AC 2012-4509: THE ROAD TO SUCCESS FOR STEM STUDENT-ATHLETES

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The Road to Success for STEM Student-Athletes

Abstract

Varsity athletics and university science, technology, engineering, and mathematics (STEM) programs are both extremely time intensive commitments. Each requires a considerable amount of discipline and self-motivation on the part of the student. Initially, it would seem that combining these two commitments would be a recipe for disaster, leading to an exhausted, time-crunched student and yield poor performances both in the classroom and on the field. Many students however, continue to prove that concurrent success is possible in both demanding disciplines. At the University of Waterloo, in Ontario, Canada, student-athletes make up approximately 2% of the full-time student population, with approximately 40% of these students enrolled in full-time STEM programs. In this work, 16 members of the university's track and field and cross country teams majoring in STEM programs have been interviewed to discuss their motivation, time management, and coping strategies for successfully navigating life as a STEM student-athlete. Their responses have been applied against Eccles' expectancy-value theory as a motivational framework for the students' continued success. Students discuss lessons they have learned, and how they have successfully been able to apply concepts from their studies to athletics, and vice-versa. These teams were chosen because they each contained the most recent (2010-2011) male and female recipients of the university's award for the varsity student-athlete with the highest academic average during a competitive season. Further, both of these students were majoring in STEM programs. Interviews were conducted with students ranging from freshman through senior undergraduate, and Master's and Ph.D. graduate programs as well. The interviews highlight a series of commonalities and differences across the students, including many of them prioritizing school and athletics above their other life commitments, and each of them possessing a variety of different time scheduling and study habits. From these personal accounts and interviews, a series of best practices for success as either a student-athlete or a regular student involved in other high time commitment co-curricular activities are developed. It also becomes clear that there are many paths leading to success as a student. This work can be used by educators to gain insight into the STEM student-athlete perspective, and by students and coaches alike as they each continue to strive for success.

Introduction

When asked to consider which program a varsity or collegiate level athlete is majoring in, science, technology, engineering, and mathematics (STEM) programs are rarely the first to come to mind. These programs are typically viewed as challenging, time intensive, and in contradiction of the stereotypical athletic archetype[1]. Student-athletes in STEM programs do exist however, and some are even at the top of their class or on the Dean's honour roll. Within the education literature, a considerable amount of research effort has gone into the attraction and retention of STEM students[2, 3, 4], as well as student athletes[5, 6, 7], but there has been little consideration for student-athletes enrolled in STEM programs. The research that does exist is limited to American Division-I schools and the military[8, 9]. What is lacking within current research findings is a general understand of how STEM student-athletes are able to succeed in two challenging, yet distinctly different, pursuits while other students struggle to get by in just one. A great deal of research has gone into time management issues for STEM and non-STEM students[10, 11], and student-athletes[12, 13]. This work considers the research questions:

1. "How do STEM student-athletes manage their time and cope with their unique set of challenges?"

2. "Do STEM student-athletes use the same frequently discussed set of student strategies available in current literature, or have they developed their own set of strategies that allow them to succeed?"

And,

3. "What motivates STEM student-athletes to pursue both endeavours in the first place?"

By answering these questions, faculty and administrators can gain better insight into the STEM student-athlete perspective and structure their programs to facilitate the success of all their students accordingly. Additionally, parallels may be draw between STEM student-athletes and other students involved in other high time commitment co-curricular activities; however, the focus of this study will remain on the STEM student-athlete perspective. Best practices are also developed for students and coaches alike for approaching their own level of success, whatever that may be.

