Exploring academic procrastination with digital trace data

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EXPLORING ACADEMIC PROCRASTINATION WITH DIGITAL TRACE DATA

by

SEMIH BURSALI

A Dissertation
Submitted to the University at Albany, State University of New York
In Partial Fulfillment of
the Requirements for the Degree of
Doctor of Philosophy

School of Education
Department of Educational Theory & Practice
2022
ABSTRACT

Procrastination is a well-known phenomenon experienced by a lot of people in everyday life. People sometimes intentionally, sometimes unintentionally put off their tasks even though they might be worse off due to the delay (e.g., not paying bills due, even though they have sufficient funds in their bank account). It is safe to say everybody procrastinates at some point, but in academia the rate is relatively higher. This dissertation is an exploratory study of the relationship and differences between self-reported academic procrastination and observed procrastination in relation to students’ achievement goal orientations and self-regulated learning. A time-management/productivity mobile application (Proccoli) was developed and used to examine how students plan their studies toward their academic goals and whether they stick to their original plans (e.g., planned vs actual time they started working on a goal), change of study pattern and frequency when getting close to deadlines, and self-monitoring patterns across different academic procrastination levels. The main purpose of this dissertation is to bring a new perspective to academic procrastination studies particularly measuring and detecting procrastination utilizing mobile technology. The results revealed that students’ perceptions and self-reports about their own procrastinatory behaviors do not match well with their actual studying behavior toward accomplishing their academic goals. Procrastinators are underestimating their actual procrastination behavior. Furthermore, higher level procrastinators are more likely to check their progress toward accomplishing their academic goals. The results, also, revealed meaningful relationships between how students carried out their initial plan on an academic goal and their achievement goal orientations.
Acknowledgments

I am deeply grateful to the Turkish Ministry of Education for providing the Ph.D. opportunity in a foreign country. This material is based upon work supported by the National Science Foundation under Grant No. (1917949) awarded to the author’s academic advisor, Reza Feyzi Behnagh (PI).
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CHAPTER 1: INTRODUCTION
1.1. Introduction

The history of procrastination is as old as human history. The first recorded literature about procrastination was found in Greek poems around 800 BC. Over the time nothing has changed, it is still a common problem in humans’ lives (Steel, 2007). Procrastination refers to the purposeful and unnecessary delay in starting or completion of a task that in relation to a deadline, for irrational reasons, despite expecting to be worse off because of the delay (Tibbett & Ferrari, 2015). Everybody procrastinates at some point but 20% of the general population do that chronically (Ferrari, Diaz-Morales, O’Callahan & Argumedo, 2007) whereas in academia the rate dramatically goes up to 85% (Ellis & Knaus, 1977; O’Brien, 2002). At least 30% of learners are considered to have serious difficulties in completing academic tasks because of procrastination (Day, Mensink & O'Sullivan, 2000). Procrastination is a widespread phenomenon among the general population as well as college students as it seems from the statistics (Gareau, Chamandy, Kljajic & Gaudreau, 2019; Liu, 2010). Many people who procrastinate believe that there is nothing wrong with it, and no matter when the work is performed in relation to a deadline does not affect the outcome. Moreover, some of them might even enjoy the adrenaline rush that tight deadline brings as a consequence of procrastination.

It is not hard to find a student who starts living in the library with unhealthy lifestyle (e.g., eating junk food, sleeping less, fearing to fail, having high stress) as a result of procrastination while a term project deadline is approaching. The moment/s that they were procrastinating, the student might have felt joyful, positive even satisfied (i.e., doing “short-term mood repair” (Sirois & Pychyl, 2013). Although, procrastination makes one feel good and avoid the negative feelings associated with a task in the short-term (termed short-term mood repair (Sirois & Pychyl, 2013)), procrastination literature argues that it has been linked to negative
outcomes in the long-term (e.g., low academic performance (Tuckman, 2002), poor mental health (Stead, Shanahan & Neufeld, 2010)). A substantial number of students tend to irrationally delay on academic tasks even if there is a chance to face a penalty (e.g., lower grade) as a result. The penalty or negative consequence sometimes lower academic performance on a task, however, in long term, might end up with life defeating results (e.g., school dropout).

Recent studies argue that procrastination is self-defeating and is associated with poor academic performance and well-being outcomes (Ferrari, Johnson & McCown, 1995; Tice & Baumeister, 1995). Procrastination has also been viewed as a failure of self-regulation (Steel, 2007). Self-regulation and self-regulated learning are important skills in academic settings (i.e., planning, management, and orchestration of one’s own learning), most prominently in the current synchronous or asynchronous remote learning modality imposed by many universities as a result of the COVID-19 pandemic.

Traditional studies of procrastination have predominantly characterized procrastination as a “trait”, a characteristic consistent across time and situation (Ferrari, 2004). This assumption is the foundation for the use of self-report surveys in these studies, asking students about their delaying tendencies, habits, decision making process, anxiety, and personality traits, to name a few. However, recent studies have pointed to the need for looking at “state” measures of procrastination, or examining what students actually do, along with what they report they do in trait procrastination surveys. The need for incorporation of trace data (i.e., digital footprint) has been emphasized as a key limitation in research on cognitive, metacognitive, and affective processes of learning (Reiman, 2019). To be more specific, recent developments in information and communications technology (ICT) have resulted in higher technology use in educational settings; especially, mobile devices (Kim, Mims, & Holmes, 2006). According to a national
survey, 92% of higher education students have two mobile devices (Dahlstrom & Bichsel, 2014). However, academic procrastination researchers have not taken advantage of tracking students procrastination tendency by widespread use of mobile phones among college students. Taking into consideration the nature of the procrastination behavior, the necessity of “real-time” data from participants cannot be ignored to explain the behavior. The necessity paves the way for this dissertation.

In this dissertation, first, problem statement and the significance of the study is explained. Second, a review of the existing theoretical and empirical works is provided: procrastination definitions and types, the difference between delay and procrastination, operationalized procrastination behavior measurement tools, and theoretical frameworks that guide this study. Lastly on the second chapter, research questions are proposed. Third, the methodology of the study is presented: participants (recruitments process), measurement tools (questionaries integrated from literature and mobile application developed for this study), overview of data sources and how the data is processed. Fourth, results are presented. Finally, findings and possible implementation of proposed and developed mobile application along with its operationalized academic procrastination model/formula in future studies are discussed in the light of existing literature.

1.2. Problem Statement

Procrastination behavior in academic settings or on a task that related to learning process is known as academic procrastination. Even though academic procrastination has been intensively investigated over the past five decades (see Blatt, & Quinn, 1967. the earliest available published study about academic procrastination on Google Scholar), taking a position for or against the behavior is difficult because of contradicting research results in the literature.
Academic procrastination is characterized as detrimental, harmless and even helpful in different studies (Tice & Baumeister, 1997). The controversy points out necessity of more intense, exploratory and descriptive studies with progressive research designs. The relationship, for instance, between academic procrastination and academic achievement is the most extensively studied topic with regards to procrastination in education. There is a group of studies reporting no correlation between procrastination and academic achievement (e.g., Beck, Koons, & Milgrim, 2000; Schraw, Wadkins, & Olafson, 2007; Solomon & Rothblum, 1984).

There are few studies in the literature linking procrastination with positive outcomes (e.g., higher quality work in small amount of time). Some individuals like to work under time pressure, they believe ‘cognitive incubation’ (an unconscious creative process) occurs when they have constant tension caused by a deadline (Chu & Choi, 2005). Similarly, some procrastinators are seeking thrill experiences, they feel pleasure while the deadline gets closer (Ferrari, O'Callaghan & Newbegin, 2005). As a result of robust thrill, they can study for a longer period of time before the deadline. In addition, some procrastinators believe that time pressure makes them study for longer blocks of time instead of smaller study chunks, therefore, they get tasks done in a shorter period of time with less or no distraction (Schraw, Wadkins & Olafson, 2007) because they do not do what they would normally do (e.g., checking social media accounts, chatting with friends) while studying.

Furthermore, some procrastinators use procrastination as an emotional coping mechanism (Tice & Baumeister, 1997). In other words, procrastinators prefer to put off working on a task in order to feel less stress and anxiety at the moment caused by the task (e.g., hard task requirements, less engaging task). Instead, they prefer to work on something less stressful,
enjoyable or even do nothing at the moment to cope with the feeling of anxiety induced by the task. By doing this, procrastinators remove their negative feeling, however; there is no research linking procrastination with any positive outcomes in long term. The controversy shows that procrastination studies in academia need a different approach to understand and measure every aspect of the behavior.

One of the biggest challenges in procrastination studies is measuring the behavior. The available measurement scales (e.g., Decisional Procrastination Scale: Mann, 1982; Pure Procrastination Scale: Steel, 2010) only use self-report style instruments. One of the drawbacks of self-report measures is that participants tend to give socially desirable responses (Veenman, 2011), moreover; participants may assess themselves inaccurately. In order to better understand procrastination, more data channels are needed (e.g., digital trace data) along with the self-report instrument data in order to draw more reliable and complete inferences from the data.

1.3. Significance of This Study

This research study is an exploratory study that aims to examine self-reported procrastination (perceived) and actual (observed) procrastination along with their relation to achievement goal orientations by using digital trace data, that helps the immediate need to understand the main characteristics of academic procrastination. In other words, I propose a novel way of operationalizing behavioral procrastination in academic settings (at the learning task and student level) by taking into account fine-grained trace data captured by a mobile app used by students during taking a university-level course. I then examine the relationship between self-reported procrastination by students and their behavioral procrastination and later discuss the findings. There are four distinct contributions of the study.
First, the state-of-the-art technology, mobile devices, are integrated as an additional data collection tool along with traditional self-report data sources. Data from the use of mobile phone application helps to draw more accurate, reliable and complete inferences regarding the components of academic procrastination.

Second, the study attempts to explore the differences, if any, between perceived and observed academic procrastination which have not been looked into before, because of the single stream of data source used (i.e., self-reports). These data help to understand the “hidden”, “un-identified” or even misidentified procrastinators in academic settings due to the reliance on self-report measures alone. Thus, future interventions could target the correct students or groups of students.

Third, the study indicates how procrastinators and non-procrastinators approach and structure their academic tasks and goals. The findings help researchers understand how procrastinators set goals and how different or similar it is with how non-procrastinators set their goals (e.g., goal type, duration of planned study, number of sub-goals, perceived level of difficulty, when the due date versus personal deadline is). The differences can help to develop more effective interventions to overcome procrastination in future.

Lastly, the broader impact of the study is developing a software and research tool that scaffolds students on any learning task to plan, monitor and reflect on their studying performance, therefore, enabling them to effectively self-regulate their learning and be successful.
CHAPTER 2: LITERATURE REVIEW
2.1. Procrastination Definitions and Outcomes

Procrastination refers to the purposeful and unnecessary delay in starting or completion of a task, for irrational reasons, despite expecting to be worse off because of the delay (Tibbett & Ferrari, 2015). It is defined in education in many different ways because of the nature of the behavior as an intra-personal process. The behavior may or may not seem to other people as procrastination because what “late” or “early” is depends on the individual’s personal circumstances, other tasks one has to accomplish, and other personal and environmental factors (Milgram, Sroloff & Rosenbaum, 1988). For instance, two students are assigned the same task. One of them might need two hours while the other one needs two days to complete the task because of individual differences (e.g., background knowledge, learning strategies used), personal circumstances (e.g., going through a family crisis), environmental conditions (e.g., power outage), among other reasons. The differences can be categorized as internal (e.g., cognitive competence, emotional and cognitive readiness) and external factors (e.g., workload, competing deadlines, family responsibilities). It is possible that when an individual has two competing deadlines, one of the tasks would take priority over the other one or, similarly, if the individual has a family gathering along with a task deadline in the same day, it is more likely that the task initiation would be delayed. These characteristics of procrastination influence how it is identified and how it manifests.

Milgram, Sroloff and Rosenbaum (1988, p.197) defined procrastination as “putting off for tomorrow what one should do today”. Tice and Baumeister (1997) approached procrastination more generally and considered it as a self-defeating behavior. Gafni and Geri (2010) explained it as a tendency to postpone working on a given task to the last possible time. There are various similar but slightly different definitions in the literature (e.g., Ackerman &
Gross, 2005; Moon & Illingwirth, 2005; Senecal, Julien & Guay, 2003). However, there is not a single academic procrastination definition that is universally accepted (Schraw, Wadkins & Olafson, 2007), but the common component of these definitions is the avoidance tendency on a given task as much as due date allows, which leads to the question “What is the difference between delay and procrastination?”. The question will be addressed in a later section. Also, the operational (working) definition of procrastination will be provided in section 3.4. This definition is made based on the data types that are collected in the app in this study.

The underlying processes of procrastination have been studied extensively, and associations have been established with self-handicapping, low conscientiousness, low self-esteem, impulsivity, poor emotion regulation skills, susceptibility to temptation, avoidance-tendencies, anxiety, shame, and fear of failure, just to name a few (Sirios, 2014).

Similarly, a substantial number of studies reported that procrastination is detrimental to well-being (e.g., Balkis & Duru, 2016; Flett, Hagbin & Pychyl, 2016; Grunschel, Schwinger, Steinmayr & Fries, 2016; Stead, Shanahan & Neufeld, 2010). Procrastination has also negative correlations with health (Sirios, Melia-Gordon & Pychyl, 2003), financial well-being (Brown & Previtero, 2014), academic performance (Lakshminarayan, Potdar & Reddy, 2013), mindfulness (Sirios & Tosti, 2012), grade point average (GPA; Rothblum, Solomon & Murakami, 1986) while it has a positive association with internet addiction (Geng, Han, Gao, Jou & Huang, 2018), cheating on exam and plagiarizing (Roig & DeTommaso, 1995), stress (Sirios & Tosti, 2012), anxiety and depression (Constantin, English & Mazmanian, 2018). A large majority of these studies have used self-report surveys of procrastination (e.g., General Procrastination Scale, GPS (Lay, 1986) examining different components of the construct.
Behavioral measures (e.g., students keeping a diary of their studying behaviors and habits) have been under-utilized in procrastination studies. To date, there are only a handful of studies that have inferred procrastinatory behaviors from individuals’ behaviors. Dewitt and Schouwenburg (2002) asked students to report the number of hours they intended to study and keep track and report the hours they actually studied in the previous week over 10 weeks. Observed procrastination, conceptualized as the intention-behavior discrepancy, was calculated by dividing the actual number of studied hours by the planned number of hours, subtracted from unity.

In another study, Moon and Illingworth (2005) operationalized procrastination as the difference between the date a psychology test was made available online and when the student actually took the test, with greater differences indicating more procrastination. The study was conducted in an introductory level psychology course ($n = 303$). The authors administered online tests with one-week open window periods, in other words, for each test, students had seven days to complete it before the deadline. The result revealed that procrastination has negative association with test performance.

In a later study, Krause and Freund (2014) examined the association between behavioral measure of procrastination and self-reported procrastination. The authors measured behavioral procrastination using Dewitt and Schouwenburg’s (2002) method (the difference between planned and actual studied time) while they measured self-reported procrastination using Academic Procrastination State Inventory (APSI; Schouwenburg, 1995) across multiple weeks to estimate the trajectory of change in procrastination. The authors found that self-reported procrastination and behavioral procrastination has moderate correlation.
More recently, Agnihotri, Baker, and Stalzer (2020) proposed a new measure of *habitual procrastination* in the context of online learning, taking into account when students started learning assignments relative to other students with the same assignment. They applied this measure to a dataset of 100,000 students and found that students who delayed working on their assignments had 21 times more risk of failing their courses compared to those who started on time. All of these operationalized procrastination studies are elaborated in detail along with their pros and cons later in this dissertation (Chapter 2.4).

From a theoretical perspective, academic procrastination is linked with self-regulated learning (SRL), more specifically, academic procrastination is seen as a case of SRL failure. Research has shown that effective SRL has been associated with important educational attainment outcomes. SRL refers to planning, goal setting, enacting plans, making adjustments or monitoring and controlling one’s own learning (Azevedo, 2009). Self-regulated learners actively manage the cognitive, metacognitive, motivational, and affective aspects of their learning. Goals which students set for themselves consist of a set of standards they use to monitor their progress while working toward accomplishing a task, such as ‘trying to get the gist of an assigned reading’ (Winne, 2018). SRL is explained in detail later in theoretical framework section (Chapter 2.6.1).

The few studies above have taken important steps toward measuring and operationalizing behavioral procrastination, however, given the complexity of the procrastination behavior, more fine-grained trace data (e.g., students’ study sessions, planning and goal setting, and time management) is needed to develop a reliable way of measuring this behavior.
2.2. Types of Procrastination

Like its many definitions, procrastination is categorized in many different ways: avoidant – arousal procrastination (Ferrari, 1992), decisional procrastination (Effert & Ferrari, 1989), active – passive procrastination (Chu & Choi, 2005), chronic procrastination (Ferrari, 1991), academic procrastination (Rothblum, Solomon & Murakami, 1986), procrastination at work (Metin, Taris & Peeters, 2016) and so forth. In the next paragraphs each of these types will be defined.

