoritized in the status quo, it manifests a vicious cycle that likely feeds biases against them, which in turn makes it increasingly difficult for such students to remain in the field. Called "stereotype threat," consequences can result in lasting effects on the environment for women in mathematics (Spencer et al., 1999).

An important example of stereotyping and implicit biases taking action is actions of microaggression, which describes any seemingly small behavior, including unvocalized assumptions, that relays hostility or prejudiced views towards a marginalized group, unintentional or not. When unnoticed or ignored, microaggressions towards ethnic minority groups feed racism, fueling a mindset that only continues to be confirmed as a correct one. As a result, impacted students fall further into the mindset of feeling less capable in the classroom.

2.2 Structural Biases by Institutions

To begin discussing how postsecondary institutions present biases against students, an understanding of how students are filtered into these institutions in the first place must be established. For a typical high school student in the US, a standard college application requires SAT or ACT scores that often are used as a metric to determine admission into the school.

The problems associated with using this score have been analyzed again and again; in particular, studies show how it tends to hold advantages for already privileged students (Buchmann et al., 2010). In mathematics, female and black students tended to score lower than male and white students, which also in turn pose more stereotype threats towards these students (Jencks, 1998). This means therefore that students admitted into notable colleges were subject to institutional biases before even setting foot on campus, which then affect their opportunities further down the road.

Even if students were to be admitted into schools, they may face roadblocks and unfairly provided opportunities at the institution. Far often then not, students are expected to be at some financial standing that enable them to have not only resources like textbooks and computers, but also essentials like meals. There exists an assumption that students can afford certain amenities or at least have ways in which they can provide the necessary costs, be it through work or loans.

This presents a bigger problem between racial identities and socioeconomic differences. The 2007-2011 census provides enough quantitative evidence of the existing, unequal distribution of poverty among different races. American Indians and African Americans came in the highest at about 26% of the population being in poverty, more than a double in comparison to the 11.6% of whites (Macartney, 2013). A 2018 New York Times article showcasing a megastudy conducted on white and black men showed that of the 5,000 white and 5,000 black boys who grew up in poverty, 48% of black boys grew up to remain in poverty and only 2% grew to be rich, while 31% of white boys remaining in poverty and 10% became rich (Badger, 2018).

Objectively, this means it is likely there are more non-white students thinking about and suffering from financial difficulties than their white counterparts. It's simply not fair to expect the same degree of achievement from students that need not think about running out of money by the end of the week to those that do. In 2013, enrollment percentages in postsecondary education showed about a near 10% difference between white (42%) and black (34%) students (Musu-Gillette, 2016). Graduation rates were similar, lowest for black students at around 41%. These numbers dip down further for STEM (Science, Technology, Engineering, Mathematics) degrees, about 11% apart.

The 2015 study conducted by the Conference Board of Mathematical Sciences showed that 71% of full time mathematics professors at PhD awarding universities were white, compared to 1% black and 4% Hispanic. 22% of total professors were women, of which 16% were white; approximately 0% were black and 1% Hispanic.

What this means for students of color sitting on the other side of the podium is a definite disparity in the number of professors that share their racial background. This lack of having a proper role model impacts the belief a student has that they can succeed, otherwise known as self-efficacy (Thevenin, 2007). With lowered self-efficacy comes lowered achievement, unsurprisingly (Motlagh, 2011). Once again, we see how the question of how these unfair societal norms factor into reducing the quality of education or effectiveness of education a student receives is rarely raised.

2.3 Cultural Obstructions

When stating that there are cultural obstructions that exist to contribute inequity in mathematics education, it is not to say that the action of finding a derivative is somehow racially charged or unfair to a specific group of people. Rather, the way institutions teach a mathematical concept and the myriad of assumptions made in the process shape the role mathematics takes in our society.

2.3.1 There is oppression.

Specifically, I contend that current practices in mathematics is biased against some and privileged against others. In his paper on anti-oppressive education, Kevin Kumashiro outlines ways in which oppression exists in classrooms today that works against "the Other," referring to traditionally marginalized in society, and discusses how to bring about anti-oppressive approaches to education, examining strengths and weaknesses of each (Kumashiro, 2000).