We investigate these issues by applying expectancy-value theory[14, 15], an achievement-based motivational framework, to a set of cross-sectional interviews of members of a Canadian university's track and field and cross country teams majoring in STEM programs. The utilization of theoretical frameworks is something relatively new within the engineering education literature[16, 17]. Although engineering faculty often find understanding theoretical frameworks to be a conceptual hurdle (pardon the track and field pun...), they provide a much needed degree of rigour to the area of engineering education research, and are important in advancing the quality of research in any field[18, 19]. The main concept behind Eccles' expectancy-value theory is that for an individual to be motivated toward a particular task, he or she must believe firstly that he or she has the ability to accomplish the task (described by Eccles as a competency belief), and secondly, the desire to do so (value belief) as well. As an example, for a student to be truly motivated toward attempting to earn an engineering degree, he or she must possess the competency belief that they have the ability to earn the degree, and the value belief that they have a reason for doing so. Within this work, propositional logic is introduced to extend the expectancy-value framework to facilitate a student's motivation toward being both a STEM student and a student-athlete. Commonalities and differences across the interviews are then discussed to highlight the time management and coping mechanisms used by this select group of students. Finally, a set of best practices is proposed.

This work has been approved by the Office of Research Ethics at the University of Waterloo.

Literature Review

This paper leverages many ideas already established within the education and engineering-education literature including: expectancy-value theory[14], subjective task values[15], procrastination modeling[9, 20], and time management strategies[21, 22]. The following section provides a brief description of each of these topics respectively.

Expectancy-Value Theory

Expectancy-value theory provides one of the most important views on the nature of achievement motivation and was first introduced in the psychology literature in 1957[23]. To put the theory broadly, an individual's expectancies for success and the values they have for succeeding are important determining factors for the individual's motivation to perform certain achievement-based tasks[14]. More recent research has expanded these definitions to include discussion on subjective task values[15] and other achievement beliefs regarding motivation and achievement within the educational setting[24].

Eccles' model of expectancy-value for achievement choices[14] acts as a framework for understanding early adolescents' and adolescents' performance and choice within the domain of educational mathematics achievement. Eccles' proposed that achievement performance, persistence, and choice of achievement tasks are most directly predicted by the subject's expectancies for success on those tasks (competency belief) and the subjective values (value belief) they attach to that success. This is illustrated through the use of an example in Figure 1 below.

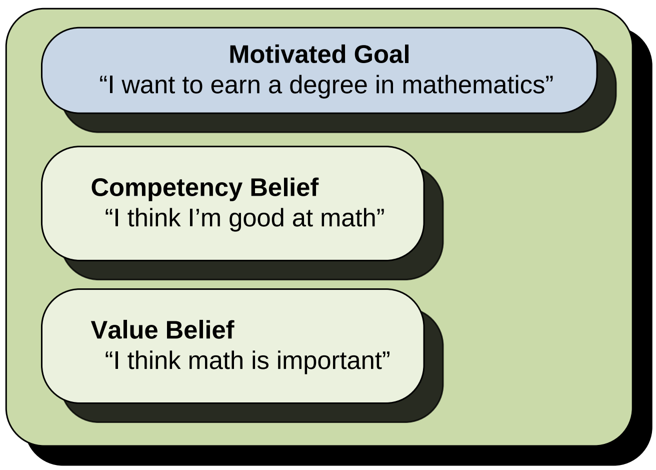

Figure 1: Example of Eccles' expectancy-value theory in the context of earning a degree

Competence and subjective values can be shaped by many contributing external factors, including but not limited to: previous experiences, influence of parents, peers, and teachers, as well as personal and collective identities. As an example, in the context of this study all of the interviewed students were pursuing STEM degrees, so the achievement of this goal is motivated into action by the students' own belief that they are competent enough to satisfy all of the degree requirements, and the students' personal belief that there is some merit (value) associated with a degree in a STEM program. An important point to note about Eccles' model is that it is based entirely on an individual's own perception of his or her abilities and values, and it is not based on his or her actual ability to complete a task.