*Arousal procrastinators* look for “thrill” or “rush” experience induced by working against a tight deadline, whereas *avoidant procrastinators* often use procrastination as a strategy to protect their self-esteem from possible outcomes (e.g., failure, embarrassment due to failure or looking incompetent in front of peers). *Decisional procrastination* is defined as “purposive delay in making decisions within some specific time frame.” (Effert & Ferrari, 1989, p. 152). In other words, decisional procrastinators use procrastination to avoid possible negative consequences of taking action (e.g., moving one state to another) or making a decision (e.g., changing job), therefore, they miss possible advancement in their life and take less responsibility if the outcome of the decision is unfavorable, since by procrastinating, they left themselves very little time to make a decision about the important matter, and they are now able to blame something else (i.e., the short time they had for decision making) not themselves for procrastinating the decision making. *Passive* procrastinators are “procrastinators who do have the intention to complete a task but engage in the task at the last minute due to indecisiveness and low self-control and are incapable of managing their time to finish tasks, and consequently suffer negative consequences” (Chowdhury & Pychyl, 2018, p. 8). Active procrastinators, on the other hand, have “stronger
self-efficacy beliefs, can make purposive use of time, and are driven by intrinsic and extrinsic motivation” (Chowdhury & Pychyl, 2018, p. 8).

Sometimes, prioritizing a task and holding to start working on other tasks might be acceptable (e.g., competing deadlines), however, repeatedly (habitually) and irresistibly doing it called *chronic procrastination* (Ferrari, 2010; Ferrari & Tibbett, 2017). It is also possible to see a classification made as *chronic* (trait) procrastination and *situational procrastination* in the literature. *Chronic procrastination* is, as stated above, one’s tendency to procrastinate constantly in almost every aspects of life whereas *situational procrastination* is one’s tendency to procrastinate constantly in one or more specific domains of life (Karimi Moonaghi, & Baloochi Beydokhti, 2017). One example of *situational procrastination* is *bedtime procrastination* defined as “failing to go to bed at the intended time, while no external circumstances prevent a person from doing so.” (Kroese, De Ridder, Evers, & Adriaanse, 2014, p. 1).

*Academic procrastination* is defined as “to voluntarily delay an intended course of study-related action despite expecting to be worse off for the delay” (Steel & Klingsieck, 2016, p. 37). *Procrastination at work* is defined “putting off work-related action by engaging in nonwork-related actions during work hours” (Metin, et al., 2016, p. 254). It is still possible to find more action or context-specific types of procrastination in the literature, and each of them has slightly different and quite similar definitions at the same time depending on what angle they were looked at.

Gueorguieva (2011) pointed out “one can readily see that different theorists use different labels when referring to similar types of procrastination, and that there is sometimes significant overlap between different theorist’s types” (p. 31). Milgram, Batori, and Mowrer (1993) classified procrastination under five categories: *life routine procrastination* (e.g., paying bills),
decisional procrastination, neurotic procrastination, compulsive procrastination, and academic procrastination. More recently, Klingsieck (2013) systematized current approaches in the literature to draw a more general picture of procrastination and ended up with four distinct broad approaches: the differential psychology perspective (i.e., procrastination is a personality trait), the motivational and volitional psychology perspective (i.e., procrastination is a case of motivational and/or volitional failure), the clinical psychology perspective (e.g., chronic procrastination), and the situational perspective (explained above).

2.3. Delay vs. Procrastination

There is almost no single day that people do not encounter a delay; a bus is delayed, a flight is delayed, a meal delivery is delayed, a conference is delayed, a meeting is delayed, an assignment submission is delayed. It is hard to avoid delaying or being delayed on something in everyday life. Even though the term “delay” evokes negativity, sometimes it might be the smart thing to do; delaying a newly-introduced vaccine until seeing the side effects, or the delay of having a child for those who are not ready to be parents yet. However, the delay sometimes might be unavoidable; the delay of one task/assignment in order to achieve a more important or compelling task (Haghbin, 2015). For instance, while having multiple competing deadlines, giving priority on one task or strategically delaying the other task/s for a reason (e.g., importance of task, motivational feeling of completing a task) is justifiable.

In general, the constant, voluntary, irrational postponing the initiation of a task in relation to a deadline while knowing one would be worse off due to the delay is called procrastination whereas delay refers to postponing starting a task. In other words, “not all delay is procrastination, but all procrastination is delay” (Pychyl, 2013). The thin line between delay and procrastination is the consistency (delaying occasionally versus regularly and consistently on the
same type of task) and the reason behind the dilatory behavior. If a task is delayed because of a logical reason, this is simply strategic delay, whereas if the same type of task is kept being delayed constantly for no-reason or even for made-up reasons, it is called procrastination. This further highlights the need for more contextual information and data on what individuals actually do and the importance of distinguishing between strategic and purposeful delay versus procrastination.

Current studies have implemented self-report style measurement tools (i.e., surveys) to assess delay (e.g., Bembenutty & Karabenick, 1998; Pinxten, De Laet, Van Soom, Peeters, & Langie, 2019; Svartdal, Klingsieck, Steel & Gamst-Klaussen, 2020) and procrastination (e.g., Sutcliffe, Sedley, Hunt & Macaskill, 2019; Wessel, Bradley & Hood, 2019). However, taking into consideration the precise difference between strategic/purposeful delay and procrastination, the need for more data channels is obvious and necessary. That’s why one of the aims of the study is expanding current data channels by including digital trace data.

2.4. Procrastination: Operational Definitions

The limitations of data channels to measure procrastination have been a well-known issue among procrastination researchers for years (Haghbin, 2015). Recent emerging digital learning platforms (e.g., learning management systems, MOOCs) bring a variety of new data channels to the field, therefore, different operational definitions of procrastination have emerged in the field. In other words, researchers come up with a formula or a way to measure and discuss procrastination based on the data available in their research studies.

Agnihotri, Baker and Stalzer (2020) put forward an operational definition of procrastination by taking into account only the time when a student starts studying or doing something toward their academic goal. The authors presented two operational definitions: task
procrastination and learner procrastination. Task procrastination as its name suggests, refers to procrastination on a task, in their case assignments. It is described as a binary variable with values of either 0 and 1; 0 referring to “not procrastinated” and 1 referring to “procrastinated”. To be able to label a student 0 or 1 on a task, the authors defined a threshold time procedure for each assignment since procrastination behavior is a dynamic process. The 75th percentile of assignment grade Z-score table was used to decide the threshold. If a student started studying after threshold time, their study session was marked at “procrastinated”.

Learner procrastination index was defined as the percentage of task procrastination. For instance, there are 10 assignments in a course, and based on task procrastination formula, the student procrastinated on 7 assignments. In this case, the student’s Learner Procrastination Index (PI) would be calculated as 0.7 (a value between 0 to 1), where higher values indicate more procrastination tendency.

Similarly, another operational academic procrastination definition comes from Moon and Illingworth (2005) under the name of behavioral academic procrastination. The participants had seven days to complete each assignment that was made available through the online learning tool. The day a student first opened (clicked the assignment link) the assignment in relation to when the one-week window started was used in the authors’ formula to calculate the procrastination score. The difference between the day the assignment was opened and the submission of the assignment day was described as behavioral academic procrastination (day indexing starts from 0). For instance, a student checks an assignment on the very first day it is published (day 0) and completed on the last day (day 6), the procrastination score would be 6 (6 – 0 = 6). The scale goes between 0 to 6, where higher scores indicate more procrastination.
Another operational definition was suggested as the time difference between students’ proposed study time and actual study time under the name of *behavioral procrastination* (Krause & Freund, 2014 based on DeWitte & Schouwenburg, 2002 works). Students were asked how much time they planned to study and how much time they actually studied on a task, and those two numbers were subtracted from each other to calculate procrastination level. The number used as an indicator of procrastination. Specifically, the authors emailed participants twice a week over eight weeks and asked about how much time they planned and how much time they actually studied in the last 24 hours. For instance, one who reported to have planned 5 hours but studied 4 hours, their *behavioral procrastination score* was calculated as: 1 (5 – 4 = 1, study minutes were used as the unit).

Solomon and Rothblum (1984) used *behavioral index of procrastination* which was described as the number of assigned tasks (quizzes) taken during the last 5 weeks of the semester. There is no explanation why the last third of the semester was picked as threshold. The study was conducted in a psychology class and at the end of each chapter students were assigned to self-paced quizzes. There was no specific deadline for each quiz, students were free to submit any of the quizzes at any time before semester ends. Number of quizzes student took in the last 5 weeks was used as procrastination indicator; higher the number indicates more procrastination. For instance, a student submitted 10 quizzes in the first 8 weeks of the semester, and 12 quizzes in the last 5 weeks of the semester. In this case, 12 is used as the *behavioral index of procrastination*.

All operationalized formulas above are examined by looking at their possible advantageous and disadvantageous in rest of the section (Table 1). Learner Procrastination Index (Agnihotri et al., 2020) has a strong advantage since it looks at procrastination as a dynamic
process and calculates the procrastination threshold for each task individually. However, the way that procrastination \textit{threshold time} is calculated disregards personal differences while embracing task characteristics. The 75\textsuperscript{th} percentile of assignment grade Z-score table was used to calculate the \textit{threshold time}. In other words, success (grade) is used as way to decide the procrastination threshold line. Moreover, labelling a student a procrastinator or not-procrastinator, in other words, binary labelling, disregards the variability among procrastinators. As the authors state that if a majority of students start studying after the deadline, the threshold time would be after the deadline which does not make sense, so in such cases the deadline is assigned as the threshold time. Also, how students should be labeled if they start working on the task on threshold time is not mentioned in the paper.

Behavioral Academic Procrastination measurement (Moon & Illingworth, 2005) points out the importance of when students first consider, noticed or were notified of a task, in other words, the formula considers when students became cognitively aware of the task and when they actually got it done. However, procrastination is a process, it cannot be fully explained and measured by only looking at time difference between becoming aware of a task versus the time the task was finished. This disregards all the actions the student takes within that time frame (e.g., how often and how long they studied). Krause and Freund’ (2014) Behavioral Academic Procrastination measurement takes into account students’ perception regarding the task (how long they planned to spend time on the task at the beginning) and their actual behavior (how much time they actually spend on the task) Again, procrastination might not be fully measured only by looking at planned versus actual time spent on a task.
### Table 1

*Operationalized Procrastination Formulas from Literature*

<table>
<thead>
<tr>
<th></th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learner Procrastination</td>
<td>Dynamic procrastination threshold</td>
<td>Third party (classmates) focused threshold time</td>
</tr>
<tr>
<td>Index (Agnihotri, Baker</td>
<td>Takes into account task characteristics</td>
<td>determination</td>
</tr>
<tr>
<td>&amp; Stalzer, 2020)</td>
<td></td>
<td>Binary procrastinator labelling</td>
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<tr>
<td></td>
<td></td>
<td>Poor edge cases handling</td>
</tr>
<tr>
<td>Behavioral Academic</td>
<td>Takes into account the time/day students</td>
<td>Poor edge cases handling</td>
</tr>
<tr>
<td>Procrastination (Moon &amp;</td>
<td>noticed the task and when they actually</td>
<td></td>
</tr>
<tr>
<td>Illingworth, 2005)</td>
<td>take action to work on it</td>
<td></td>
</tr>
<tr>
<td>Behavioral Academic</td>
<td>Takes into consideration perception versus</td>
<td>Insufficient variable to explain procrastination</td>
</tr>
<tr>
<td>Procrastination (Krause</td>
<td>reality</td>
<td></td>
</tr>
<tr>
<td>&amp; Freund, 2014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral Index of</td>
<td></td>
<td>Arbitrary constant</td>
</tr>
<tr>
<td>Procrastination (Solomon</td>
<td></td>
<td>procrastination threshold</td>
</tr>
<tr>
<td>and Rothblum, 1984)</td>
<td></td>
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</tr>
</tbody>
</table>

There are other studies in the literature that utilized the current technologies to measure “procrastination” without clearly explaining the measurement tools’ theoretical or logical standpoint. Levy and Ramim (2012), for instance, conducted an exploratory study on a relatively big online exam dataset by investigating students’ procrastination. The study was conducted on 10 similarly designed courses that were taught to sophomore through senior level undergraduate students. Each course had 6 online exams that had a one-week open window frame.

Procrastination was measured as “…the proximity to due time and was measured in hours before the due time.” *(p.100).* For instance, one who complete an exam exactly one day before the due, would be assigned procrastination score of 24. Apparently, higher score indicates lesser procrastination tendency. Similarly, Sumaya and Darling (2018) claim to propose an alternative methodology for assessment of procrastination along with flow (“…what makes experience genuinely satisfying is a state of consciousness called flow” (Csikszentmihalyi &
Csikzentmihaly, 1990, p.1). They utilized Experience Sampling Method in an introductory level psychology course \((n = 14)\). Procrastination was measured throughout 6 days before a major writing task was due by calling the participants 3 times a day over the phone and asking what they currently do as an activity, \textit{how challenging the activity is} (10-point Likert Scale), how confident they are about their skill set on the activity (10-point Likert Scale). Procrastination was measured “…based on one of the major tenets of flow: the ratio between perceived challenge and perceived skill.” \((p.3)\). In other words, one — who claims challenging a task 5 and claims to have 3 confidence level out of 10 about his/her skill set to achieve the task—would have 1.6 \((5 / 3 = 1.6)\) procrastination score.

\textbf{2.5. The working definition for Observed Procrastination}

As it mentioned previous section, the field of academic procrastination is actively seeking more data channels to understand the cognitive, metacognitive, and affective characteristics of the behavior. MOOCs (e.g., Agnihotri, et al., 2020), learning management systems (e.g., Moon & Illingworth, 2005), even emails (e.g., Hensley & Munn, 2020) were utilized so far to enhance these data channels. However, mobile technology (e.g., mobile phone, tablets) has not been taken advantage of on this matter yet. It might be due to the lack of resources (e.g., financial) or shortage of multidisciplinary studies. In this dissertation study, data from a custom designed mobile application is used to understand academic procrastination along with traditional data channels (i.e., self-report surveys). The mobile application design and data collection procedure are explained later in the paper (Chapter 3.2.2). In this section, points of justification for the operational definition of academic procrastination that is used in this study is explained.

To be able to accomplish an academic task or goal, every student spends a certain amount of time on it. This time duration, in other words, may consist of a number of small study sessions
or chunks, or one long study session where the student starts and completes the task all at once. The durations and number of sessions may vary based on task characteristics (e.g., an easy vs. a difficult task), the student’s personal differences and preferences (e.g., self-efficacy, prior knowledge and background, goal orientations), and outside factors (e.g., whether they work full time and have other family responsibilities for a part of the day).

As noted before, procrastination is defined in the literature as the voluntary and unnecessary delay of starting to work or continuing working on an intended task despite expecting to be worse off because of the delay (Sirois, Yang & van Eerde, 2019) or “putting off for tomorrow what one should do today” (Milgram, Sroloff & Rosenbaum, 1988, p.197), a tendency to postpone working on a given task to the last possible time (Gafni & Geri, 2010, p.115). Based on these definitions and taking into account that every task requires a different amount of time to accomplish because of its characteristics and students’ personal differences (e.g., background knowledge, skills), in this dissertation, I operationalize the term observed procrastination as a behavior characterized by: postponing starting to work on a task and postponing working on the task until the last few days or hours before the deadline. In the context of the trace data in this study, postponing to start working on a task can be inferred from students starting to study on their task later than their proposed start date that they identified while setting goals in the mobile app. Waiting until the last days or hours to study can be inferred from a high number of and longer durations of study sessions just before the deadline. In other words, I hypothesize that students who procrastinate study more frequently and for longer periods of time on the days preceding the due date of an assigned task. Later in the Methods section, I will explain how I formulize the hypothesis in detail along with an example case.

2.6. Theoretical Frameworks
2.6.1. Self-Regulated Learning and Procrastination

The idea of becoming master of one’s own learning processes paved the way to emergence of self-regulated learning (SRL). Unlike the name “self” suggests, SRL combines individual and social forms of learning processes (e.g., how one regulates their learning as a result of feedback from teachers or peers) (Zimmerman & Schunk, 2001, p.1). SRL refers to a learner’s “deliberate planning, monitoring, and regulating of cognitive, behavioral, and motivational/emotional processes toward completion of an academic task/goal” (Hadwin, Järvelä & Miller, 2011, p. 68). It is “an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment” (Pintrich, 2000, p. 453).