What Kumashiro discusses includes understanding the need for education for and about the Other, education that is critical of privileging and othering, and education that works to bring change in students and society. He points out that oppression in all four of these flavors comes from the underlying belief that "normal" equates to cis-gendered, heterosexual white men. Furthermore, a flawed and misleading understanding of the Other perpetuated by stereotypes add to further setting normalcy away from the Othered. In this way, he points to how whiteness has served in projecting mathematics as a "neutral" subject. As Rochelle Gutierrez writes on how mathematics assumes to have no "color" or cultural associations:

> [In] many mathematics classrooms, students are expected to leave their emotions, their bodies, their cultures, and their values outside the classroom walls, stripping them of a sense of wholeness (Gutierrez, 2012).

2.3.2 This is a racial project.

Mathematics is historically not led uniquely by white Europeans. Prominent advancements were made by individuals from all over world. But when I ask fellow math majors for names of famous mathematicians, what I hear are not Srinivasa Ramanujan, Hypatia, or Dorothy Vaughn; but Euler, Pythagoras and Fermat. The problem in question lies exactly here–whiteness is rarely questioned in this context of mathematics. Perhaps then a valid question to ask is, why has mathematics education been so predominantly white?

Danny Martin attempts to answer the question by discussing the deliberate and prevailing racial agendas that use mathematics education as a tool aligned with sustaining a white framework in society, particularly in attaining market-oriented goals (Martin 2012). He describes beyond what statistics describe of underrepresentation in mathematics; analyzing literature that is meant to promote mathematics education reform, including Friere's *Pedagogy of the Oppressed*, stays vague and removed from describing race and racialization in the picture.

Furthermore, he argues that mathematics education has aligned in keeping whiteness in control because it has been able to stay away and immune from possibilities of being racially charged or placed under racial politics. The way in which this was possible, he describes, is the existence of white institutional spaces that conform to particular characteristics:

> (a) numerical domination by Whites and the exclusion of people of color from positions of power in institutional contexts, (b) the development of a White frame that organizes the logic of the institution or discipline, (c) the historical construction of curricular models based upon the thinking of White elites, and (d)

the assertion of knowledge production as neutral and impartial, unconnected to power relations (Martin, 2013).

Many points made previously directly support how white institutional spaces exist and have existed in society today; domination in number by white professors, curricular concepts based on and named off of historical white mathematicians, and implications that there are no relations between mathematics in societal and racial constructs. If these four points do manifest in reality, Martin's claims suggest the deep-rooted locus of power residing in whiteness and calls for the need to critically analyze institutions.

While these points of indication are clear, they are broad. Thus in fulfilling the need for specificity and examples, Dan Battey and Luis Leyva describe these characteristic indicators of such spaces by breaking down into specific areas:

Dimension	Elements
Institutional	Ideological Discourses
	Physical Space
	History
	Organizational Logic
Labor	Cognition
	Emotion
	Behavior
Identity	Academic (De)Legitimization
	Co-construction of Meaning
	Agency and Resistance

Table 2.1 Framework of Whiteness in Mathematics Education. A more detailed breakdown of each dimension is detailed in their paper (Battey and Leyva, 2016).

This table outlines a way in which institutions can use to check whether whiteness is being perpetuated, and how so. But an even better understanding of how mathematics has continued to be used as a tool of racial and ethnic justice is through an example. Nicole Joseph uses these characteristics to identify and recognize how white institutional spaces influence the mathematics learning of black female students (Joseph, 2017).

In particular, she describes how critical race theory permits the claim that mathematical spaces are not neutral. Critical race theory, which stems from legal backgrounds, serves to present a model that recognizes inequities in race and challenge existing predominant ideologies (Solorzano, et al., 2000). Her identification of how mathematics education has been unfair toward black female students presents a concrete way in which individual students and their educations are affected by an institution.

2.3.3 It is possible to change.

I've thus far presented a problem in which inequitable practices in mathematics education are real and impacts students. Remodeling education to eliminate inequitable practices in mathematics seems a daunting task for any one single institution, let alone an entire nation, to tackle. For all four educational approaches presented in his article, Kumashiro argues that there needs a prominent desire for change for any change to even occur (Kumashiro, 2000). As it is with any kind of change, there is resistance from the presiding body of power.