Subjective Task Values

While competency beliefs consider an individual's viewpoint on his or her ability to complete a designated task, value beliefs consider the individual's desire to complete the task. Eccles defines subjective task values as the individual's incentives for engaging in a given task based on his or her personal belief structure[15]. These values are divided into four separate categories, including: attainment value, the value a task has due to its consistency with one's self image;

intrinsic or interest value, the expected enjoyment of engaging in the task; utility value, the perception of the task facilitating one's long term goals or providing a reward; and finally, cost value, the penalty or consequence associated with engaging in the task. Ideally, one's motivation for engaging in a task or activity comes when the significance of the former three categories outweighs the significance of the cost category. As an example, if a student is considering joining an athletic team, thoughts they may consider include: the degree to which they identify themselves as an athlete (attainment value), their level of enjoyment when playing a particular sport (interest value), how involvement in a sport might look on their résumé (utility value), or the weekly time commitment required to participate in a sport and how it may prevent them from doing other activities (cost value). In the engineering education literature, Matusovich et. al. showed that a student's persistence in an engineering program is significantly influenced by their identity as an engineering student and with the engineering profession. The research concluded that if the student does not identify with these roles, then he or she will have a greater challenge persisting throughout their studies as compared to those that do identify with their program and the engineering profession[3].

Procrastination Model

Within an engineering classroom environment, previous research has been done to investigate the effect of procrastination on students' capability to perform[9]. By utilizing a dynamic systems approach Sterman showed that, within a business environment, those with higher levels of procrastination were consistently outperformed by those with lower tendencies toward procrastination[20]. The model, when applied to an academic setting[9] consists of a causal structure and takes the form illustrated in Figure 2 below.

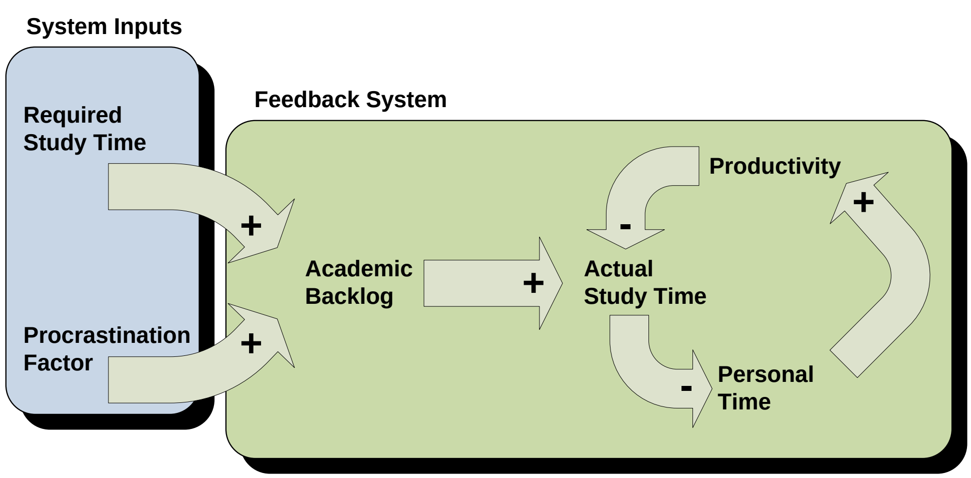

Figure 2: Procrastination modeling applied in an academic setting[9]

The model takes an estimation of a student's required study time for a given academic workload and a procrastination factor as inputs. This generates an academic backlog which increases proportionally as a function of these inputs. The greater the academic backlog, the more study time is actually required. With a finite set of hours per week, the increase in actual study time results in a decrease in available personal time. If a student's personal time is insufficient for them to be able to adequately rest and recharge, academic burnout can set in and result in a decrease in productivity. This decrease in productivity produces inefficiencies in a student's studying behaviour and can lead to an increase in the amount of actual study time. This feedback loop can produce instability (term or course failure) within the system unless the level of procrastination or workload is reduced. This system has been used within the engineering education literature to show that engineering students with increased procrastination levels will often sacrifice sleep and personal time in an effort to maintain a desired level of performance[9]. The unsustainability of this approach however provides justification for monitoring students' procrastination habits, and undertaken workload.