Although there are numerous SRL theoretical frameworks in the literature, there are four key assumptions in common among them (Zimmerman & Schunk, 2001). The first assumption is being an active learner. Learners are not passive knowledge recipients, rather, they are seen as active and constructive participant of the learning process. The second assumption is that learners have more or less power to control over essential learning activities. In other words, learners have the potential to control and monitor various aspect of their learning (e.g., cognitive, motivational, affective, etc.). The third assumption is that learners have criteria, standards, or goals to evaluate the learning progress against, which gives them a chance to assess or compare their learning progress. The last assumption is that SRL processes facilitate the associations between personal factors and performance outcomes (Pintrich, 2000).

Zimmerman (2000) proposed three cyclical self-regulatory phases; forethought and planning, performance, and self-reflection (Figure 1). Forethought phase includes task analysis
(goal setting, strategic planning) and self-motivation beliefs/values (self-efficacy, outcome expectancies, task interest, goal orientation). This is the phase where a learner sets sub-goal/goal and plans the learning journey by aiming to enhance their current state of learning. The next phase is performance which consists of self-control (self-instruction, imagery, attention focusing, task strategies, environmental structing, help seeking) and self-observation (metacognitive monitoring, self-recording). In this phase, learners monitor their performance to be able to make improvements on their learning strategies while they engage in a task. The last phase of the cyclical model is self-reflection which contains self-judgment (self-evaluation, causal attribution) and self-reaction (self-satisfaction, adaptive/defensive inferences). In this phase, learners evaluate their performance and make necessary adjustments to optimize their learning strategy taking into account self-evaluations. The optimized learning strategy affects next forethought process; therefore, the self-regulatory cycle gets completed.

Managing one’s limited resources, cognitive or otherwise, while studying is important. A meta-analysis by Richardson, Abraham and Bond (2012) found that effort and time management, help seeking, elaboration, and critical thinking was closely linked to academic achievement in higher education. Continuous time management or monitoring progress toward goals by the learner produces cognitive ‘products’ that can help the learner decide whether to adopt a new strategy, drop the one they’re using, or revise how they are deploying that strategy. For example, in studying for an exam which is due in two days, the learner might evaluate that the amount of
content left to cover is too much compared to the time they have left and decide to review and skim the content and use the ‘note-taking’ strategy instead of deep reading of texts.

Procrastination is identified many times as a failure of SRL, or failure to effectively plan (set goals), monitor (monitor progress toward goals, time management), and self-reflect (revise plans based on feedback from monitoring) in the literature (see Balkis & Duru, 2016; Ferrari, 2001; Howell & Watson, 2007; Pychyl & Flett, 2012; Steel, 2007; Steel & Ferrari, 2013; Wolters, Won & Hussain, 2017). Even it is defined as the “lack or absence of self-regulated performance” (Tuckman, 1990, p.4). Senecal, Koestner and Vallerand’s (1995) experimental
study with a large sample size (N = 498) found that 25% of variance in academic procrastination can be explained by self-regulation. Similarly, Cosnefroy et al. (2018) conducted a study to examine the relationship among self-regulated learning (specifically forethought phase), procrastination and academic performance in a French university. The result revealed that procrastination has statistically significant moderate negative relationship with forethought phase ($r = -.44, p < .001$) whereas no relationship was found between procrastination and academic performance ($r = - .11, p > .05$).

Similarly, Asri, Setyosari, Hitipeuw, and Chusniyah (2017) investigated learning achievement gap between procrastinator and non-procrastinator students. The authors examined the low high school mathematic achievement by looking into the role of procrastination in the learning process to figure out the reasons behind procrastination in mathematic learning. The study was designed with qualitative methodology; with interviews, observations and questionnaires used as data collection instruments. Six mathematic teachers and 154 students from six different high schools in Madiun, Indonesia, participated the study. Questionnaire data were collected from students while interviews were conducted on teachers. The data were analyzed in three stages: data reduction, data presentation, and the data conclusion/verification, respectively. The results showed that academic procrastination has an effect on low mathematic achievement. Further, high procrastinators showed low self-regulated learning. Although, SRL does not embrace or explain every aspects of procrastination, their relationship cannot be disregarded and requires in depth exploration with new approaches such as digital trace data and data triangulation.

One of the key components of SRL is self-monitoring which refers to how students monitor their learning and progress toward their goals. Self-monitoring has been measured in
different ways based on research context, for instance, asking participants to keep track of how much time they spent on taught concepts (e.g., Lan, Bradley & Parr, 1993), implementing a subscale of Self-Regulation of Learning Self-Report Scale (SRL-SRS; Toering, Elferink-Gemser, Jonker, van Heuvelen, & Visscher, 2012), asking participants to keep learning diaries (e.g., Fabriz, Dignath-van Ewijk, Poarch & Büttner, 2014), or reflective journaling (Hensley & Munn, 2020).

There is a very limited number of studies in the literature that explore specifically the association between self-monitoring and academic procrastination. Pfister (2002) examined the effects of self-monitoring on academic procrastination among high and low procrastinators. In his study, Tuckmans’s (1991) procrastination measurement tool was implemented which assesses the procrastination score between 16 to 64. The study was designed as a quasi-experimental study by dividing participants as high (>40) and low (<30) procrastinators based on Tuckmans’s scale (medium level procrastinators were eliminated in the study), thereof, four groups emerged: high/low procrastinators who self-monitor and high/low procrastinators who do not self-monitor. The study was conducted on undergraduate level students in educational psychology courses (N = 208) in two universities, and each universities’ data were analyzed separately due to the concern of sample representation. Experimental groups received a form every week that included key terms that were taught over the semester and were asked to keep track of study time amounts on those terms and return back to instructor each week. Multiple independent sample t-test were run to see if there is a difference among groups, each group were compared with its own counterpart group (e.g., high procrastinator who do/do not self-monitor). One of the tested hypotheses was “High procrastinators who self-monitor will have lowered tendencies to procrastinate than high procrastinators who do not self-monitor” (p.95).
Procrastination tendency was measured as binary variable: turning in the form (1) and not turning in the form (0). University I’ data revealed that there are significant differences between high procrastination groups. In other words, high procrastinators who do not self-monitor are more likely to show procrastination tendency whereas University II’ data suggested there is no significant difference between the two groups of students.

As mentioned above, self-monitoring is examined via different tools. Wäschle, Lachner, Stucke, Rey, Frömmel and Nückles (2014) explored the effect of visual feedback (as a self-monitoring tool) on procrastination by presenting participants’ procrastination level on previous tasks on a color-coded line chart. The authors investigated if the presenting previous task procrastination to participants has an effect on their subsequent procrastination level. This experimental study consisted of two parts. First, visual feedback effect was tested with two groups: visual feedback and no visual feedback group \( (n = 18) \). In a later study, the visual feedback group was divided into two conditions: randomly-generated visual feedback and regular feedback group \( (n = 49) \). Procrastination level was calculated as the mean value of a four survey items designed by the author (e.g., *I postponed my task until the very last minute*, 1 = I disagree, 5 = I agree). Both studies showed that presenting back previous procrastination level has statistically significant decreasing effect on future procrastination level.

Another tool utilizes self-monitoring is journaling (i.e., asking participants to write their reflection about how have done on a goal). Hensley and Munn (2020), for instance, conducted a qualitative study to examine the effect of journaling on procrastination as an intervention \( (N = 11) \). All the participants were self-identified procrastinators in the study and asked to write their recent procrastination experience biweekly, then follow up interview sections were conducted. Thematic analysis revealed that journaling (self-monitoring) helps a- understanding
procrastination, b - making changes in the moment, c - motivating action, d - finding direction for change.

2.6.2. Achievement Goal Theory and Procrastination

Individuals engage in a task for many reasons, but when they engage with the purpose of showing competence to others, developing their competence and advancing their understanding, they are more likely to focus on the task (Kaplan & Maehr, 1999). Demonstrating competence (and avoiding failure) is defined as performance orientation where developing competence (learning for one’s own sake and learning not to fail oneself) is defined as mastery orientation. Both mastery and performance goal-orientations are further ramified as approach and avoidance orientations. As a result, four distinct goal orientations emerge: performance avoidance, performance approach, mastery avoidance and mastery approach goal orientations (Elliot, & McGregor, 2001, Table 2). For instance, when a task deadline is approaching, the individual can engage the task with the goal of getting a better grade than others (performance-approach), or they might avoid to show incompetence because there is a chance to get a worse grade than others (performance-avoidance). Both performance goal orientations focus on demonstrating either competence or avoiding failure or appearing incompetent. Similarly, the individual can engage the task to truly learn the task objectives (mastery-approach), or they might engage in the task to avoid disappointing themselves (master avoidance).
Table 2

2 x 2 Achievement Goal Framework

<table>
<thead>
<tr>
<th>Approach</th>
<th>Mastery</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastery</td>
<td>Mastery-approach</td>
<td>Performance-approach</td>
</tr>
<tr>
<td>Performance</td>
<td>Mastery-avoidance</td>
<td>Performance-avoidance</td>
</tr>
</tbody>
</table>

Since individuals’ type or level of engagement in a task can affect when the task is started, goal orientations are investigated in relation to procrastination. It is a logically-correct standpoint that avoidance goal orientations (mastery and performance) should have positive correlation with procrastination since students are avoiding a task/goal by definition, whereas approach orientations should have negative or arguably no-correlation at all. However, controversial results were reported in the literature. Wolters (2003) reported a positive relationship between performance approach goals and procrastination, whereas there was no relation between performance avoidance goals and procrastination. On the other hand, McGregor and Elliot (2002) found a positive relationship between both performance goals and procrastination. On the contrary, negative association was reported between mastery/performance approach and procrastination but positive association with mastery avoidance (Howell & Buro, 2009). More recent studies generally reported performance-avoidance as significant predictor of procrastination (e.g., Strunk, Cho, Steele & Bridges, 2013).

Ganesan, Mamat, Mellor, Rizzuto and Kolar (2014) pointed out the contradicting results and stated that cultural differences might cause the discrepancy, because cultural differences affect achievement goal orientations (e.g., Western culture might be more performance oriented). Therefore, they conducted a survey study with a large sample size in a non-Western population,
in Malaysia ($n = 450$). Tuckmans’s (1991) procrastination measurement tool and Achievement Goal Questionnaire (AGQ; Elliot, & McGregor, 2001) were utilized in the study. Pearson’s correlation results revealed that mastery approach ($r = 0.23, p < .001$) and performance approach ($r = 0.15, p < .01$) were positively associated with procrastination, while mastery avoidance ($r = -0.02, p > .05$) and performance avoidance ($r = -0.01, p > .05$) had no correlation with procrastination. Further, the author ran multiple linear regression and found that mastery approach explains more variance in procrastination than other goal orientations. The study showed that the contradiction in the literature cannot be explained only with participants’ cultural background.

Similarly, Seo (2009) investigated, specifically, mastery goal orientations (approach and avoidance) and avoidance goal orientations (mastery and performance) in relation to procrastination as two separate models. The study utilized Aitken Procrastination Inventory (API; Aithen, 1982) to measure procrastination and the 2x2 achievement goal orientation scale (Park & Lee, 2005) to assess goal orientations. The study was conducted with 307 undergraduate students who enrolled in a psychology course. The results revealed that mastery approach goal orientation ($r = -0.46, p < .001$) had a statistically significant negative correlation with procrastination whereas performance approach goal orientation showed no relation to procrastination ($r = -0.02, p > .05$). Both mastery ($r = 0.39, p < .001$) and performance ($r = 0.24, p < .001$) avoidance goal orientations showed statistically significant and positive association with procrastination. Further, structural equation modelling was run to test the proposed two models. The first model which is: avoidance goal orientations (mastery and performance) in relation to procrastination have better model fit than the second model (mastery goal orientations (approach and avoidance) in relation to procrastination). This suggests that mastery avoidance
and performance avoidance goal orientations have significant positive effect on procrastination. In other words, higher tendency on mastery avoidance or performance avoidance goal orientations results in higher procrastination tendency.

More recently, Shi (2018) examined reasons behind academic procrastination by considering achievement goal orientations. The study was conducted within a secondary-level education institute in China ($n = 141$). Procrastination Assessment Scale Students (PASS; Solomon & Rothblum, 1984) and AGQ (Elliot & McGregor, 2001) were utilized in the study to measure related variables. Interestingly, the results revealed that mastery avoidance orientation ($r = -0.46, p < .001$) had a statistically significant negative correlation with academic procrastination, whereas performance avoidance orientation ($r = 0.52, p < .001$) had a significantly positive correlation with academic procrastination. Both mastery approach ($r = -0.52, p < .001$) and performance approach ($r = -0.66, p < .001$) goal orientation showed significant negative association with academic procrastination.

There are very limited studies in the literature that investigate academic procrastination in the light of the 2 x 2 achievement goal framework. The existing ones are already presenting contradicting results as mentioned above, and this points out more comprehensive relation investigation among goal orientations and procrastination in the area. Among the reviewed studies, all of them implemented self-report style procrastination measurement tools (surveys) to assess procrastination but none of them looked at the relationship between behavioral procrastination and goal orientations, which is one of the goals of this dissertation study.

2.7. Research Questions

Although procrastination is linked to various variables, self-regulation failure (Steel, 2007), motivation and emotion regulation (Wypych, Matuszewski & Dragan, 2018), personality
variables (Brownlow & Reasinger, 2000), flow experience (Lee, 2005), very few studies conducted an experimental study to comprehensively understand procrastination because of over-reliance on self-report measures. The shortage reveals the necessity of a new approach. Therefore, I propose the following research question to examine the relationship between self-reported procrastination (perceived) and actual (observed) procrastination:

**R.Q. 1**- What is the relationship and differences between perceived and observed procrastination?

Students’ motivation for engaging in a task is considered an important variable that might affect procrastination, therefore, the association between achievement goal orientation and procrastination is investigated. However, contradicting results were found in the literature (e.g., McGregor and Elliot, 2002; Wolters, 2003). The contradiction calls for an in-depth investigation of the area because “engagement” is undeniable truth that affects one’s action on a goal. The current studies, in the literature, have included self-report instruments results only. However, I propose to compare self-reported goal orientations results with actual planning and goal setting, as indicated by the trace data of students’ goal setting for their academic goals in the app. Hence, the following research question is put forth:

**R.Q. 2**- What are the relationships between students’ self-reported goal orientations and their actual planning and goal setting?

**R.Q. 2.1**- What are the differences between observed procrastination on different goal types (e.g., exam vs. assignment)?

Procrastination, more broadly, is linked in the literature to time management skills (Eerde, 2003; Lay & Schouwenburg, 1993). Time management is a multidimensional process that can be explained with the theory of self-regulated learning (SRL) (Zimmerman, 2008). SRL entails forethought (planning and setting goal/sub-goal), performance (self-control), and self-reflection (metacognitive monitoring). Time management is a key aspect of the ‘planning’
process, where the learner evaluates task (time, resources) and cognitive conditions (e.g., domain knowledge), and sets goals/sub-goals that he/she deems attainable given these conditions. During learning process, the learner monitors the learning process himself/herself by making evaluative judgments about the extent of the knowledge understanding, whether they have met the goals or sub-goals (Zimmerman, 2002). Although, procrastination has been reported self-regulation failure many times (e.g., Balkis & Duru, 2016; Steel, 2007), specifically on what multidimensional process procrastinators fail is lacking in the literature. Thus, I propose the following research question to explore, if there is any association between procrastination level and monitoring progress toward goals. Monitoring progress toward goals is measured in the app by how often and for how long students view the progress charts provided.

**R.Q. 3- What is the relationship between procrastination level and how in-app progress reports are viewed?**

In the next chapter, I will be describing the design of this dissertation study and the methods I employed to gather and analyze data.
CHAPTER 3: METHODOLOGY
3.1. Participants

A total of 61 graduate and undergraduate level students who registered for any class offered in Fall 2020, Spring and Fall 2021 semesters at University at Albany, SUNY were recruited. Recruitment letters were distributed electronically to graduate student association (GSA) email list and students in individual departments (e.g., computer science, educational psychology) (Appendix 1). All participants were compensated for their time with a $50 Amazon electronic gift card at the end of the semester, in return for filling out a survey battery via Google Forms at the beginning of the semester and using a mobile application throughout the semester, also a survey pushed in mid-semester via the mobile application. The details about the survey battery and the mobile application will be explained in next section. There was no gender, race, ethnicity, age, background and departmental restriction in the recruitment process.

3.2. Instruments

In the proposed study, there are two main data channels: survey data and digital trace data. General Procrastination Scale (GPS; Lay, 1986), Academic Procrastination State Inventory (APSI; Schouwenburg, 1995), and Achievement Goal Questionnaire Revised (AGQ-R, Elliot & Murayama, 2008) were administered as a survey battery (Appendix 3). The mobile app (Proccoli, http://www.albany.edu/proccoli/) and questionnaires will be explained in the next section in detail.