But Rochelle Gutierrez tells us there is hope. In her quote earlier she describes how students are "stripped away" of their sense of wholeness in the mathematics classroom, hence addressing an issue of how students are dehumanized objects in the classroom (Gutierrez, 2012, 2017). In discussing possible ways to "rehumanize" students, she emphasizes the necessity to recognize hierarchies in classrooms and shifting the role of authority (Gutierrez, 2018).

More broadly, Gutierrez's ideas are grounded in her theory of two axes that cross in describing dimensions of equity: Access and Achievement make up the dominant axis, while Identity and Power make up the critical axis (Gutierrez, 2009). The dominant axis describes what would determine a student's ability in mathematics, while the critical axis describe what would measure a student's ability to think critically of mathematics, perhaps bringing change. Gutierrez contends all four are needed to build an equitable mathematics learning environment. In particular, she describes the Access dimension being a "precursor" to Achievement and Identity to Power, which implies the two former need to exist and establish before the latter.

Thus, her proposal that moving the locus of power is one way in which the critical axis is being used–she brings the students' identities into the conversation. In the next chapter, we explore a way in which this can be done via self-regulation.

Chapter 3

Self-Regulation

3.1 Definition

This is the definition of self-regulation provided by Zeider, Pintrich and Boekaerts' *Handbook of Self-Regulation*:

> Self-regulation refers to self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals (Zeider, et al., 1999).

This can be broken into two parts. First, it focuses on self-generation, indicating the necessity for an individual's own efforts and thus emphasizing power in the self. That way, the generated thoughts and actions can be structured to their own goals and needs, not those of the society or instructor. The word "cyclically" should be underlined here, as it points out how the process can be a self-sustained one, reinforced by practice and initial support.

Adopting a focus on self-generation of thoughts and actions which lead to attaining personal goals is a statement describing the achievement of power. In a typical classroom setting composed of a single instructor and a group of tens to hundreds of individuals, there exists a power dynamic. The instructor is given an unchallenged amount of control over the students' actions and knowledge.

Thus, promotion of self-regulation will accomplish two parts for students: one in which the process of self-generating their own thoughts and actions will shift the locus of power away from being centralized at the instructor, and two in which the learning experience can be shaped to fit personal needs and goals, instead of generalized versions often presented in traditional classes.

The use of self-regulation in mathematics learning can be a driving force in achieving a change in perspective of mathematics in society, both by institutions and students alike. As I discussed in the previous chapter, it is important to keep in mind that the goal of self-regulation lies in rehumanizing students and bringing more equity in a postsecondary mathematics classroom.

3.2 In history.

To begin looking into how the core ideas of self-regulation came about, mastery-based learning is a fit place to start. Simply put, mastery learning seeks to incorporate individualized pacing of progression through the course material. Developed by Benjamin Bloom, mastery-based learning expects students to have complete or near-complete mastery of concepts before proceeding further into the material (Bloom, 1968). Over the years mastery learning has taken on many variations, some more successful than others, but all focus on individual pacing and developing autonomy in a student's ability to learn. The biggest takeaway from studies done in mastery learning is the positive impact it has on students despite how much it differs from traditional methods of teaching (Zollinger, 2017, Bradley 2017).

As shown with the many studies done of the impact of mastery learning, self-regulation is a foreign concept in traditional instruction. Thus, how or why self-regulation should be a part of school does not come easily to most educators, nevertheless students, today. For a large part, if not all, of a young student's life in academics, the classroom is where they are instructed to do one thing or another. Report cards and other assessments and evaluations are the only sources of feedback.

For college and postsecondary education where classroom sizes go upwards to hundreds and even thousands of students, the feedback received is rarely refutable, with chances to improve given once or twice a semester when a midterm is returned.

In particular, mathematics education is rarely in the form different from the lecture-recitation style classes. Seminar or discussion-heavy classes are generally unheard of, let alone calling on students for participation in any shape or form. With bigger classes, asking questions in itself becomes a challenge, often perceived as being a waste of lecture time; practically impossible if the lecturer spares zero opportunities for questions. Truly, the conversation is one-sided, with little or no reception from the students' in their understanding.