Time Management Strategies in Literature

Many guides exist within the literature and on the web that offer time management and study skills for students and student-athletes alike[12, 13, 21, 22]. They each offer a variety of different strategies for managing time effectively. A sample of these strategies include,

- Keeping a daily, weekly, and monthly calendar including all of your responsibilities
- Prioritizing your tasks and focussing on the most important ones
- Incorporating planned recreation and personal time into your schedule
- Being on time for classes, meetings, practices, appointments, etc...
- Maintaining a balance between your athletic, academic, and personal life
- And, trying to complete at least one major task per day

The idea is that by incorporating these suggested strategies into their lives, students may make a more efficient use of their time. The interviewed students' actual use of many of these strategies will be discussed in the Finding and Discussion sections.

Application of Propositional Logic to Expectancy-Value Theory

In an effort to facilitate a framework for concurrent motivated actions, this work introduces the concept of propositional logic to the expectancy value theory. Propositional logic works to join or modify certain statements or propositions to form more complex propositional structures.

Within the context of propositional logic, there are fundamental and compound propositions[25]. Each proposition is a statement that can be evaluated as being either true or false. Fundamental propositions are non-divisible within their given context, whereas compound propositions are combinations of other propositions and logical connectives such as, conjunction (AND), disjunction (OR), and negation (NOT). Once constructed, the fundamental propositions can be assigned values of either true or false and the compound propositions can be evaluated (also as either true or false). As an example, let "Math is fun", and "Sports are exciting" be two fundamental propositions. We can combine the two fundamental propositions by use of the logical conjunctive connective (AND) to form the compound proposition "Math is fun AND sports are exciting". This compound proposition will evaluate to true if and only if the two fundamental propositions "Math is fun" and "Sports are exciting" are individually true.

This idea can be applied to STEM student-athlete behaviour by combining the motivated goal of a student obtaining a STEM degree described previously with that of the motivated goal toward being a collegiate-level athlete. The conjunction of these two goals from separate areas forms the new motivated goal of becoming a STEM student-athlete. This concept is illustrated in Figure 3 below.