3.2.1. Self-report measures

3.2.1.1. General Procrastination Scale

General Procrastination Scale (GPS: Lay, 1986) was originally developed as a 20-item 5-point Likert scale with high internal consistency (alpha = 0.82, Lay, 1986) to measure global or everyday procrastination. However, in this study, a short version of GPS was implemented called
GPS-9 (Sirois et al., 2019, Appendix 3. 1.) which is developed as a 9-item 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) with 3 reverse scored items (e.g., “Even with jobs that require little else except sitting down and doing them, I find they seldom get done for days.”). As the original scale, GPS-9 shows high internal consistency (alpha = 0.89, Sirois et al., 2019). After reverse scoring and averaging into a single score, higher numbers indicates a higher level of procrastination tendency.

### 3.2.1.2. Academic Procrastination State Inventory

Academic Procrastination State Inventory (APSI: Schouwenburg, 1995, Appendix 3. 3.) is a 23-item 5-point Likert scale (1 = not at all, 2 = incidentally, 3 = sometimes, 4 = most of the time, 5 = always), and consists of three sub scales; *Procrastination* (13 items, e.g., “Gave up studying early in order to do more pleasant things.”), *Fear of failure* (6 items, e.g., “Wondered why you would study if this would mean so much trouble for you.”), *Lack of Motivation* (4 items, e.g., “Doubted that you should have ever taken this course.”) with good reliability as measured by Cronbach’s alpha = 0.90, 0.85 and 0.79, respectively. APSI measures specifically academic procrastination as its name suggests, in other words, it focus on how students procrastinate in academic settings (e.g., delaying studying for a midterm) versus procrastination in everyday life (e.g., going to the doctor, getting an oil change).

### 3.2.1.3 Achievement Goal Questionnaire

Achievement Goal Questionnaire is originally developed as a 12 item 7-point Likert scale instrument (AGQ; Elliot, & McGregor, 2001). Later, the authors realized and identified some measurement problems and revised the instrument. In this study, in order to measure goal-orientation, a 12-item Achievement Goal Questionnaire Revised will be administered (AGQ-R, Elliot & Murayama, 2008; Appendix 3. 4.). AGQ-R scale ranges from 1 (Strongly Disagree) to 5
(Strongly Agree) and measures mastery-approach ($\alpha = 0.84$, 3 items, e.g., ‘I desire to completely master the material presented in this class.’), mastery-avoidance ($\alpha = 0.88$, 3 items, e.g., ‘I am worry that I may not learn all that I possibly could in this class.’), performance-approach ($\alpha = 0.92$, 3 items, e.g., ‘My goal in this class is to get a better grade than most of the other students.’), and performance-avoidance ($\alpha = 0.94$, 3 items, e.g., ‘I just want to avoid performing poorly.’) goal orientations with high reliability.

### 3.2.2. Mobile Applications

#### 3.2.2.1 Proccoli

For this study, I developed a mobile application (under iOS operating system: [Proccoli, http://www.albany.edu/proccoli/](http://www.albany.edu/proccoli/)) that helps students with planning their academic tasks (e.g., setting goals/sub-goals, scheduling reminder notifications) and monitoring their progress from beginning to end of the task (e.g., tracking time spent, checking progress bars) all in one place. The app is developed in Swift programming language and can be used on iPhones and iPads.

First, when the app is opened, students were asked to create an account with their email address (Figure 2a) along with a username. Once the account is created, they received an authentication email to verify the email for security reasons (Figure 2b). After verification process is completed, they were able to log in (Figure 2c) and ready to create a goal.

Once logged in the app, they saw their profile page (Figure 3a). On the profile page, the app has three functional buttons that enable students to edit their profile, create goal, and see their overall progress (proposed study time versus actual studied time) of all the goals that they have created in the app. In the next paragraph, each of these functionalities are discussed in detail.
Other than buttons on this page, students were able to see the number of total goal/tasks separated as individual and group along with how many of them have already been completed on the upper right corner of the page. On the middle to bottom of the page, student saw all the goals based the goal status (active, expired, or completed) sorted by deadline along with the option of sorting with personal deadline versus due date.

“Edit profile” button takes the user to a page where they can change their profile icon by one of the given options (Figure 3b) and provide demographic information (e.g., age, occupation) (Figure 3c), in other words, user can personalize the account on this page.
“Progress” button takes the student to a page that shows proposed study time versus actual studied time data side by side as a bar chart graph separated by the status (active, completed, expired) of the goal (Figure 4a). On this page, the student saw the overall picture/progress of their past, current and future academic goals. The “Create Goal” button gives students two options: “group” and “individual” goal creation (Figure 4b). Each of the goal creation processes are explained separately in the next paragraph.
3.2.2.1.1 Setting goals for individual projects

The individual goal creation process takes two or three steps depending on how the goal is structured. First, students need to click on “Create Goal” button and select the single person icon (Figure 4b). Second, filling out necessary goal information; goal name, personal deadline, estimated start date, due date, goal type (e.g., exam/midterm, exam/final, assignment, discussion/form, reading) and course number (Figure 5a). If students prefer to structure the goal with sub-goals, there is an “Add Subgoal” button to take the student to another page where they can enter sub-goal details, such as: sub-goal name, deadline, estimated time needed to be spent on the sub-goal, perceived difficulty level from 1 to 10 and estimated start studying time (Figure 5b). If they do not set sub-goals, they can proceed with “Create Goal” button to finish the process which triggers an alert that asks the amount of time they think they need to spend on the
goal (Figure 5c). However, if they structured the goal with sub-goals, the proposed time to be spent calculated as the sum of sub-goals study times.

**Figure 5**

*Individual Goal Creation Process Screenshots*

After an individual goal is created, Proccoli takes the student to *individual goal wall* page (Figure 6a). To simplify the explanation, I divide the page into three sections; upper, middle and lower parts. The upper part has goal information dashboard which shows goal name and deadline along with six functioning buttons; back, timer, reminder, complete, progress chart and settings. The “Back” button takes the student to profile page. “Complete” button as the name suggests completes the goal. Once the goal get completed, on profile page, the goal lines up under the *finished* goals segment. The “Set Reminder” button pops-up a date picker to set a push
notification (Figure 6b). When the predetermined time comes up, the student gets a friendly reminder on their device along with a ring tone to work on their goal (Figure 6c).

**Figure 6**

*Individual Goal Wall’s Features Screenshots I*

“Start Working” button takes the student to timer page (Figure 7a). On the page students can set a time duration by using the slider on the middle of the page. Once they tap “start” button, two other buttons appear on the screen; “stop” and “break”. As the names suggest, they can stop studying and take break for as many times and for as long as they need. They can even turn off their phones after the timer is set, they still got notified when timer runs out (Figure 7b). The 25-minute default time-frame is set based on the Pomodoro method of studying or working in chunks of 25 minutes each, and taking a 5 minute break (Cirillo, 2006). At the end of the study section, students get one question pop-up survey by asking their satisfaction level from not very well to very well with five faces from sad to happy (Figure 7c).
The “Setting” button on the upper right corner takes students to a page where they can update deadlines and delete, edit and add new sub-goals (Figure 7d). The last button on upper individual wall is the “Progress” button. It takes the student to a page that shows all the studied times (the sum of all their study sessions, as kept track using the timer) on the specific goal along with dates as color-coded stacked bar chart (Figure 7e). Color coding is done based on sub-goals. The chart also helps participants monitor their progress, and monitoring one’s progress increase the effectiveness of their studying plan (Bull & Kay, 2008).

Figure 7

*Individual Goal Wall’s Features Screenshots II*
The middle part of the individual wall is allocated for sub-goals. On this section, all sub-goals associated with a big goal are displayed, sorted by their deadlines. The student was able to complete a sub-goal by checking off a checkbox next to the related sub-goal (Figure 8). Lastly, the lower part of the screen is used as a note taking area. Students had a dedicated place for each goal to keep track of relevant notes (Figure 8).
3.2.2.1.2 Setting goals for group projects

The group goal creation process takes only two steps. First, students need to click on “Create Goal” button and select the multiple person icon (Figure 4b). Second, they need to fill out the required goal information; goal name, due date, goal type and course number (Figure 9a).

After group goal is created, Procolli takes the student to group goal wall which has a similar design structure with individual wall for the sake of design consistency (Figure 9b). The upper part of the wall has goal information dashboard which shows goal name and deadline along with eight functioning buttons; back, timer, reminder, report progress, see progress, invite group member, add sub-goal and group member status. The “Back” button takes student to profile page. “Start Working” (Figure 7a) and “Set Reminder” (Figure 6b) buttons works similarly as explained above on individual goal wall.
The upper right corner of the group wall shows group member status (the member invitation and assigned/claimed sub-goal status), group member invite and add subgoal buttons. The “➕” button takes students to add sub-goal page (Figure 9c). Sub-goal can be created in two ways either assigned to self or made available to be claimed by other group members. ”👥” button takes students where they can invite group members for collaboration (Figure 10a). Invitation can proceed in two different ways; in-app invitation which allows to invite users who have already downloaded the app, or e-mail invitation which sends a download link for the app along with the consent form link to the email address of the person identified by the group member (Appendix 1). Once invitation is sent to a student, the student receives a push notification along with in-app notification on the related tab bar area on the bottom of their
screen (Figure 10b). On this notification page, the student had the option to “accept” or “decline” the collaboration. “ ” button takes students to group member status page (Figure 10c).

**Figure 10**

*Group Goal Screenshots II*

On this page, the student saw the general structure of the group goal and all invited group members and assigned sub-goals. The left side of the page shows invited collaborators’ name and their status (active member, waiting for response, waiting for app download and declined member). The right side of the page shows group members along with claimed sub-goals and their color-coded status (completed ‘🟢’, in progress ‘🟡’, not claimed any sub-goal yet ‘🔴’).

If a member’s status is “waiting for app download”, on the right side “Cancel Invitation” button appears instead of sub-goal status.
“Report Progress” button allows students to report their progress on a sub-goal on a percentage scale from 1 to 100. The button pops up a table view with claimed sub-goals if there is any (Figure 11a). Once the student taps the “report” button on selected sub-goal percentage scale appears at the bottom (Figure 11b). On this pop-up style view, students can see all sub-goals and their progress along with who is assigned for that sub-goal in color coded horizontal bar chart (Figure 11c).

**Figure 11**

*Group Goal Screenshots III*

The middle part of the group wall is allocated for sub-goals. On this section, all sub-goals appear, with either *ready to claim by group members* or *assigned group member name* status, and the sub-goals are sorted by their deadlines. Lastly, the lower part of the screen is used as a group chat area. Group members were able discuss, talk, ask questions to each other in this designated area.

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3.2.2.1.3 Filling out in-app surveys

On the bottom of the “Profile Page” (second button from left), a survey button is located (Figure 3a). Once a survey is pushed from Survey Controller Application, participants receive push-notification on their phone as well as an in-app notification as a red bubble on top of the survey button (Figure 12a, Figure 12b). The controller application is explained in a later section in detail (Chapter 3.2.2.2). The in-app notification bubble stays on until the participant fills out the survey.

3.2.2.1.4 Study time and grade report in-app

On the bottom of the “Profile Page” (third button from left), there is a button for study time and grade reporting (Figure 3a). The button takes participants to a page where they can report their study time on a specific goal, in case they forget or were unable (e.g., out of phone battery) to use the in-app timer functionality while they were studying. On the page, all the goals created by the participant show up as scrollable table view along with search option on the top. Each goal has two buttons on the right and left side of the goal name (Figure 12d). The button on the right (time-report icon) allows participants to report past study times as many as they want (Figure 12e). The button on the left (grade icon) helps participants to report the grade they received on a specific goal on either percentage or letter grading scale (Figure 12f).
**Figure 12**

**In-App Surveys and Study Time & Grade Report**

(a) Survey in-app notification

(b) Survey push-notification

(c) Example survey

(d) Study time & grade report

(e) Study time report prompt

(f) Grade report prompt
3.2.2.2 Survey Controller Application

To be able to push predetermined surveys to Proccoli users, I developed a “Survey-Control” iPad application. In the application, three main functionally exists; creating surveys with four different type of survey questions style (check box, radio button, rating scale and open-ended), creating random or planned control-experimental groups, and pushing surveys. In the next section each of the functionalities is elaborated with related visuals.

**Figure 13**

*Survey-Control Application Screenshots 1*

![](image1)

(a) Main page  
(b) Create group page

Once the application is launched, the main page appears with three buttons; “create group”, “add survey”, and “push survey” (Figure 13a). “Create group” button takes the user to a page where one or more groups of users can be formed to send a survey to. On the top of the page, two buttons appear; “split in 3 groups” and “split half” (Figure 13b). As the buttons’ name
suggest, these buttons randomly split all students in Proccoli into either Group A or Group B. Later, some minor group form changes can be made based on research needs (e.g., switching student’s groups, removing some students).

The “Add survey” button launches the page where survey questions are created. Survey display name refers to the name of the survey that appears on student’s phone screen and survey description refers to the text that would appear on top of the survey information. The “Add question” button pops-up a page that provides questions style options and textboxes based on selected question type (check box, radio button, rating scale and open-ended). Once necessary question information is provided, the question shows up on the middle of “Add survey” page (Figure 14a). After all questions are created, the survey can be saved by tapping “save survey” button on the upper left part of the page. Saved surveys are stored in the database to be able to use/re-use in any time.

Lastly, the “push survey” button launches the page that shows all saved surveys in the database. On this page multiple survey selection is possible. After intended survey/s are selected, the last page pops-up which is “student/s selection” page (Figure 14b). On this page, either pre-created group (e.g., control) can be selected, or an individual student can be searched by using related textboxes and buttons. Once the indented group or student/s are chosen, survey/s can be pushed by using the related button on the page.
3.2.2.3 Data Sources

The proposed time management application and control application uses serverless (cloud) architecture and stores the data on Google’s Firebase/Firestore\(^1\) NoSQL database. Firebase’s advanced security rules (e.g., server-to-server authentication) ensures the participant’s data are kept secure all the time. In the database, wide range of data have been storing even have no direct contribution to the study (e.g., phone ids to be able to send notification later). A list of research related digital trace data/variables the apps continuously logs on the server is presented in Table 3 and Table 4.
Table 3

*Digital Trace Data/Variables Generated by the App*

<table>
<thead>
<tr>
<th>Individual Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main goal</td>
</tr>
<tr>
<td>Goal Title, Deadline, Intended start date to study, Intended finish date, Intended total study time duration for the goal</td>
</tr>
<tr>
<td>Sub-goal(s)</td>
</tr>
<tr>
<td>Sub-goal Title, Deadline (due date), Intended study time duration, Perceived level of difficulty, Intended start date and time to study, Timestamp of the sub-goal marked as complete, Timestamp started/finished working on sub-goal.</td>
</tr>
<tr>
<td>Time spent on a goal</td>
</tr>
<tr>
<td>If in-app timer used: Start/break/finish timestamps on the timer/unfinished timers/locations (if allowed) of study session</td>
</tr>
<tr>
<td>If self-report preferred: Start/finish timestamps of study session</td>
</tr>
<tr>
<td>Notes/ Chat messages</td>
</tr>
<tr>
<td>Notes or comments to self about goal</td>
</tr>
<tr>
<td>Progress bars</td>
</tr>
<tr>
<td>Timestamp of progress bar opened, Timestamp of progress bar closed (i.e., how long progress bar was viewed) Progress visual preferences (robust vs blank)</td>
</tr>
</tbody>
</table>

1 [https://firebase.google.com/docs/firestore](https://firebase.google.com/docs/firestore)
2 Individual goal has two options to visualize the progress. First, “blank” is default option which shows the progress from start-date to the current day even there is a day never made a progress on the goal, it will be on the screen. Second, “robust” option eliminates the dates from calendar view that user showed no progress on the goal and squeezes the progress bar each other.
Table 4

*Digital Trace Data/Variables Generated by the App (continued…)*

<table>
<thead>
<tr>
<th>Profile Page</th>
<th>Self-Report Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descriptive data</td>
<td>Individual goal- Group goal</td>
</tr>
<tr>
<td>Profile Page</td>
<td>Self-Report Page</td>
</tr>
<tr>
<td>Overall progress bar</td>
<td>Individual goal- Group goal</td>
</tr>
<tr>
<td>Overall progress bar</td>
<td>Grade on goal</td>
</tr>
<tr>
<td>Overall progress bar</td>
<td>Study time report on goal/sub-goal(s)</td>
</tr>
<tr>
<td>Overall progress bar</td>
<td>Timestamp of progress bar opened, Timestamp of progress bar closed</td>
</tr>
</tbody>
</table>

3.3. Procedure

The study was conducted in Fall 2020, Spring and Fall 2021 semesters. At the beginning of the semesters, participants were asked to fill out the survey battery (GPS: Lay, 1986; APSI: Schouwenburg, 1995) through Google Forms. Achievement Goal Questionnaire Revised (AGQ-R, Elliot & Murayama, 2008) was pushed around mid-semester via Survey Controller Application. This triggered a notification on all users’ phones, clicking on which took them to a page inside Proccoli where AGQ-R questions are presented. All responses were recorded on the Firebase cloud servers. The reason AGQ-R was administered later is that the survey asks students about the types of goals they set (e.g., to get a good grade, to learn as much as possible) while studying for different courses. Administering the AGQ-R in the middle of the semester is to provide an opportunity to students to get familiar with their courses and then answer questions about the types of goals they are setting.