In this status quo, it is unthinkable to "personalize" a course to meet a particular student's needs. More so, students have few chances to champion for themselves what they were lacking in the education they received. It is hardly reasonable to claim that one form of learning is the best way for every student to achieve success, as will be discussed in further detail later in this paper.

Looking only in terms of providing individual attention for academic achievement, attempts so far include remedial classes. Unfortunately, these often further reduce self-efficacy in underachieving students, as the students are singled out and required to take these extra classes under the description that they are struggling or behind, increasing both physical and mental stress factors (Martin, 2017).

Nevertheless, self-regulation takes many different forms and can be adapted to any type of classroom. In both methodology and focus, self-regulation can be incorporated at small or large scales. Detailed below are some (but certainly not all) ways in which self-regulation can take place in instruction (Montague, 2007). In addition, self-regulative strategies will often encompass a mix or overlap of the listed forms, thus none are mutually exclusive of another.

3.3 Self-Assessment and Evaluation

Self-assessment and evaluation can be pertinent to either qualitative evaluations of cognitive skills related to work ethic and habits or quantitative assessment of knowledge on concepts. The goal of most self-assessment and evaluation methods circles around helping students practice independent realization of their own necessities and strengths in learning, and hence increase self-efficacy as well as a feeling of empowerment.

Evaluating work practices in mathematics can be achieved through a variety of ways, including worksheets that ask students to outline how they did certain problems, reflection assignments that encourage students to evaluate their own weaknesses and strengths, and checkboxes to ensure certain practices were done (Montague, 2007). Such metacognitive processes can help students find and understand for themselves where they can improve in a way that doesn't explicitly expose particular weaknesses to their peers or instructors.

In recent years, self-assessment of course material and knowledge recollection is sometimes found in form of online-based classrooms, which reduces the work load of instructors to grade and follow through with each individual's assessments, as well as prevent academic dishonesty. However, the nature of online based learning is that a computer and a reliable internet connection is a luxury that students should not be expected to have, especially when equitable practices are in concern, as mentioned before.

A section below outlines more specifically the kinds of self-assessments that can accurately aid student learning and provide ways the reduce unequal power dynamics. Moreover, the case study found in this paper describes one specific example of self-assessment that seeks to implement a fair way to provide student autonomy and improve self-efficacy in college mathematics. Once again, the goal of any method should be to increase empowerment of students and reduce inequitable practices, thus it is key to think about the benefits and fallbacks of everything discussed below.

3.3.1 Self-Instruction

Self-instruction looks into empowering students to learn the material on their own, thereby also instilling the belief that they are capable. Naturally, there is some risk associated to self-instruction, and therefore is often paired with supplementary activities or practices that solidify or clarify learning.

Examples of self-instruction cross an entire spectrum of student independence in the classroom, from full-autonomy where students decide what should be covered and how, to partial-autonomy that expects students to learn the material provided by an instructor (Burris, 1972).

Recently, self-instruction in mathematics has taken form via flipped classrooms, in which the learning of material is done outside of the scheduled class time through slides and recorded lectures (Lage, 200). This type of instruction reserves space and time for students to spend class time on group activities and more in-depth discussions of mathematics beyond the surface level of concepts, but also increases responsibility on the students to learn the material correctly on their own.

3.3.2 Self-Monitoring

Self-monitoring is similar in nature to the other self-regulation forms, but focuses more on providing immediate feedback. In mathematics, a checklist of commonly found errors are provided for students to check intermediate steps while solving problems (Dunlap, 1998). The checklist is subsequently personalized for each student as mistakes are made, and eventually they were removed as a form of assistance. Results from some studies showed an increase in achievement (Dunlap, 1998).

There are obvious challenges with this form of self-regulation, as it poses massive workloads realistically impossible for teachers or instructors. Furthermore, such a checklist is often difficult to formulate for mathematics classes above introductory, more computational courses. It is important, still, to see the benefits of introducing students to metacognitive methods such as creating a checklist on their own to aid their learning.