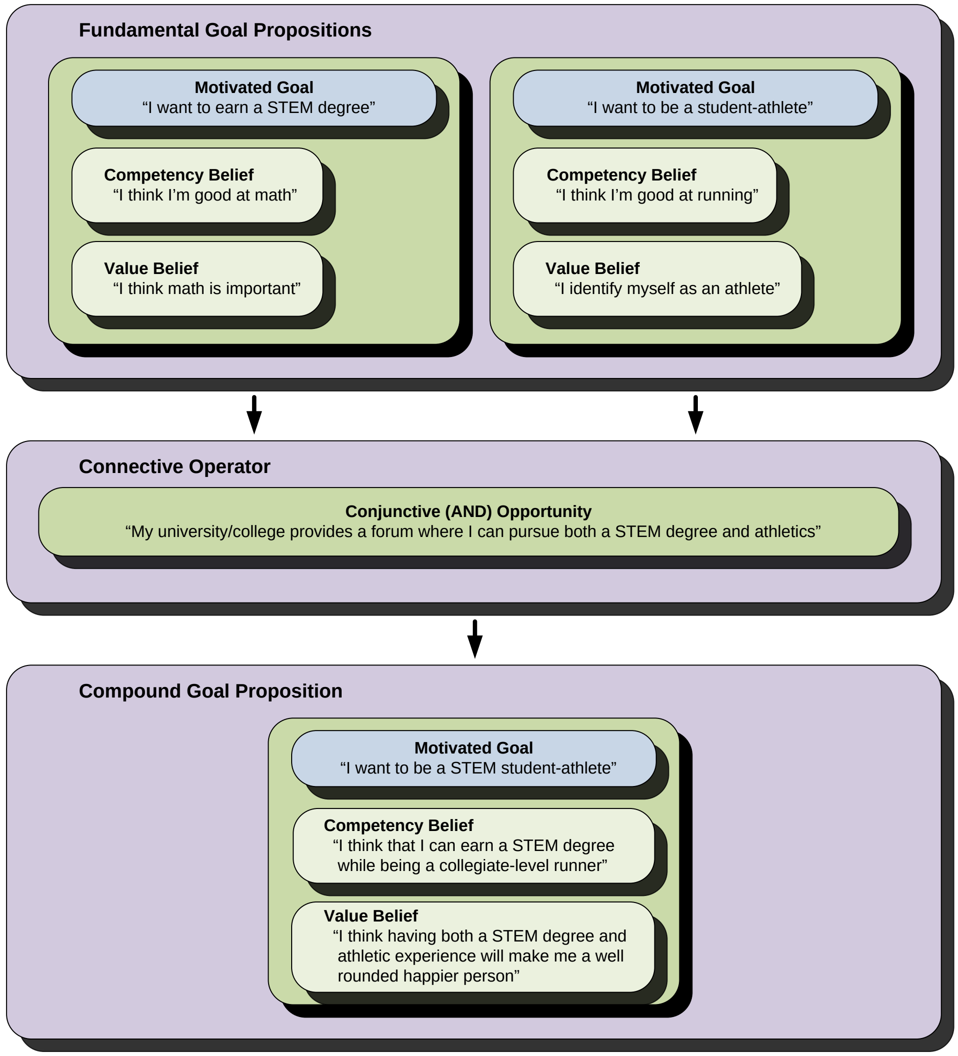

Figure 3: Application of propositional logic to expectancy-value theory

Each individually motivated goal has its own competency and value belief pair. A student motivated toward earning a STEM degree must believe that he or she is competent enough to obtain the degree ("I think I'm good in math") and have a desire to do so ("I think that math is important"), and a student motivated toward becoming a student-athlete must believe in his or her ability to play the sport ("I think I'm good at running") and see purpose in doing so ("I identify myself as an athlete"). The goals of obtaining a STEM degree and being a student-athlete act as the fundamental propositions for the compound proposition of being a STEM student AND a student-athlete, otherwise known as a STEM student-athlete.

Even if a student is motivated toward both individual goals however, it is critical for the opportunity to achieve both goals exists. It is necessary for the logical conjunctive connective (AND) operation to be available to the student, i.e., "my university, or college, provides a forum where I can pursue both a STEM degree and my sport of choice". Provided the conjunctive opportunity is in place, students have the opportunity to form more complex competency and value beliefs such as, "I think that I can earn a STEM degree while being a collegiate-level runner" and "I think having both a STEM degree and athletic experience will make me a well rounded, happier person". This new set of beliefs can motivate a student toward the conjunctive action of becoming a STEM student-athlete. The existence of each of these propositions will be implicitly examined throughout the remained of this report.

Methodology

This section describes the research procedure followed for this investigation. It discusses the context, selection and overview of participants, interview protocol, data analysis, and research quality for this study.

Context

This study was conducted at the University of Waterloo in Ontario, Canada. The University of Waterloo is known as one of Canada's top universities in the fields of mathematics, engineering, computer science and the physical sciences, and hosts one of the world's top co-operative education programs[26]. In contrast, Waterloo's athletics program is of average size and calibre relative to other schools of its size throughout Canada. The university hosted 31120 full-time students (27440 undergraduate, 3680 graduate) as of the Fall of 2011 semester, and its varsity athletics program carried 631 athletes, including 250 STEM students, across 19 sports for the 2011-2012 competitive season. STEM student-athletes made up approximately 40% of the student-athletes and less than 1% of the university's full-time students.

Selection of Participants

To make the interview process and data analysis more manageable, the scope of the participant selection was limited to two of the university's varsity athletics teams. The two teams chosen include the track and field and cross country teams. Each team includes both male and female members. These teams were selected because they each contain the most recent male and female award recipients of the university's outstanding student-athlete award. This award is given annually by the university to the one male and one female student-athlete with the highest academic grade point average (GPA) during their competitive season. Additionally, each of these students was enrolled in full-time STEM programs for the 2010-2011 season.

Once the teams were selected, a call for participants was sent out via the two team's email lists asking for willing participants enrolled in full-time STEM programs. An in-person request was also made at a track and field team practice. The cross country team had just finished their competitive season, and were no longer holding regularly scheduled practices for the remainder of the school term, so a similar in-person call for participants at a cross country practice could not be made.