Participants downloaded the Proccoli app on their iPhones or iPads through Apple app store for free (https://apps.apple.com/us/app/id1492747694). All the necessary links (e.g.,
survey battery link, how to use and download the Proccoli links, etc.) and steps participants need to take were provided via email once they signed the consent form (Appendix 2).

3.4. Data Analysis

There are two main data sources in this study as mentioned before. The first is the self-report survey data which are stored on Google Forms and are exported in a table format for analysis. The second is the students’ trace data from the app that are stored on Google Firebase Cloud Servers, which requires intensive pre-processing since it is in raw data format. I developed several code modules using Python programming language for all the data pre-processing. In next paragraphs each research questions are elaborated individually by how the variables are operationalized and measured and what statistical analysis tests are run. Specific examples for each formula are provided in the Result section before results of relevant questions presented. Table 5 summarizes data sources and how data are analyzed pertaining to each research question.
### Table 5
**Data Analysis Table**

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Sources</th>
<th>Statistical Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R.Q. 1</strong> - What is the relationship and differences between perceived and observed procrastination?</td>
<td>Perceived procrastination: GPS, APSI</td>
<td>Observed procrastination: ( 1 - \frac{\sum(\text{The day before deadline} \times \text{Duration of the study session})}{(\text{The deadline} - \text{Proposed start study date}) \times \sum(\text{Total study durations})} )</td>
</tr>
<tr>
<td><strong>R.Q. 2</strong> - What are the relationships between students’ self-reported goal orientations and their actual planning and goal setting?</td>
<td>Self-reported goal orientations: AGQ-R; mastery-approach, mastery-avoidance; performance-approach, performance-avoidance</td>
<td>Actual planning and goal setting: Proposed Start Date versus Deadline Actual Start Date versus Deadline Proposed total study time versus Actual studied time</td>
</tr>
<tr>
<td><strong>R.Q. 2.1</strong> - What are the differences between observed procrastination on different goal types (e.g., exam vs. assignment)?</td>
<td></td>
<td>Goal types: Number of participant-labeled goal types</td>
</tr>
<tr>
<td><strong>R.Q. 3</strong> - What is the relationship between procrastination level and how in-app progress reports are viewed?</td>
<td>Procrastination: GPS, APSI Progress reports viewed: ( \sum(\text{Time Spent on General Progress} + \text{Individual Goal Progress charts}) \times \frac{\text{number of tasks}}{\text{number of tasks}} )</td>
<td>Observed procrastination:</td>
</tr>
</tbody>
</table>

---

3 (Deadline – Total studied amount)

4 (Figure 3a, Figure 6e respectively)
The value of observed procrastination (for a goal created by a student) scales between 0 and 1, where the higher number indicates a greater level of procrastination. To be able to formalize the definitions mentioned in The Working Definition for Observed Procrastination section above (Chapter 2.5.), first multiply the duration of study sessions in a day and the number of days until the task/goal deadline. In other words, the weighted sum of the duration of study sessions per day is calculated, weighted by the number of days remaining to the deadline. This formulates the numerator of a fraction that “rewards” studying early for a goal by assigning greater values to the days that are furthest from the deadline. Then the weighted sum value is normalized to keep it bounded between zero and one. To this end, the numerator is divided by how far the proposed start day is from the deadline multiplied by the total study times that the student had spent on the goal. Finally, the product of this fraction is subtracted from 1 to result in the observed procrastinations score. In summary, I propose the following formula as a way to capture the extent to which students procrastinate toward their goals (Eq. 1):

$$1 - \frac{\sum \text{Day before deadline} \times \text{Duration of the study session}}{\text{Deadline} - \text{Proposed start study date} \times \sum \text{Total study durations}}$$

Where, Day number refers to the number assigned to each specific day, in reverse chronological order as its distance from the deadline (see Fig. 15); total duration of study sessions refers to the sum of the study duration spent by the student within the specific day. On the denominator, Proposed start day number refers to the number of days before the deadline that the student had planned to start studying, and Total study durations for all days constitutes the sum of all durations of study sessions for each goal. In Figure 15, the days are numbered in reverse chronological order (backwards) staring from the deadline as Day 0. The assumption in
formulating this measure is that the student who does not procrastinate would start to study when they proposed they will, and the farther after their start date they begin studying, the more they are procrastinating. Please note that the bars in Figure 15 represent the accumulation of all study session durations that took place in that particular day to illustration purposes. In the calculation, each study section/block is exactly calculated how far from the deadline.

**Figure 15**

*Example Representation of a Student’s Study Times in Relation to The Deadline*

Self-reported goal orientations, as part of the forethought and planning phase of self-regulated learning (Zimmerman, 2008), were measured by a reliable and valid questionnaire (AGQ-R, Elliot & Murayama, 2008) via in-app survey tool while students’ actual planning and goal setting were measured by the goals and sub-goals created in app over the semester. AGQ-R reveals four distinct goal orientations: mastery approach, mastery avoidance, performance approach, and performance avoidance. The actual planning and goal settings is divided into three variables based on the data collected in the app: The time period between deadline and the
student’s proposed start studying date (Proposed Start Date versus Deadline), The time period between deadline and student’s actual start studying date (Actual Start Date - Deadline), and The time duration difference between student’s planned and actual duration of studied time (Proposed-Study-Amount versus Actual-Studied-Amount). Here I propose formulas (Eqs. 2) to represent how these variables are extracted from the app data. The formulas are unique to this study in that they use variables collected in the app. In the next paragraphs, each formula are explained in detail and example cases are provided in the Result section.

Proposed Start Date vs Deadline is how many days before deadline the student is planning to start studying for their goal. In other words, how early or late the goal is planned to study (Eq. 2a), where Actual Start Date versus Deadline is how many days before deadline the student in fact started to study on the goal (Eq. 2b). Proposed Study Amount versus Actual Studied Amount refers to the difference between the amount of time the student planned to study initially and the amount of time they actually spent studying for that goal (Eq. 2c). Values closer to zero mean student’s perception and actual study time are close to each other. In other words, if the result of the equation is zero, the plans students made for their study and how they actually studied match perfectly. If the variable is less than zero, we can say that the student underestimated the time they need to spend on the goal, or if the variable is greater than zero, the student overestimated the time they need to spend to accomplish their goal. In the data obtained from the app, first these variables are calculated for each goal created by a student and later averaged over all goals (Eqs.2.):

$$\frac{\sum (\text{Deadline} - \text{Proposed Start Studing Date})}{\sum (\text{number of goals})}$$

$$a - (\text{Proposed Start Date versus Deadline})$$
Procrastination has been characterized as the failure of self-regulation many times in the literature (e.g., Balkis & Duru, 2016; Steel, 2007), however, specifically on what multidimensional process procrastinators fail is lacking in the literature. The last phase of the SRL cycle (in Zimmerman’s model of self-regulated learning) is self-reflection (e.g., metacognitive monitoring), where learners monitor their learning process and make evaluative judgments about whether they have met their goals. Many studies show that online self-monitoring tools have great potential to enhance SRL, specifically the self-reflection processes (Pérez-Álvarez, Maldonado-Mahauad & Pérez-Sanagustín, 2018). Thereof, I propose the following formula to represent how students’ self-monitoring can be identified and characterized from the app trace data. The formula is, again unique to this study in that it uses variables collected in the app to calculate a self-monitoring value for students (Eq. 3):

\[
\frac{\sum (\text{Deadline} - \text{Actual Start Date})}{\sum \text{(number of goals)}}
\]

\[
b - (\text{Actual Start Date versus Deadline})
\]

\[
\frac{\sum (\text{Proposed time amount} - \text{Actual studied time amount})}{\sum \text{(number of goals)}}
\]

\[
c - (\text{Proposed-Study-Amount versus Actual-Studied-Amount})
\]

There are two charts that summarize students’ progress toward their goals and students can monitor their progress in the app using those charts. One of the charts is where the student can see their overall progress on all goals they have created (Figure 4a), and the other displays students’ progress on individual goals (Figure 7e). The former page displays the durations of
planned study time and actual studied time side by side, the latter shows how much time the student had studied every day between the time they set the goal until the deadline on a calendar. To standardize the time spent on these pages, first the time durations spent on each of these charts are summed up and then averaged over the number of goals the student had created. In the next section, I will be presenting the findings of this study.
Chapter 4: RESULTS
4.1. Research Question 1

In this section, I present the findings for my first research question: What is the relationship and differences between perceived and observed procrastination? Before reporting findings, I will clearly explain how observed procrastination is calculated with the formula proposed in this dissertation by giving three examples from the original data for three different goals with low, moderate, and high observed procrastination.

In the example in Figure 16, the observed procrastination value calculated by the proposed measure is equal to 0.94 (Eq. 3). As seen in the figure, the student has two study sessions working toward the goal with durations of 65 and 225 minutes (for precision, all study sessions data were measured and plugged in the formula in seconds in the original data analysis). The study sessions are 0.75 and 0.2 day away from deadline, respectively, and the proposed start studying day is 5.92 days further away from deadline. The observed procrastination value (of 0.94) indicates relatively a high level of procrastination, where the student did most of the study sessions close to the deadline as opposed to closer to the proposed (planned) start study date. In the other example in Figure 18, the observed procrastination value is calculated as 0.65. This value indicates a moderate level of procrastination, where the student did most of their studies closer to the deadline, but the study sessions were relatively spread out between the proposed start studying date and the deadline, contrary to the former example. Additionally, the further sessions from the deadline were shorter in time and sparser in terms of frequency.

Eq. 1:

\[
1 - \frac{(225 \times 0.2) + (65 \times 0.75)}{5.92 \times (225 + 65)} = 0.94
\]

In another example in Figure 17, the observed procrastination score is measured as 0.18 which indicates relatively low level of observed procrastination. The score suggests a relatively
low-level observed procrastination where the student did most of the study sessions close to the proposed start studying day. Also, the study sessions closer to the proposed start date were longer in time.

**Figure 16**

*High Level Observed Procrastination Example*

\[
1 - \frac{(225 \times 0.2) + (65 \times 0.75)}{5.92 \times (225 + 65)} = 0.94
\]

Example representation of high level observed procrastination
Figure 17

Low Level Observed Procrastination

Example representation of low level observed procrastination

\[
1 - \frac{(59 \times 21) + (59 \times 16.8) + (59 \times 16.7) + (59 \times 16.7) + (54.8 \times 15.7) + (19.3 \times 14.6)}{21.1 \times (59 + 59 + 59 + 54.8 + 59 + 19.3)} = 0.18
\]
Figure 18

Moderate Level Observed Procrastination

Example representation of moderate level observed procrastination

\[
1 = \frac{(59 \times 9.2) + (59 \times 9.1) + (9.7 \times 9) + (34.8 \times 8.9) + (59 \times 7.9) + (57 \times 7.8) + (59 \times 5.9) + (59 \times 1.1) + (59 \times 1.1)}{17.87 + (59 + 59 + 9.7 + 34.8 + 59 + 57 + 59 + 59 + 59)} = 0.64
\]

Example representations of studying behaviors for students with high, moderate, and low observed procrastination scores

Two self-report questionnaires of procrastination were administered: GPS and APSI, the former measuring general or dispositional and the latter situational or academic procrastination.
For each participant, one mean score was calculated for their GPS and one for their APSI survey responses. GPS survey included three items that were reverse scored before calculating the average (e.g., “I usually accomplish all the things I plan to do in a day”). APSI survey had no reverse worded items. These per-student averages are used as the measure of each student’s self-reported procrastination. Table 6 summarizes GPS, APSI, and observed procrastination values.

Table 6

Summary Statistics Table

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed proc</td>
<td>61</td>
<td>.982</td>
<td>.000</td>
<td>.982</td>
<td>.326</td>
<td>.292</td>
<td>.085</td>
</tr>
<tr>
<td>GPS</td>
<td>61</td>
<td>3.333</td>
<td>1.333</td>
<td>4.666</td>
<td>2.993</td>
<td>.809</td>
<td>.654</td>
</tr>
<tr>
<td>APSI Proc</td>
<td>61</td>
<td>2.923</td>
<td>1.692</td>
<td>4.615</td>
<td>3.144</td>
<td>.699</td>
<td>.489</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Next, the observed procrastination value was calculated using the formula proposed above for each goal completed by the students (goal-level value), and later computed the average of all goal-level observed procrastination scores as one average value per student (student-level value).

To be able to see whether there is statistically significant difference between self-reported and observed procrastination behaviors, Paired Samples t-Test was utilized. In order to test for the assumption of normality, I examined a number of items including, a histogram of the distribution of differences, along with a Q-Q plot, and Shapiro-Wilk test. In addition, examining the descriptive statistics, specifically skewness and kurtosis, will help to inform the decision of whether the assumption of normality is met.
Table 7

Descriptive Statistics for Variable Difference APSI-Observed Procrastination and GPS-Observed Procrastination

<table>
<thead>
<tr>
<th>Difference</th>
<th>Statistic</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>APSI proc</td>
<td>Mean</td>
<td>1.513</td>
</tr>
<tr>
<td>Observed proc</td>
<td>95% Confidence Interval for Mean</td>
<td>1.122</td>
</tr>
<tr>
<td></td>
<td>Lower Bound</td>
<td>1.903</td>
</tr>
<tr>
<td></td>
<td>5% Trimmed Mean</td>
<td>1.521</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>1.710</td>
</tr>
<tr>
<td></td>
<td>Variance</td>
<td>2.326</td>
</tr>
<tr>
<td></td>
<td>Std. Deviation</td>
<td>1.525</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>-1.913</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>4.615</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>6.529</td>
</tr>
<tr>
<td></td>
<td>Interquartile Range</td>
<td>2.331</td>
</tr>
<tr>
<td></td>
<td>Skewness</td>
<td>-.163</td>
</tr>
<tr>
<td></td>
<td>Kurtosis</td>
<td>-.645</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Difference</th>
<th>Statistic</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>Mean</td>
<td>1.361</td>
</tr>
<tr>
<td>Observed proc</td>
<td>95% Confidence Interval for Mean</td>
<td>.984</td>
</tr>
<tr>
<td></td>
<td>Lower Bound</td>
<td>1.739</td>
</tr>
<tr>
<td></td>
<td>5% Trimmed Mean</td>
<td>1.363</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>1.519</td>
</tr>
<tr>
<td></td>
<td>Variance</td>
<td>2.174</td>
</tr>
<tr>
<td></td>
<td>Std. Deviation</td>
<td>1.474</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>-1.174</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>4.111</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>5.285</td>
</tr>
<tr>
<td></td>
<td>Interquartile Range</td>
<td>1.950</td>
</tr>
<tr>
<td></td>
<td>Skewness</td>
<td>-.111</td>
</tr>
<tr>
<td></td>
<td>Kurtosis</td>
<td>-.897</td>
</tr>
</tbody>
</table>
Table 7 shows a skewness value of the pair APSI - Observed procrastination -.163 and kurtosis value of -.645 while showing skewness value of the pair GPS - Observed procrastination -.111 and kurtosis value of -.897. Both pairs’ data is within normal range, indicating a normal distribution. In the Q-Q plot, displayed in Figure 19 and Figure 20, all points fall close to or on the line of normality, which again indicates that the data is approximately normally distributed. Further, the Shapiro-Wilk tests in Table 8 shows for both paired variable’s result that is not statistically significant ($p > .05$), therefore I fail to reject the null hypothesis of “the data is normally distributed.” and assume normality of the data. Lastly, the histograms (Figure 21 and Figure 22) appear to deviate a bit from normality, by examining other tests of normality I assume normality of the data.

**Table 8**

*Summary of Shapiro-Wilk Test*

<table>
<thead>
<tr>
<th></th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
</tr>
<tr>
<td>Difference APSI proc Observed proc</td>
<td>.981</td>
</tr>
<tr>
<td>Difference GPS Observed proc</td>
<td>.963</td>
</tr>
</tbody>
</table>

**Figure 19**

*Normal Q-Q Plot of Difference APSI proc – Observed Proc*

**Figure 20**

*Normal Q-Q Plot of Difference GPS– Observed Proc*
As Table 10 shows, the obtained t-statistic for Pair 1 is more extreme than the $t^* (± 2)$, I reject the null hypothesis that there is no significant difference in APSI and Observed Procrastination scores and state the following: On average, participants show a statistically significant different score on in-app data calculated by Observed Procrastination ($M = 1.632, SE = .187$) than when the same participants self-reported their academic procrastination level on APSI ($M = 3.145, SE = .09$). This difference is statistically significant and represents a large effect size $t (60) = 7.746, p < .001, d = 0.992, 95\% CI [1.12, 1.9]$.  