3.4 An example of self-assessment: self-paced assessment.

While all of the various ways self-regulation that takes place in the classroom has benefits, self-assessment of course material has tangible and scalable opportunities that touch upon self-instruction and self-monitoring as well. More specifically, self-paced assessment allows for the students to take control of the pace they are expected to learn the material.

The idea behind self-paced assessment is as simple as its name sounds. All assessments are conducted by the students on their own time and in their own choice of setting. Of the many stressful factors students are exposed to in college, examinations are one of the most prominent sources of stress. Students are expected to cover a hefty chunk of the course material and regurgitate it coherently within a set amount of time. In a traditional setting, all students in the course are asked to have the material digested by the time the exam is given to a level where basic concepts can be extended to applications. There is no chance or way to show that improvements can be made after exams are taken–in other words, a one-time assessment is the determining factor of a student's understanding of the material.

Described in this way, it is rather ridiculous as to how traditional methods of assessment and instruction are considered fair and accurate ways to judge the complex and multidimensional understanding of material students can have. In particular, examinations rarely ask for furthering of knowledge; in mathematics, the demand for using the creative process is simply left out in most exams despite how critical, creative thinking is necessary for mathematical research and exploration.

Self-paced assessment seeks to remedy a solution to some of many issues with traditional methods of teaching. For one, instead of one large assessment that covers weeks to months of material, multiple smaller assessments will ultimately achieve the same goal of checking the state of students' understanding while entirely removing the stressful factor of having to review and cram large amounts of material at once.

Second, students are relieved of the burden of having understood everything on a strict schedule. Individual styles and paces of learning is entirely ignored in the status quo, despite just how vastly spread out these can be (Busato, 2000). The only expectation is that students are to complete the set of assessments by the end of the course. It is expected that the assessments would be handed out on a timely manner when the material being assessed is covered, but it is not expected that the student would be prepared at that moment to be tested on it. Having the independence to be able to take the assessments at their own pace is essentially how self-regulation takes a role here.

Third, students will have a chance to retake these assessments if they feel as though they were not sufficiently prepared or think that they did not fully comprehend the material upon taking the assessment. Penalizing students who simply made an algebra mistake or could not finish an assignment that covered an important concept are simply unfortunate events that should not be deterministic of a student's achievement in the course. Rather, it should be encouraged for students to self-evaluate and test where they are in the course and use the retake opportunity to their advantage to figure out where they are lacking and where they are strong. This not only removes the unnecessary time spent on reviewing material a student may be already strong on, but also creates efficient study habits that builds metacognition.

Self-paced assessment as described here relies heavily on trust between students and teachers. Often in pop culture students are compared to prisoners, both groups of individuals under complete control, following a rulebook of a system set in stone. Though it sounds extreme, students from a young age are praised for following directions and punished for acting out. Eventually those who "succeed" in school are those students who were most obedient and studied what was given to them, without question. The snowball effect goes the other way as well, in which incriminating or humiliating students for some actions and grades lead to building further negative associations to school, reducing their desire to learn or participate.

Thus, giving students control over their own learning is essentially an action of giving students trust. If a snowball can form in one direction, the other direction is no different. Construction of trust in each other can work to flatten the strict hierarchy that exists today. Particularly for higher level postsecondary institutions, students are impending members of academia and society at a level of maturity that deserves trust, and subsequently, equity in power in the classroom. Trusting that students can be responsible for their own learning leaves greater individual impact that in turn affects how society views education.

As a more explicit example of how self-paced assessment can be implemented is explored in the case study.

Chapter 4

The case study

4.1 Introduction

Enter my US College Education: projector screens, chalkboards, individual desks and syllabi stating exact dates to assignments and exams. Despite the 200 or so liberal arts colleges in the US, the variety of student experience is almost nonexistent. In any of these colleges, large lecture halls are ready to be filled with hundreds of students for them to watch a single professor or instructor. Whether a thousand-person introductory course or a ten-person advanced class, a student is expected to consume the material and spit it out, correctly. This is not to ridicule the efforts of certain colleges that are trying to actively reform education, but still the vast majority has remained stagnant.