Overview of Participants

Across the two teams there were 79 student-athletes (53 male, and 26 female) for the 2011-2012 season. Of these, 59 (42 male, 17 female) or 75% (79% male, 65% female) were in STEM programs. In total, 16 STEM student-athletes, or 27% of the potential candidates, volunteered to participate in the study. A summary of the participants is provided in Table 1. The names of all participants have been changed to protect their identities.

Table 1: Summary of participants

Participant	Gender	Program Year	Program Major	GPA
Angela	Female	Grad	Math	95-100
Becky	Female	Senior	Science	70-74
Cathrine	Female	Sophomore	Science	55-59
Danielle	Female	Freshman	Science	90-94
Aaron	Male	Grad	Engineering	95-100
Brett	Male	Grad	Science	90-94
Colin	Male	Senior	Math	95-100
David	Male	Senior	Science	75-79
Elliot	Male	Junior	Engineering	90-94
Freddie	Male	Junior	Math	85-89
Greg	Male	Junior	Math	80-84
Harrison	Male	Junior	Engineering	70-74
Ivan	Male	Junior	Engineering	70-74
Jason	Male	Sophomore	Engineering	75-79
Kevin	Male	Freshman	Engineering	90-94
Liam	Male	Freshman	Science	65-69

Of these student-athletes, six were enrolled full-time within a science program, six in an engineering program, and four within either a computer science or mathematics program. In regard to gender, 12 subjects were male (29% of potential candidates) and four were female (24% of potential candidates). Of these students, there were three freshmen, two sophomores, five juniors, three seniors, two Master's graduate students, and one Ph.D. graduate student. For participation in Canadian Interuniversity Sport (CIS), Canada's equivalent of the National Collegiate Athletic Association (NCAA) in the United States, each student is given five years of eligibility. There are no restrictions on the age or program of participants, provided that they are full-time students in good academic standing, during their time of eligibility. For the graduate students, this typically means they are in their last year of eligibility during the first year of a Master's degree, or they did not participate in collegiate athletics for a portion of their undergraduate degree.

At the University of Waterloo, student grades are awarded based on a 100% (100 point) scale. A histogram of the participants' cumulative academic averages is provided in Figure 4. A student's cumulative academic average is the arithmetic mean of all of the student's course grades in their current program of study up until the current point in his or her academic career. In this paper, this term will be used synonymously with GPA. For graduate students, this value only includes courses taken within the student's current graduate program. Since the interviews were conducted during a Fall term, an exception was made for freshmen students that had not yet completed a full academic term. For these three students, only their midterm averages were considered.