**Table 9**

*Paired Samples Statistics*

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>APSI proc</td>
<td>3.145</td>
<td>61</td>
<td>.700</td>
</tr>
<tr>
<td></td>
<td>Observed proc</td>
<td>1.632</td>
<td>61</td>
<td>1.459</td>
</tr>
<tr>
<td>Pair 2</td>
<td>GPS</td>
<td>2.993</td>
<td>61</td>
<td>.809</td>
</tr>
<tr>
<td></td>
<td>Observed proc</td>
<td>1.632</td>
<td>61</td>
<td>1.459</td>
</tr>
</tbody>
</table>
Similarly, the obtained t-statistic for Pair 2 is more extreme than the $t^* (\pm 2)$, I reject the null hypothesis that there is no significant difference in GPS and Observed Procrastination scores and state the following: On average, participants show a statistically significant different score.

**Table 10**

*Paired Samples Test*

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>95% Confidence Interval of the Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Std. Error</td>
</tr>
<tr>
<td>Pair 1</td>
<td>APSI proc</td>
<td>1.513</td>
</tr>
<tr>
<td>Observed proc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 2</td>
<td>GPS obs</td>
<td>1.361</td>
</tr>
</tbody>
</table>

on in-app data calculated by Observed Procrastination ($M= 1.632, SE=.187$) than when the same participants self-reported their general procrastination level on GPS ($M=2.993, SE=.104$). This difference is statistically significant and represents a large effect size $t (60) = 7.212, p < .001, d = .923, 95\%$ CI [0.98, 1.74].

Further, a post hoc power analysis is conducted using G*Power3 (Faul et al., 2007) to test the difference between paired sample group means using a two-tailed test ($\alpha = .05$), large effect size .992 and .923 respectively. Result shows that a total sample of 61 participants (n= 61) achieves a power of 1 and .99 respectively (Table 11).
Table 11

Power Analysis Table for Pair 1 and Pair 2

<table>
<thead>
<tr>
<th></th>
<th>Test Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Power&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>APSI proc - Observed proc</td>
<td>1</td>
</tr>
<tr>
<td>GPS – Observed proc</td>
<td>.999</td>
</tr>
</tbody>
</table>

a. Two-sided test.
b. Based on noncentral t-distribution.
c. Number of group pairs.
d. Standard deviation of the mean difference.

Lastly, I ran a Pearson correlation to find out the relationship between self-reported (i.e., GPS and APSI surveys) and observed procrastination values. Findings indicate that GPS or global procrastination averages were correlated statistically significant with observed procrastination scores \( r = 0.26, p < .05 \) and APSI or academic procrastination scores show positive correlation with observed procrastination scores \( r = 0.14, p = .272 \) as well. Responses from GPS and APSI were statistically significant and positively correlated \( r = .73, p < .001 \). In other words, students’ perceptions and self-reports about their own procrastinatory behaviors do not match well with their actual studying behavior toward accomplishing their academic goals. The relationship between these two variables was slightly higher in the case of general or chronic procrastination, which is a domain-general indication of procrastination tendencies. This mismatch could point to a miscalibration between students’ perceptions and their actual behavior. This finding is relatively in line with findings of Moon and Illingworth (2005) where they found correlation values of .25, .22, .21, .27, and .19 between their measure of behavioral procrastination (i.e., difference between the date a test window opened and when it was taken by...
the student) and the self-report survey over 5 weeks. Krause and Freund (2014) and Dewitte and Schouwenburg (2002) used the same formula (i.e., planned – actual study duration) as a measure of behavioral procrastination and found correlations of .59 and .12 with self-report measures respectively.

**Table 12**

*Procrastination Scores Correlations*

<table>
<thead>
<tr>
<th></th>
<th>Observed Proc</th>
<th>GPS</th>
<th>APSI Proc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Proc</td>
<td>Pearson Correlation</td>
<td>1</td>
<td>.258*</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.044</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>GPS</td>
<td>Pearson Correlation</td>
<td>.258*</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.044</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>APSI Proc</td>
<td>Pearson Correlation</td>
<td>.143</td>
<td>.732**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.272</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>61</td>
<td>61</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).**

*. Correlation is significant at the 0.05 level (2-tailed).**

One thing to note is that these studies used different surveys to measure self-reported procrastination, and part of the difference between the correlation measures could be attributed to that. Nevertheless, the relationship between self-reported/trait and behavioral procrastination has been found to be moderate to very low, regardless of the formula. I argue that the proposed formula takes into account more features of procrastinatory behavior, such as the proposed start date, deadline, distance of study sessions from the deadline, and allows for multiple study sessions per day, since each is considered as one distinct study session and entered in the formula separately.
4.2. Research Question 2

In this section, I present the findings for my second research question: What are the relationships between students’ self-reported goal orientations and their actual planning and goal setting?

All the necessary data to measure these variables are captured both when the goal is created (e.g., when asked how long they plan to study, Figure 5c) and when participant interacts with the app (e.g., using timer, reporting past studied time, Figure 7a). From more general perspective, Achievement Goal Orientation Theory (Elliot & McGregor, 2001) is interested in what engages a learner in a goal (e.g., studying for the sake of learning) and it posits four categories based on learners’ goal orientations as mentioned earlier (Chapter 2.6.2.). Learners with mastery avoidance goal-orientation, for instance, avoid working toward a goal because they are afraid to achieve lesser than before in comparison to their previous achievement or afraid of failing to complete the goal. One aspect of academic procrastination behavior is avoidance tendency on a goal, therefore, procrastinators’ goal orientation category in relation to the difference between their planned and actual study time amount might give more insight in understanding the behavior. Similarly, procrastinators’ goal orientation category and its association with actual time interval (starting to study a goal date – goal deadline) and planned time interval (date initially planned to start studying on a goal on– goal deadline) might help to understand the behavior more. In addition, the first phase of SRL, forethought and planning (Zimmerman, 2002), comprises task analysis and strategic planning by learners. Taking into consideration that academic procrastination has been reported many times in the literature as a failure of SRL (e.g., Steel, 2007), the research question will shed light on learners’ actual goal planning process as well. The difference between planned study time and actual studied time, for
instance, can show if one has under-estimated or over-estimated how long it would take to work to achieve a particular goal in the *forethought and planning* phase.

To clarify how *Actual Start Date versus Deadline*, *Proposed Study Amount versus Actual Studied Amount*, and *Proposed Start Date vs Deadline* variables are calculated, I describe an example here. For instance, a goal is created with the deadline of November 28th, *planned start studying date* (“When do you plan to start studying for this goal?”) of November 20th, and 8 hours of *expected study duration* in total (“How long do you think you will need to study for this goal?”) (Figure 23). When the student got to work on the goal, in actuality, the first study session happened on November 24th, and in total they spent 10 hours working toward their goal. In this example case, *Proposed Start Date vs Deadline* is 8 days (November 28th – November 20th) where *Actual Start Date versus Deadline* is 4 days (November 28th – November 24th). *Proposed Study Amount versus Actual Studied Amount* is -2 hours (8 hours proposed – 10 hours actually spent). The number shows the difference between student’s planned and actual study times: in this case, the student underestimated 2 hours duration of total study time on the goal. There is no assumption for all three of the variables that I expect to see as perfect scenario. All the values are used to compare students and their goals across one student relatively. Table 13 summarizes the descriptive statistics among variables in the research question.
Next, I ran Pearson correlations to find out relationships among variables measured in app and goal orientation types measured by AGQ-R questionnaire (Table 14). The results show that there are no significant correlations between achievement goal orientations and how early students plan to start studying for their goal. However, students with performance goals orientations, performance approach \((r = -.03, p > .05)\) and performance avoidance \((r = -.03, p > .05)\), planned to start studying their goals slightly later than those with mastery avoidance \((r = -.004, p > .05)\) and mastery approach \((r = .002, p > .05)\) goal-orientations. In other words, students with performance goal orientations give themselves less time to finish their goals. The correlations between the actual start studying time and goal-orientations range from moderate to none. The result shows that there are statistically significant negative correlations between performance goal-orientations and how many days before deadline students actually
| Table 13 |
|-------------------|--------|--------|--------|--------|--------|--------|
|                  | N     | Possible | Minimum | Maximum | Mean   | Std. Deviation |
| Performance approach | 61    | 1 - 5    | 1       | 5       | 3.861  | 0.970         |
| Performance avoidance | 61    | 1 - 5    | 1       | 5       | 3.894  | 1.077         |
| Mastery approach   | 61    | 1 - 5    | 2.333   | 5       | 4.138  | 0.681         |
| Mastery avoidance  | 61    | 1 - 5    | 1       | 5       | 3.666  | 0.834         |
| Proposed Start Date vs Deadline | 61 | 0 - ∞    | 0.665   | 7       | 3.453  | 1.419         |
| Actual Start Date vs Deadline | 61 | 0 - ∞    | 0.123   | 7.094   | 3.081  | 1.599         |
| Proposed vs Actual Studied time amount | 61 | -∞ - ∞  | -12.750 | 15.666  | 1.835  | 4.082         |

started studying whereas mastery goal-orientations reveal non-significant negative correlations.

To be specific, performance avoidance goal orientation is found to be negatively and significantly correlated with Actual Start Date versus Deadline variable, $r(59) = -.29, p < .05$ while mastery avoidance goal orientation shows negative but non-significant correlation $r(59) = -.18, p > .05$. Similarly, performance approach goal orientation is found to be negatively and significantly correlated with Actual Start Date versus Deadline variable, $r(59) = -.37, p < .05$ while mastery approach goal orientation reveals no correlation, $r(59) = -.01, p > .05$. In other
words, student who show performance approach or performance avoidance tendency are more likely to actually start studying later or closer to deadline on their goals than one who shows mastery goal orientation tendency.

*Proposed versus Actual Studied Amount* and goal orientations do not have strong correlations. The result indicates that students with performance avoidance goal orientation have moderate positive correlation \((r = .19, p > .05)\) with *Proposed versus Actual Studied* while mastery approach goal-oriented students show small positive correlation \((r = .01, p > .05)\) with *Proposed versus Actual Studied*. Students with performance approach \((r = -.02, p > .05)\) and mastery avoidance \((r = -.02, p > .05)\) goal orientations have very low non-significant negative correlations with how students stick with their initial plan on studying their goals.

**Table 14**

*Summary of Correlations*

<table>
<thead>
<tr>
<th></th>
<th>Performance Approach</th>
<th>Performance Avoidance</th>
<th>Mastery Approach</th>
<th>Mastery Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Start Date -</td>
<td>Pearson Correlation</td>
<td>-.375**</td>
<td>-.29*</td>
<td>-.008</td>
</tr>
<tr>
<td>Deadline</td>
<td>Sig. (2-tailed)</td>
<td>.002</td>
<td>.023</td>
<td>.949</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>61</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>Proposed Start Date</td>
<td>Pearson Correlation</td>
<td>-.026</td>
<td>-.034</td>
<td>.002</td>
</tr>
<tr>
<td>Deadline</td>
<td>Sig. (2-tailed)</td>
<td>.842</td>
<td>.789</td>
<td>.986</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>61</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>Proposed Study Time-</td>
<td>Pearson Correlation</td>
<td>-.016</td>
<td>.191</td>
<td>.011</td>
</tr>
<tr>
<td>Actual Studied</td>
<td>Sig. (2-tailed)</td>
<td>.902</td>
<td>.14</td>
<td>.93</td>
</tr>
<tr>
<td>Amount</td>
<td>N</td>
<td>61</td>
<td>61</td>
<td>61</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
**R.Q. 2.1-** What are the differences between observed procrastination on different goal types (e.g., exam vs. assignment)?

Task characteristics data (e.g., goal type) are labeled by participants when they create a goal in-app, and observed procrastination is assessed by the formula (Eq. 1). Over the semesters, goals \((N = 356)\) with different goal type categories \((N = 17)\) were created by 61 participants. During data pre-processing, goal types were filtered into 6 categories by grouping too detailed goal type names entered by participants (e.g., “assistantship duties”, “other”, “personal book writing” etc.) into ”Studying (Other)” category. The categories provided in the app for selection by participants (along with the number of goals with each label) are Assignment \((N = 180)\), Discussion/Forum \((N = 47)\), Project \((N = 30)\), Exam \((N = 45)\), Studying (Other) \((N = 25)\) and Studying (Reading) \((N = 29)\) as seen on Figure 24.

**Figure 24**

*Goal Type Frequency*
Descriptive statistics are presented in Table 15. The highest average observed procrastination score belongs to Exam category ($M = 0.34$, $SD = 0.31$), in other words, participants show more procrastination tendency on average on Exams than other types of goals. Studying (Others) ($M = 0.3$, $SD = 0.34$), Assignment ($M = 0.28$, $SD = 0.29$), Project ($M = 0.18$, $SD = 0.25$), Studying (Reading) ($M = 0.16$, $SD = 0.21$), Discussion/Forum ($M = 0.13$, $SD = 0.21$) goal types follow the Exam respectively (see Mean of Observed Procrastination Graph, Figure 25).

Table 15

*Observed Procrastination Scores and Number of Sub-goals Descriptive Table*

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Observed Procrastination</th>
<th>Number of Sub-goals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Std. Deviation</td>
</tr>
<tr>
<td>Assignment</td>
<td>180</td>
<td>0.284</td>
<td>0.299</td>
</tr>
<tr>
<td>Discussion/Forum</td>
<td>47</td>
<td>0.129</td>
<td>0.217</td>
</tr>
<tr>
<td>Project</td>
<td>30</td>
<td>0.185</td>
<td>0.249</td>
</tr>
<tr>
<td>Exam</td>
<td>45</td>
<td>0.341</td>
<td>0.310</td>
</tr>
<tr>
<td>Studying (Other)</td>
<td>25</td>
<td>0.298</td>
<td>0.338</td>
</tr>
<tr>
<td>Studying (Reading)</td>
<td>29</td>
<td>0.158</td>
<td>0.210</td>
</tr>
<tr>
<td>Total</td>
<td>356</td>
<td>0.253</td>
<td>0.290</td>
</tr>
</tbody>
</table>

As stated earlier in the Methods section, after setting big goals, students were able to set one or more sub-goals for each goal, to break down their work into smaller chunks. The goal type with the least number associated sub-goals in average was found to be Discussion/Forum ($M = 0.17$, $SD = 0.6$) while the goal type with greatest number of sub-goals associated in average was Project ($M = 0.64$, $SD = 1.6$) category. In other words, students divided their goals that were categorized as Project into more sub-goals compared to their Discussion/Forum goals, which
makes sense when considering the nature of these categories. This will be elaborated more in the Discussion section later (Chapter 5.1).

**Figure 25**

*Mean of Observed Procrastination Graph*

Pearson’s correlation was run to look into associations between the number of sub-goals associated with a goal, and the observed procrastination score calculated for the goal. The results reveal that the number of sub-goals of Assignment ($r = .27, p < .001$), Discussion/Forum ($r = .16, p > .05$), Project ($r = .36, p < .05$), Studying (Other) ($r = .41, p < .05$), and Studying (Reading) ($r = .41, p < .05$) have positive, while Exam ($r = .01, p > .05$) has no correlation with the associated observed procrastination scores (Table 16). Students, for instance, who structured their goals with more sub-goals on *Studying (Reading)* goals tended to show more observed procrastination score. Similarly, students who created a goal with fewer sub-goals on their *Project* goals had lower procrastination scores (Table 16).
Later, all goal types were combined into “All Types”, and Pearson correlation was run again. The result shows that, in general, the number of sub-goals and observed procrastination score have statistically significant positive correlation ($r = .26$, $p < .001$). In other words, breaking a big goal into smaller sub-goals is associated with higher level observed procrastination tendency. Possible explanations for this finding are discussed in the Discussion section.

**Table 16**

*Observed Procrastination Scores and Number of Sub-goals Correlations*

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Discussion/Forum</th>
<th>Project</th>
<th>Exam</th>
<th>Studying (Other)</th>
<th>Studying (Reading)</th>
<th>All Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Procrastination</td>
<td>Pearson Correlation</td>
<td>.273**</td>
<td>.166</td>
<td>.359*</td>
<td>.011</td>
<td>.414*</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>&lt;.001</td>
<td>0.262</td>
<td>0.05</td>
<td>0.942</td>
<td>0.039</td>
<td>0.026</td>
</tr>
<tr>
<td>N</td>
<td>180</td>
<td>47</td>
<td>30</td>
<td>45</td>
<td>25</td>
<td>29</td>
</tr>
</tbody>
</table>

**4.3. Research Question 3**

In this section, I present the findings for my third research question: *What is the relationship between procrastination level and how in-app progress reports are viewed?*

GPS-9 (Sirois et al., 2019) and APSI (Schouwenburg, 1995) surveys were used as the self-reported procrastination level where *observed procrastination* (OP) was calculated by the proposed formula in Eq. 1. Time spent looking at in-app progress reports (i.e., self-monitoring which is one of the key components of SRL (Zimmerman, 2008)) was calculated by summing up time participants spent on viewing *general* and *individual goal* charts (Figure 4a; Figure 7e, respectively), then averaged across the total number of goals created. To clarify how self-
monitoring variable was calculated by app data I present an example. Assume that 5 goals are created by a student. The student has spent 3, 2, 1.5, 5, 3.5 minutes looking at goal-level progress chart (i.e., self-monitoring page) in total for each goal, respectively. Also, the student spent 15 minutes in total viewing the general level progress chart. In this case, self-monitoring variable is calculated by summing up the time durations spent on 5 goals and general progress chart first, dividing by 5 (i.e., the number of goals) later (see Table 17).