As mentioned in the earlier chapter, I want to see if there can be positive change in this status quo via self-regulation–specifically, through the use of self-paced assessments. The case study was designed as an attempt to show direct effects of making a small change and adding an element of self regulation in a mathematics course. To do so, self-regulated, self-paced assessments were put in place of midterm and final examinations.

4.2 Method

This study focused on a mandatory introductory linear algebra course, listed as Math 40, offered as a part of the common graduation requirements. Math 40 is typically a 7 week course, and historically assign students about 10 assignments and two exams consisting of one midterm and one final. There were total 49 students involved being first year students, and students were split between 2 sections randomly, taught by the same instructor. One of the sections underwent the study. The other section remained unchanged as a control. For ease in distinguishing the two, I will refer to the test section as the “quiz section” and the unchanged section as the “control section.”

The 24 students of the quiz section did not have any midterm or final examinations. Instead, these students were required to finish a total of 10 small, one or two problem assessments, dubbed quizzes, by the end of the course. All 10 closed-book, closed-notes assessments consisted of questions that pertained to the knowledge of the material that was taught up to the day of release. Students were able to retake these quizzes without penalty, but the ultimate grade of the quiz would be determined by the latest attempt. There were no deadlines to any of these quizzes except for the final deadline at the very end of the semester. Students were also expected to finish each within 15 minutes. In other words, all quizzes were self-paced and take-home, meaning students had autonomy over when, where, and how they wished to take these assessments.

The control section took one midterm and one final exam as traditionally done, appropriately timed around half way and at the end of the semester. Homework assignments remained identical to the other sections, and instruction was similar for the two sections under the same instructor. There were no extra or additional assignments, nor were there fewer assignments, in any one of the sections.

There were six other sections of Math 40 being taught at the same time by other instructors, but other than the same material being taught, had nothing to do with the study. Students were not given the choice to opt out of the study while in either the quiz or control section, but could choose to drop or switch into a different section not part of the study. No students in other sections were allowed to switch into either sections in study.

Students in both sections were asked to fill out a pre-survey during the first week of the course asking for information including demographics, high school math courses, and family backgrounds. This survey also asked for: self-confidence and assessment in mathematic ability, belief in the need for certain elements in creating an intellectual environment, and level of comfort in asking questions.

After the course ended, students were asked to fill out a post-survey, which included questions about students’ perceived growth in mathematics ability and confidence. They were also asked to participate in a Focus Group session for qualitative feedback using questions presented by a noninteractive individual not part of the study (neither I nor the instructor were present in the room).

4.3 Results

During the pre-test, students were asked for information on their demographics. Below, table 4.1 gives an overview of the students' racial/ethnic identities.

Section	Asian	Black	Hispanic	White	AIAN/ NHPI*
Control	6	0	5	18	3
Quiz	7	5	8	16	0

*American Indians and Alaskan Natives / Native Hawaiians and other Pacific Islanders

Table 4.1 Number of students per each racial/ethnic group. Total is greater than sample size (accounting students of mixed race).

Overall, the pre- and post-surveys found little statistically significant evidence of differences between the two sections. Qualitatively, there were notable differences in descriptions of the experience in the course; in particular, many students in the quiz section noted a lower level of perceived stress.

Using $\alpha = 0.05$, two-tailed t-tests were run on the differences in averages were taken regarding student scores of self-assessment of math knowledge and self-perceived growth in confidence and knowledge of mathematics.

1. H_0: Students self-assessed scores their math did not change (before = after).

Students were asked to assess their own knowledge of mathematics in both the pre- and post-surveys. Table 4.2 shows the difference in averages of how students assessed their knowledge before and after the class.

In both sections, the hypothesis H_0 was not rejected.

2. H_0: Students perceived their growth in mathematical knowledge eqally in both sections (quiz = control).

Students were asked in the post-survey of their self-perceived growth in mathematical knowledge. With a p-value of 0.151, the hypothesis was not rejected.

Section	Before	After	Difference	p-value
Control	3.164	3.160	0.024	0.890
Quiz	3.136	3.208	0.0720	0.652

Table 4.2 Differences in average of how students rated themselves on self assessment of math knowledge (lower value indicating lower score).

3. H_0: Students perceived their growth in confidence in mathematics equally in both sections (quiz = control).

Students were asked in the post-survey of their self-perceived growth in confidence in mathematics. With a p-value of 0.482, the hypothesis was not rejected.

4.3.1 Focus Group

During the Focus Group session, students were asked to answer questions on the classroom atmosphere and give broad ideas and opinions of positive and negative things about the course. When asked for three words to describe the course, the students from the control section used words like "lots of proofs" and "solid linear systems" (in reference to course content), the quiz section students also shared some of these answers but also emphasized "fun" and "[having a] good time."

Similarly in the answers for the other questions, students in the control section were mostly focused on the intensity of the course and the material, students in the quiz section expressed opinions about the quizzes themselves and the overall lowered stress levels. In part, they discussed how the quizzes as a tool that "forced [them] to break up" the material as well as a way to test their learning of the material, knowing that they could retake it without penalty. Others noted the abundance of time there was to take a quiz, compared to its relative brevity, in particular to how midterms are traditionally given in a block of time. Some students mentioned how quizzes could "pile up if [they] were not careful" and expressed a desire for a deadline for the first take of the quiz in order to help them not fall behind.

Furthermore, some students from the quiz section raised a question of fairness for their peers and friends from other classes, expressing how it was "hard to see them fail" after an exam while not being able to help or relate to them.

4.4 Discussion

The results of the study were showed no significant differences quantitatively in both sentimental factors and academic achievement between the two sections. Qualitatively, however, students experienced a much lower level of stress in the quiz section. Considering these two facts together, I contend that the study ended up having a positive impact on the students overall, since introducing this change could mean introducing better opinions of the learning environment while maintaining the academic rigor. That being said, the sample size and population of the study were not only small but also unique.

4.4.1 A (not so) brief note on Mudd

To understand how self-paced assessments fit into the classroom in this case study, it is critical to note the nature of the college in study as well. The college in this study is a small liberal arts college named Harvey Mudd College with about 800 undergraduate students, located an hour from Los Angeles. The college focuses primarily on 6 departments in STEM, where all students are required to complete at least two semesters of coursework in each department, referred to as the Common Core. The introductory linear algebra course in this study, Math 40, is part of the Common Core. All students are therefore expected to take this course regardless of intended major. Moreover, particular traits of this school make the self-paced assessment ideal in achieving desired results in self-regulation.

The Honor Code

Mudd, short for Harvey Mudd College, places great importance on its Honor Code, which is maintained by students for students to be responsible for integrity in actions for all academic and non-academic affairs on campus. The Honor Code is not decided by faculty nor administration but created and maintained by the student body and respected by all parties of the College. There are consequences to breaking the Honor Code that are decided by students; often, students at Mudd are willing to take on these consequences via self-reporting incidents that are caused, regardless of intention. In many ways, it is a bridge to securing trust between one another that allows for more freedom and power for students as an active member of the College community.

The Honor Code plays a vital role in the practicality of self-paced assessments. It was expected for students to complete the assessments closed-book and independently. Another expectation was that there would be no discussion of the assessments with other students at any point in the semester so as to avoid benefitting students that may not have had completed them. To trust that students would follow these rules, which are impossible to enforce given the intentional absence of supervision, all parties involved must agree to promise integrity. Thus students need to be able to adhere to the Code, and instructors need to be able to trust that students will do so.

Therefore, I contend that a level of respect towards a code similar to that the Honor Code allows for self-paced assessments to maximize effectiveness. Without this, other measures can be taken to enforce integrity involved in the proposed method, such as having designated proctors or times for students to take assessments supervised, but this asks for further effort and resources that make the method harder to implement.

Class sizes, college demographics

Hovering around 227 students, the first year class from which this sample was taken was composed of 22 percent Asian, 21 percent Latino/Latina, 5 percent African or African-American, 31 percent white and 14 percent multiracial students. *Add information about the first year class demographics and insight into how this differs from a traditional college*

Mental Health and Wellness

Describe the atmosphere of Mudd and academic rigor

4.4.2 Problems

Scalability, instruction burdens

4.4.3 A question to consider

Proposal of possible use cases and experiments that can be conducted at other colleges with similar demographics for different courses, student populations.

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