Table 17

*Example Representation of Self-monitoring Variable Calculation*

<table>
<thead>
<tr>
<th>Example Case</th>
<th>Time spent in detail</th>
<th>Time spent frequency</th>
<th>Time spent in total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal 1</td>
<td>1 m., 0.5 m., 1 m., 0.5 m.</td>
<td>4</td>
<td>3 m.</td>
</tr>
<tr>
<td>Goal 2</td>
<td>0.5 m., 1 m., 0.5 m.</td>
<td>3</td>
<td>2 m.</td>
</tr>
<tr>
<td>Goal 3</td>
<td>0.3 m, 0.2 m, 0.5 m., 0.5 m.</td>
<td>4</td>
<td>1.5 m.</td>
</tr>
<tr>
<td>Goal 4</td>
<td>1 m., 2m., 3 m.</td>
<td>3</td>
<td>5 m.</td>
</tr>
<tr>
<td>Goal 5</td>
<td>0.1 m., 0.4 m, 0.5 m, 0.2 m., 0.3 m., 1 m., 1m., 1 m., 0.9 m., 0.1 m., 1 m., 1 m., 1 m., 0.7 m., 0.3 m., 1 m., 1 m., 1 m., 1 m., 1 m., 1 m., 1 m.</td>
<td>7</td>
<td>3.5 m.</td>
</tr>
<tr>
<td>General level</td>
<td></td>
<td>18</td>
<td>15 m.</td>
</tr>
</tbody>
</table>

Self-monitoring (Eq. 3):

\[
\frac{\sum \text{Time spent on General Progress + Individual Goal Progress charts}}{\text{number of tasks}} = \frac{3 + 2 + 1.5 + 5 + 3.5 + 15}{5} = 6
\]

Pearson’s correlation was run to investigate associations among procrastination scores and self-monitoring \((M = 0.73, SD = 1.22)\). The results shows that self-monitoring has statically significant moderate level positive correlation with Observed Procrastination \((r = .38, p < .01)\), and non-significant weak positive correlation with GPS \((r = .06, p > .05)\) and APSI \((r = .01, p > .05)\) scores. In other words, students who have higher observed procrastination score are more
likely to check their progress bar charts in the app, compared to participants who had lower level of observed procrastination score. Possible explanations for this behavior are discussed in the Discussion section.

**Table 18**

*Descriptive Statistics and Correlations*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (Std. Deviation)</th>
<th>N</th>
<th>OP</th>
<th>GPS</th>
<th>APSI</th>
<th>Self-monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP</td>
<td>0.326 (0.291)</td>
<td>61</td>
<td>1</td>
<td>.258*</td>
<td>.142</td>
<td>.383**</td>
</tr>
<tr>
<td>GPS</td>
<td>2.99 (0.809)</td>
<td>61</td>
<td>.258*</td>
<td>1</td>
<td>.732**</td>
<td>.063</td>
</tr>
<tr>
<td>APSI</td>
<td>3.144 (0.699)</td>
<td>61</td>
<td>.142</td>
<td>.732**</td>
<td>1</td>
<td>.013</td>
</tr>
<tr>
<td>Self-monitoring</td>
<td>0.727 (1.219)</td>
<td>61</td>
<td>.383**</td>
<td>.063</td>
<td>.013</td>
<td>1</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.05 level (2-tailed).**

***Correlation is significant at the 0.01 level (2-tailed).***
Chapter 5: Discussion and Conclusion
5.1. Discussion

The broad purpose of the current study was to explore academic procrastination from a perspective that has not been looked at before. To be able to approach the behavior from a different perspective, characteristics of academic procrastination and existing approaches on operationalizing academic procrastination were discovered from the literature as well as the theoretical components of the behavior. This comprehensive literature review revealed that existing measures of operationalization of academic procrastination has suffered from a holistic approach, which means the behavior was generally measured by taking into account either assignment submission time and the assignment deadline, or the date an assignment was announced and when the assignment was actually submitted (e.g., Moon & Illingworth, 2005; Krause & Freund, 2014). This approach disregards details of the process of how students tackle academic goals. The studying process is not always binary (0 = not procrastinated, 1 = procrastinated) or black and white, in other words, an academic goal does not always get finished in one study session or in one day of cramming right before the deadline. There might be multiple attempts or study sessions to complete the goal which, I believe, each individual session should contribute to the measurement of procrastination level on the goal. Therefore, it is disputable to measure academic procrastination only by looking into how much time students allocated for studying towards an academic goal at the beginning versus how much time they actually spent on it (e.g., Krause et al., 2014). In the forethought and planning phase of studying (Zimmerman, 2008) time allocation or budgeting required time for accomplishing a goal is related to how student perceives the goal (i.e., task characteristics) (e.g., is the goal difficult, easy, important), and it can depend on a variety of other factors such as prior knowledge and available resources. Some of those factors might even be beyond the student’s control, such as
unclear goal instructions in the syllabus, having an unstable internet connection, and having a hard time to access materials relevant to the goal. Therefore, operationalizing and measuring academic procrastination by arithmetically subtracting actual study time amount from initially planned study time (e.g., Krause & Freund, 2014) does not seem warranted.

Similarly, it is questionable to measure academic procrastination by subtracting when (the date) a goal is completed (i.e., student submission date on LMS) from when the student become aware of it (e.g., generally the student’s first click into assignment on LMS used as proxy) (e.g., Moon & Illingworth, 2005). In this case, we are labeling students as low-level procrastinator or non-procrastinator because they find out about a goal and take an action sooner than later, and submit it. There might be a lot of different reasons why the student did not take an action once they become aware of it. They can have competing deadlines, are overwhelmed with non-academic goals with the same deadline, have family issues (e.g., family gathering, family emergency), have personal issues (e.g., being sick), might not think the goal is that important or even they might not be consciously aware of the goal (e.g., mistakenly click on the task on LMS, and navigated away to another page right after). There might be even more reasons for this observation. Also, this approach over-simplifies the operationalization of procrastination behavior by seeing the behavior as a time frame between when you find out about the goal and when you submit the product for the goal. In the current study, operationalized procrastination takes into account more features of procrastinatory behavior, such as the proposed start date, deadline, distance of study sessions from the deadline, and allows for multiple study sessions per day, since each session is considered as one distinct study session and entered in the formula separately.
I designed and developed a mobile application (Chapter 3.2.2) where students can plan, create, and manage their academic goals while monitoring their progress with intuitive graphs (https://www.albany.edu/proccoli/). More specifically, I created a research and productivity tool that collects detailed data on how students tackle academic goals, such as deadline, study sessions (including duration of session, when they studied, how often), subgoals, expected (planned) and actual time spent towards accomplishing a goal and many more data points (see Table 3-4). Next, I operationalized academic procrastination as *Observed Procrastination* (OP) by hypothesizing students who procrastinate more show study sessions that are more frequent and closer to each other as the deadline approaches, or similarly, students who procrastinate to a lesser extent show more frequent study sessions closer to their planned start study date, well before the deadline, and I formulized it (Eq. 1). I administered two self-report questionnaires regarding procrastination behavior: GPS-9 and APSI, the former measures general procrastination tendency (chronic or global procrastination), the latter measures academic procrastination. The results revealed that student’s perception of to what extent they procrastinate in academic and general domains is different than their actual academic procrastination behavior. Further, the operationalized procrastination has significant positive correlation with general procrastination while having lower positive correlation with academic procrastination. Even though there is relatively a small positive correlation, this finding aligns with other existing studies (e.g., Agnihotri et al., 2020; Moon & Illingworth, 2005; Krause & Freund, 2014), the findings clearly show there is discrepancy between students’ self-reported procrastination behaviors and actual behavior, in other words, student’s perception about their own procrastination behavior does not match well with their own actual studying behavior towards achieving an academic goal.
The association within self-reported procrastinations (between APSI and GPS self-reports) was relatively higher than the correlation with operationalized procrastination. The higher correlation, again, indicates miscalibration between student’s perception and actual behavior, and it reinforces the necessity of the new data channels to detect and measure academic procrastination behavior. Since both questionnaires evaluate the behavior from self-perception perspective, it is not surprising to see greater correlation between them.

Later, in order to examine students’ planning and goal setting, as the first phase of self-regulated learning (Zimmerman, 2008), I investigated correlations among three variables calculated based on data obtained in the app: the time frame between planned start study date and goal deadline, the time amount difference between planned and actual study time duration, the time frame between the date the first study session actually happened and goal deadline, in relation to Achievement Goal Orientation Theory’s four type of goal orientation: mastery-avoidance, mastery-approach, performance-avoidance, and performance-approach (Elliot & McGregor, 2001). One aspect of academic procrastination behavior is having a hard time to take the first step into studying towards a goal, therefore, what drives or sparks learner to accomplish a goal might give more insight to understanding the behavior. In the literature, there are several studies that looked into these relationships, however, all of them used available self-report questionnaires to measure academic procrastination and reported controversial results. Some of them, for instance, reported negative correlation between academic procrastination and mastery-avoidance goal orientation (e.g., Shi, 2018), some noted positive correlation (e.g., Seo, 2009), and others even reported no correlation at all (e.g., Wolters, 2003). There might be various reasons why these discrepancies happened, for instance, the measurement tools being administered in the studies because in some studies academic procrastination scales are different
than each other. However, the current study focused on students’ actual planning and goal setting processes in relation to their different goal-orientations. It should not be forgotten that some of the calculated in-app variables here, were defined as ‘operationalized academic procrastination’ in some studies explained in previous paragraphs such as Proposed Study Amount versus Actual Studied Amount as a measure of behavioral procrastination (e.g., Dewitt & Schouwenburg, 2002; Krause & Freund, 2014).

The findings, in the current study, are relatively well-aligned with more current studies. The first in-app variable that I calculated is Actual Start Date versus Deadline (Eq. 2) which shows negative correlation with mastery-avoidance goal orientation alike Ganesan et., al. (2014) and Shi (2018). The calculated variable refers to time frame between when the student’s first study session happened, and the goal deadline; in other words, the maximum time interval that the student gives a goal a chance to get it accomplished. The negative correlation indicates here, students who started to work on their goal later, rather than earlier, are more likely to show mastery-avoidance goal orientation tendency. This means that, they show a tendency to avoid working on a goal because they are afraid of not achieving as much they accomplished before or not reaching their own quality benchmark for the goal. On the other hand, Actual Start Date versus Deadline shows no correlation for students with mastery-approach goal orientation. A number of studies in the literature reported contradictory results on mastery-approach goal orientation in relation to academic procrastination, even in recent studies. For instance, Shi (2018) found negative ($r = -0.52, p < .001$) and Ganesan et., al. (2014) noted positive ($r = 0.39, p < .001$) correlation. The current study revealed no correlation at all between Actual Start Date versus Deadline and mastery-approach goal orientation ($r = -.008, p > .05$) which means students who study for a goal only for the sake of learning and having the focus in their mind to
improve their current state of knowledge (i.e., has Mastery-Approach goal orientation), are not concerned about when they start to work on a goal. It makes perfect sense, if students are not in competition in their mind that they need to perform better than their counterparts or compared to their previous success, they would not rush themselves to start early working on a goal. Conversely, if they are not afraid of failure or performing worse than their counterparts (i.e., performance avoidance) and their own previous achievements (i.e., mastery avoidance), they would not keep delaying or procrastinating on a goal. Instead, they would perform the goal based on what they have in their schedule, so, how further, or closer to deadline they study for a goal would be dictated by their workload (e.g., competing deadlines), and other external factors (e.g., friend gathering).

Further, Actual Start Date versus Deadline revealed significant negative correlations with performance-approach goal orientation which is aligned with some of the literature (e.g., Howell et al., 2009; Seo 2009; Shi, 2018) while contradicting others (e.g., Ganesan et., al., 2014; McGregor et al., 2002; Wolters, 2003). Students with performance-approach goal orientation care about how well their classmates and counterparts perform on a goal. So, from logical standpoint, it is normal for students with performance-approach goal orientation to watch, observe and analyze what their counterparts are doing on a goal first and perform better later. For instance, in an online discussion post assignment, if students would like to perform better than others in the class, they would wait for someone else to post first instead of posting first because they do not know how high they need to set the bar in terms of quality of the post yet. Therefore, they would give shorter time frame for themselves to complete the goal which explains negative association between performance-approach and Actual Start Date versus Deadline.
The last goal orientation is performance-avoidance which is the other goal orientation type about which the mostly controversial results are reported in the literature. Again, there are studies in the literature that report positive (e.g., Shi, 2018), negative (e.g., Ganesan et al., 2014) and no correlation (e.g., Wolters, 2003). In the current study, Actual Start Date versus Deadline revealed significant negative association with performance-avoidance goal orientation ($r = -0.29$, $p < .05$). As Achievement Goal Orientation Theory (Elliot & McGregor, 2001) suggests, students with performance-avoidance goal orientation are avoiding working on a goal because they are afraid of performing worse or lesser than their peers. So, it is expected that students with performance-avoidance goal orientation can avert working on a goal as much as possible, thereof, they can have smaller time frame to accomplish the goal which explains the negative association with Actual Start Date versus Deadline found in the current study.

The second in-app calculated variable in relation to goal orientation types is Proposed Start Date vs Deadline, which refers to the time interval between student’s planned start study date (scheduled first study session) and goal deadline. The calculated variable does not show any significant correlation with any goal orientation types. Since the variable predicates on student’s initial planning on a goal, it accounts for many other factors such as competing deadlines and personal life issues. However, setting a date to start working on a goal might be seen tentative date for students with some goal orientations such as performance-approach. As mentioned in previous paragraph, they would like to see how their counterparts doing first, then they can act on it. So, their initial study section might depend on their counterparts’ study date not their initially set study date. Or students with performance and mastery avoidance goal orientations, they are already in the motion of “avoiding” the goal for one reason or the other. So, it is not unlikely that they set reluctant and random studying date for a goal. It should be noted, of course,
this might not apply to all learning situations and is more in online learning, where learner can see others’ work.

The last in-app calculated variable in relation to goal orientation types is *Proposed Study Amount versus Actual Studied Amount*. It measures the difference between how much time student initially (at the sub-goal setting phase) allocated to work on a goal and how much time they actually spent on it. Higher or lower value for *Proposed Study Amount versus Actual Studied Amount* indicates greater discrepancy between student’s perception of time needed to be spent on a goal and how long they actually end up spending working on the goal. A negative value demonstrates the time amount needed to be spent on a goal is underestimated, similarly, a positive value indicates the time amount is overestimated, while zero shows the perfect match for student’s prediction and reality. Surprisingly, there is no significant correlation between *Proposed Study Amount versus Actual Studied Amount* and any goal orientation in the current study. There might be various reasons such as limited number of participants, and some in-app related assumptions. These reasons and many mores are discussed in Limitations section in detail.

Later, I examined the observed procrastination scores on different goal types. In other words, I looked into what type of goals (e.g., project, reading) students are on average more likely to show procrastination tendency. The findings revealed that *Exam* category (*M* = 0.34, *SD* = 0.3) has the highest average OP scores among others which means students are more likely to study and longer study sessions closer to exam deadline. There can be multiple different explanations for this. One, exams generally have bigger percentage effect on final course grades which incentivizes students to work harder to obtain higher grades, but it comes with burden of being evaluated of more comprehensive knowledge than any other academic tasks that instructor
assigns. The volume of knowledge that students need to study can be intimidating and this might motivate them to avoid the task as much as possible (i.e., avoidance is directly linked to procrastination). Two, the procrastination literature demonstrates that student’s burnout level has a positive association with academic procrastination (e.g., Balkis, 2013). Exam generally takes place at the end of semesters which might bring mental and physical fatigue of the semester. This burnout can lead to academic procrastination as well.

The findings also revealed that Discussion/Forum goal type has the lowest average observed procrastination scores. In other words, students are more likely to stick with their initial plan on forum discussion goals than other academic tasks. Arguably, discussion post tasks generally require less time to perform (e.g., reading two articles and writing a post) compared to some other academic tasks such as preparing for a final exam (e.g., being responsible to learn and review a whole semester’s worth of readings to answer questions). Additionally, the weight of grades for discussion posts on final grades is relatively low which could discourage perfectionism on the task. It should be noted, in the literature, perfectionism is pointed out multiple times in positive relation to academic procrastination (e.g., Abdollahi et al., 2020; Jadidi et al., 2011) which explains why Discussion/Forum category has the lowest OP scores on average in the current study.

Further, I investigated, if there is any association between observed procrastination level and how these goal types are structured in terms of number of subgoals students created for each goal. The finding revealed that the number of sub-goals for Reading, Others, Project, and Assignment big goal categories show significant positive correlations with observed procrastination, while the number of sub-goals for Discussion/Forum category shows non-significant positive correlation with observed procrastination. This means dividing a big goal
into smaller chunks to study these goals is associated with higher level of procrastination. On the other hand, number of sub-goals assigned to Exam category shows no correlation with observed procrastination at all. These results are understandable if we dive deep into how these academic tasks are structured in the first place by an authority (i.e., the instructor). For instance, reading and forum discussion, these types of academic tasks are generally assigned to student in each course module, and their required volume of study time intensity and time amount is relatively lesser than an exam. Therefore, structuring a goal into subgoals more than it needs might increase procrastination. In other words, let’s say there is a one hour reading goal and a student divided this goal into six smaller reading sub-goals: each ten minutes instead of one block reading section. Therefore, the student might increase the chance of procrastinating on the task six times by having hard time to start each sub-goal. Of course, this does not mean every goal should start and end in one study section, or focusing on six small subgoals, versus just tackling the task as one big goal and getting it done, however, it should be noted that, having multiple sub-goals comes with its increasing effect on procrastination or the student might have a hard time to start working on it. Moreover, since some goal types are assigned every module again and again (e.g., readings), student can get familiar with the general structure of the goal, and might underestimate or overestimate the time required to work on the goal in the planning and goal-setting phase of their studying. For instance, a twenty-pages reading goal. It is hard to say every twenty pages of reading requires same amount of cognitive effort or time duration, such as a soft-reading article as opposed to a theory paper. There is no study that has looked into “familiarity of a goal effect” on procrastination and how a goal is structured yet, however, this should be one of the future directions to understand the behavior more.
Next, I examined the relationship between procrastination level and self-monitoring. Procrastination is pointed out many times as *failure of self-regulation* in the literature (e.g., Steel, 2007); however, there is no study looking at what phase of SRL students are failing on specifically, and what the mechanisms are. Self-regulated learning refers to a learner’s “deliberate planning, monitoring, and regulating of cognitive, behavioral, and motivational/emotional processes toward completion of an academic task/goal” (Hadwin et al., 2011, p. 68). This research question specifically focuses on monitoring phase of the SRL. *Self-monitoring* variable is measured by in-app data (Eq. 3) while OP, GPS, and APSI are used as procrastination indicators. The findings revealed that *self-monitoring* had a statistically significant positive correlation with OP, and non-significant positive correlation with GPS and APSI. The correlation indicates that students who have greater level of procrastination are more likely to check their progress. Of course, correlation does not mean causation, but the current study shows that at least procrastinators are not failing on *monitoring* phase. Moreover, this shows us those students, higher level procrastinators, are curious about accomplishing their goals because they are more frequently checking their progresses towards a goal. Maybe, they seek help or more resource. They might be worried that they have not worked sufficiently on the goal, and are checking the graphs to find out how much they have actually worked. If that’s the case, *self-monitoring* could be an early detection point for procrastination by providing what those students need in this phase, thereof, hence decrease the procrastination level. The current research invites more in-depth studies to investigate why procrastinators show tendency to check their progress more.

To sum, the current study advances the field of procrastination research by introducing a novel way to operationalize academic procrastination considering some factors that are
commonly used in the literature (e.g., deadline of a goal) as well as factor that has never been proposed or applied before (e.g., consideration of multiple study sessions towards accomplishing a task). This is an improvement on previous studies in the literature (e.g., Agnihotri et al., 2020; Krause & Freund, 2014; Moon & Illingworth, 2005; Schouwenburg 2002) in that it incorporates many more variable in inferring academic procrastination from studying behavior. In other words, this work takes the critical step in measuring and incorporating more variables in operationalizing academic procrastination. A possible way to calibrate this metric is to present the calculated value for each goal back to the student and inquiring them if it reflects their study behavior for their current goal, and if not, what has the formula missed (e.g., a study session not reported due to a high stress of studying for an upcoming exam). This can help further fine-tune the formula I am proposing here, and include the learner’s voice and input in arriving at a more reliable reflection of a student’s past studying behavior. Additionally, the self-report measures of procrastination asks students to report in general, based on past experience, how often they delay studying for an important task. This could elicit a response that is based on the students’ self-efficacy, past successes, and failures, and render a broad judgment about one’s behavior. However, the same student could exhibit different studying behaviors when working toward one goal versus the other (i.e., delay working on one not the other, for any reason).

5.2. Limitations

The first limitation of this study is the assumption that students would regularly use the developed mobile application, especially, the timer functionality while studying. Although, the feature for self-reporting previous study sessions was implemented when some students forgot to use the in-app timer (or due to unstable internet connection, low battery), there were still students who neither used the app timer to log their study times nor self-reported past study sessions.
The second limitation of the study is that using the mobile application can be considered as self-reporting. As mentioned before, one of the focal points of the study is bringing a new data channel as an alternative way to self-reported surveys to measure academic procrastination. Although, the mobile application data keeps this promise, the usage of the mobile application relatively can be seen as self-report. However, the well-known limitation of traditional self-report surveys is that students provide socially desirable responses or there are biases in participants’ self-assessment (Veenman, 2011) which could compromise the reliability of a study. Taking into consideration the nature of the data collection process from the app (e.g., keeping track of studied time amount instead of asking participants self-report about their procrastination behavior), it is safe to say that those shortage of self-reported surveys are minimized.

The third limitation of the study is that feasibility of implementing the operationalized procrastination formula in large scale educational institutions. As seen in formula 1, it requires detailed study sessions data as well as planned start studying date and deadline. Considering conventional widely implemented learning management systems (e.g., Blackboard, Canvas) by education institutions, it can be hard or impossible to collect these types of data and track students’ procrastination tendency in real time at the moment. Therefore, it decreases the generalizability of the proposed formula. However, learning management systems keep tracks of wide range of data (e.g., when students logged-in/out, the amount of time spent on specific content). In near future, they might start collecting detailed study session data as well or make their current data more available to educational researchers.

The fourth limitation of the study is the inability of some participants to use the mobile application due to known and unknown reasons. One of the known reasons is the mobile
application accessibility. Unfortunately, *Proccolli* is only available on App-Store for iPad and iPhone users. Therefore, it prevented the study to reach out a broader portion of the student population (e.g., Android users). Additionally, there are some students who even though they filled out the questionnaires and downloaded the application, they chose not to use the application.

Fifth, the sample of participants in this study comprised graduate and undergraduate level students taking courses in different disciplines. Therefore, the findings cannot be generalized to students in other levels (e.g., high school) or other contexts (e.g., at work, out of school). Moreover, taking into consideration the number of explored variables in the study, sample size is relatively small to generalize the results to population.

**5.3. Implications and Future Research**

The current study sheds light on many possible research directions from wide variety of perspective and some potential implications. First, I will explain the theoretical connection perspective, later I will talk about proposed operationalized procrastination in the study. From *Achievement Goal Orientation Theory* (Elliot & McGregor, 2001) viewpoint, performance-approach, and performance-avoidance goal-oriented students give themselves shorter time interval and study closer to deadline in the present study. The reason might be, as the theory suggests, they mostly focus on what and how their counterparts are doing to be able perform better than them. Especially, for performance-approach goal orientated students, instructor can provide “best” example assignment from previous semesters in addition to providing the grading rubrics. Therefore, for instance, they would not wait to someone to post for discussion forum assignment. Similarly, for a midterm paper, the instructor can provide a high-quality paper submitted before (on a similar topic) as an example. Arguably, this might prevent students in
putting their full potential on the assignment. They might have potential to do better than the “high quality” paper, but since “high quality” paper is bar for them, they might choose not to go beyond, but it should not be forgotten, students with performance-approach goal orientation already focus on doing just better than their classmates.

From *Self-Regulated Learning Theory* (Zimmerman, 2008) perspective, the current study points out academic procrastinators are having miscalibration issue with setting aside and planning for the right time duration they need to spend for a goal on *forethought and planning* phase. Also, academic procrastinators are not failing on *monitoring* phase of SRL; on the contrary, they are more interested in how much progress they have done (as evidenced by the finding that they check their progress charts more frequently and for longer periods). This indicates that they might need extra help or resources to accomplish their goals which refers possible implication of the developed mobile application. The app can send notification to instructor about student who is in this stage specifically and the instructor can help the student at risk. Therefore, the student can overcome whatever the challenge they have and get over dilatory behavior instead of keep checking the progress they have made. Lastly, it should be noted that the current study is exploratory and the findings need to be supported by further experimental and more in-dept studies to draw more concrete conclusions. Future research could aim to investigate why procrastinators show tendency to check their progress more often as well as other self-regulation phases to find out which phase academic procrastinators are failing, to be able to develop evidence-based and effective interventions later. Hence, there is no research that investigates the “familiarity of a goal effect” on academic procrastination, in other words, how being familiar with a goal affects the miscalibration issue procrastinators are having on goal setting phase. This could be another future research direction to pursue.
The current research, also, shows greater association between academic procrastination (APSI) and general procrastination (GPS) than operationalized procrastination in the study which points out the necessity of the different way of approaching the behavior along with the question: Do procrastinators procrastinate no matter what? Therefore, future research can aim the group of students who do not show general procrastination but show academic procrastination tendency, to be able to understand academic procrastination behavior alone, focusing on the domain-specificity of this behavior.

To sum, in the present study I proposed a novel way to operationalize behavioral academic procrastination in terms of trace data of students’ studying behavior gathered by a mobile application. The advantage of this proposed formula lies in that it advances the existing proposed ways of operationalizing academic procrastination by including more features of this dilatory behavior, such as the distance of individual study sessions from the deadline and the proposed start date. This takes into account how well students’ plans match when they initiate studying for their academic goals. I compared the method with the existing ways in the literature and discuss advantages and ways forward. Future work could look into subgoal level procrastination behavior and include student performance metrics in the analyses. In this study, I did not have sufficient subgoal level data and performance metrics to run these analyses. Furthermore, the calculated observed procrastination score could be made available to students as part of their feedback dashboard to enable them to reflect on it and monitor their learning and manage their time toward improved learning outcomes and lower levels of dilatory behaviors. Feedback mechanisms can also be devised to prompt students when the app notices dilatory behavior and provide strategy suggestions and helpful feedback.
References


Mann, L. (1982). The decisional procrastination scale. Flinders University of South Australia.


Appendix 1. Recruitment Letter

We are looking for students to participate in a semester-long research study involving using a mobile application that helps students in planning, time management, keeping track of assignments, and class projects. Our goal is to study procrastination in individual and group tasks. The study also involves completing a number of questionnaires electronically initially and during the semester. You will receive **$50 in Amazon electronic gift card** upon completion of this study. If you are interested and have an **iPhone or iPad** to install the app on, please complete the following consent form, and we will get in touch with you for the subsequent steps. If you have an Android device, you can participate starting next semester when we have the Android version available.

https://docs.google.com/forms/d/e/1FAIpQLSfp15_8nqEKY_FmPncYoWcdMFzbyrG8aFdGonCl0OSnME5uMg/viewform?usp=sf_link

If you participated in our study last semester, you are eligible to participate this semester as well!

Thank you for your time!

*If you have already graduated or you do not want to be contacted regarding this study again, please reply to this email and we will take you off the list.*
Appendix 2. Invitation Email

Dear Participant,

Thank you for your interest in participating in our research study! We’re glad to have you on board!

For the first step, please take a few minutes to fill out a few short surveys by clicking on the link below. It should take about 10 minutes to answer them all. We appreciate your time!

https://docs.google.com/forms/d/e/1FAIpQLSfeLufmxubJC3-sUjb-3bI6mWfU-8n8bvOFmsT2QJaBaQcwHw/viewform?usp=sf_link

Next, click on this link to download our app on your iPhone or iPad (https://apps.apple.com/us/app/id1492747694). Proccoli is completely free to use!

These are two short videos that walk you through the features of the app and how to use it. Feel free to watch them before using the app:
https://www.youtube.com/watch?v=wkiyrWq8xvo
https://www.youtube.com/watch?v=SQI6e6It4aM

The purpose of the app is to help you plan and set goals for your individual and group academic tasks, keep track of how long your study (using an in-app timer and the Pomodoro method), manage your time, and see your progress visually in graphs produced by Proccoli.

Please remember to use the app as often as possible when you are working on any assignment, test, project, or class reading.

At the end of the semester, we will get in touch with you to send you the Amazon electronic gift card to your email address. Please see below this email for more information.

If you are a return participant from last semester, make sure to delete the old version of Proccoli and install this new one. You will then be asked to create a new account in the app.

If you encounter any problems, technical issues, bugs, have any questions about using the app, or would like to give us feedback, please feel free to reach out by email to procresearchalbany@gmail.com.

We appreciate your participation in our study!

Best Regards,
Proccoli team
## Appendix 3. Survey Battery

### Appendix 3. 1. GPS-9

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<tr>
<td>1.</td>
<td>In preparing for some deadlines, I often waste time by doing other things.</td>
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<td>2.</td>
<td>I am continually saying I'll do it tomorrow.</td>
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<td>3.</td>
<td>I often have a task finished sooner than necessary.</td>
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<td>4.</td>
<td>I generally delay before starting work I have to do.</td>
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<td>5.</td>
<td>I usually accomplish all the things I plan to do in a day.</td>
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<td>6.</td>
<td>I usually take care of all the tasks I have to do before I settle down and relax for the evening.</td>
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<td>7.</td>
<td>Even with jobs that require little else except sitting down and doing them, I find they seldom get done for days.</td>
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<td>8.</td>
<td>I often find myself performing tasks that I had intended to do days before.</td>
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<td>9.</td>
<td>I usually buy even an essential item at the last minute.</td>
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1 = Strongly Disagree  
5 = Strongly Agree
### Appendix 3. 2. Academic Procrastination State Inventory

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1. Drifted into daydreams while studying.</td>
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<tr>
<td>2. Studied the subject matter that you had planned to do.</td>
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<tr>
<td>3. Had no energy to study.</td>
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<tr>
<td>4. Prepared to study at some point of time but did not get any further.</td>
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<tr>
<td>5. Gave up when studying was not going well.</td>
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<tr>
<td>6. Gave up studying early in order to do more pleasant things.</td>
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<tr>
<td>7. Put off the completion of a task.</td>
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<tr>
<td>8. Allowed yourself to be distracted from your work.</td>
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<tr>
<td>9. Experienced concentration problems when studying.</td>
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<td>10. Interrupted studying for a while in order to do other things.</td>
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<tr>
<td>11. Forgot to prepare things for studying.</td>
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<tr>
<td>12. Did so many other things that there was insufficient time left for studying</td>
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<td>13. Thought that you had enough time left, so that there was really no need to start studying</td>
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<td>14. Had panicky feelings while studying.</td>
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<td>15. Had doubts about your own ability</td>
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<td>16. Experienced fear of failure</td>
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<td>17. Wondered why you would study if this would mean so much trouble for you.</td>
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<td>18. Felt tense while studying</td>
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<td>19. Gave up studying because you did not feel well</td>
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<tr>
<td>20. Found the subject matter boring</td>
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<td>21. Felt that you really hated studying</td>
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<tr>
<td>22. Doubted that you should have ever taken this course</td>
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<td>23. Felt, while studying, that you disliked the subject.</td>
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1 = not at all  
2 = incidentally  
3 = sometimes  
4 = most of the time  
5 = always
### Appendix 3.3. Achievement Goal Questionnaire Revised

<table>
<thead>
<tr>
<th>Statement</th>
<th>Rating</th>
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<tbody>
<tr>
<td>My aim is completely master the material presented in this class.</td>
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<tr>
<td>I am striving to do well compared to other students.</td>
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<tr>
<td>My goal is to learn as much as possible.</td>
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<tr>
<td>My aim is to perform well relative to other students.</td>
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<tr>
<td>My aim is to avoid learning less than I possibly could.</td>
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<tr>
<td>My goal is to avoid performing poorly compared to others.</td>
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<tr>
<td>I am striving to understand the content as thoroughly as possible.</td>
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<tr>
<td>My goal is to perform better than the other students.</td>
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<tr>
<td>My goal is to avoid learning less than it is possible to learn.</td>
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<tr>
<td>I am striving to avoid performing worse than others.</td>
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<tr>
<td>I am striving to avoid an incomplete understanding of the course material.</td>
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<tr>
<td>My aim is to avoid doing worse than other students.</td>
<td></td>
</tr>
</tbody>
</table>

1 = Strongly Disagree  
5 = Strongly Agree

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