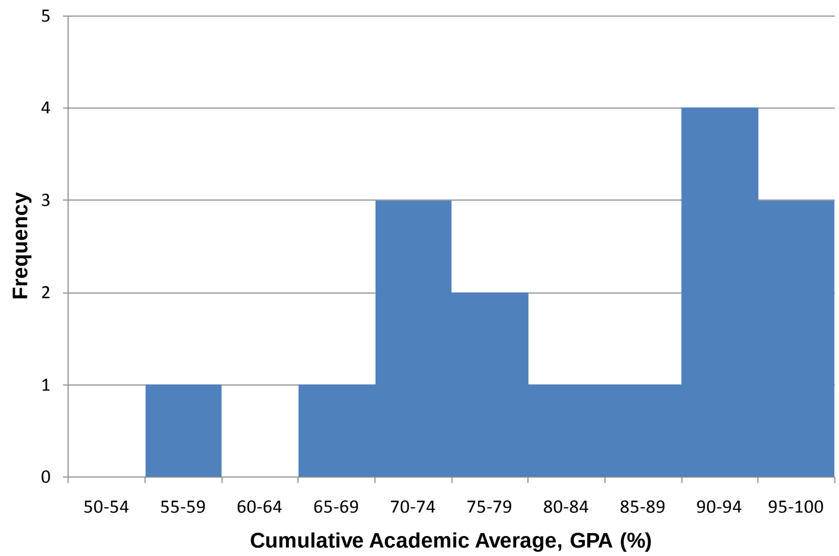

Figure 4: Participant GPA histogram

Figure 4 shows that the majority of students interviewed perform well academically. Only two of the 16 students interviewed had GPA's below 70%, and seven of the students within the interview sample had averages above 90%. It should be noted that of those students with academic averages above 90%, three of them were the three graduate students that participated in the study. In an effort to put these GPA's into perspective, a typical core undergraduate engineering class at the University of Waterloo may have 10-15% of its students with averages above 90%, 20-30% below 70%, and a typical mean score in the low to mid 70%.

Interview Protocol

15 of the 16 interviews were conducted one-on-one by the same student investigator each time at a public and mutually agreed upon time and location. The 16th interview was conducted electronically via e-mail, to which the participant provided written responses to each question. Each interview began with the interviewee being provided with an information and consent letter describing the purpose of the study and requesting his or her consent to the interview process. Once completed, the interviewee would complete a standardized, closed-form, 14-question multiple choice survey regarding a self-assessment of the student's study skills. These survey questions were identical to those in Pierce[8] and acted as a primer for the interviewee to begin reflecting on his or her own personal study habits. The results of the survey are outside of the scope of this report and will be published with a full comparison to Pierce's work at a later date. Participants were then asked a series of 38 standardized questions divided into a set of themes. These themes included introductory (13 questions), time management (12 questions), transferable skill between academia and sports (3 questions), exam and study skills (6 questions), and finally summative style questions to complete the interview (4 questions). A full list of the interview questions is provided in Appendix A. The questions include those seeking both qualitative and quantitative, open- and closed-form responses, and have been developed using a mixed methods research approach[27]. Slight deviations would occur from the prepared interview questions based on the responses of the students. These deviations would occur if a student provided a unique answer to a question that warranted further explanation or discussion, or

answered a question that was intended to be asked later in the interview. Aside from these deviations, the interviewer would ask each interviewee the questions in a standardized order each time. An effort was made to conduct the interviews as a candid conversation rather than a "traditional interview" to allow the students to answer the questions as truthfully and honestly as possible.

Data Analysis

Interviews conducted with the student-athletes were audio recorded and reviewed by two investigators independent of one another. The interviews were analyzed using methods based on those of Miles and Huberman[28]. The interviews were first summarized to extract all information and interesting quotations for each individual interview. Each interview was analyzed separately and responses were then grouped by question for all students. Responses were then analyzed for themes and patterns, and quantitative data such as weekly hours of sleep, athletic and academic time commitments, and degree of procrastination were tabularized and plotted. Commonalities and differences were then analyzed for each question and compared against each student's GPA to identify any correlations.

For coding the data, an inductive approach was used with expectancy-value theory in mind. This was performed iteratively by two researchers until a final convergence was achieved.   The coding output was summarized by interview question. Different colours were used to indicate which responses related to different themes, and letters were used to indicate if that response was positive (P) or negative (N). Neutral responses did not receive a colour coding.

Research Quality

To ensure integrity in the findings of this study, once the interview summaries were complete, they were sent back to the individual student-athlete interviewees for verification to mitigate against research bias. Summaries were sent to students within a one week turnaround time from the interview. Data coding did not begin until all of the interviews had been completed and summaries verified by the participants. Additionally, the findings were integrated into an existing framework to ensure the validity of the findings logic.

Findings

This section presents a summative description of the participants' responses to the interview questions of particular interest. Throughout the interviews, each student expressed their competency and value beliefs associated with being a STEM student-athlete. All four of Eccles' subjective task value categories were represented in participants' choices toward earning their respective STEM degree and being a student-athlete, and these are mentioned where appropriate. Additionally, students commented on their own set of time management skills and coping mechanisms for being STEM student-athletes, and on their views of procrastination.

Definition of Success

To be successful it is important to define what success actually means. To do this, participants were asked the questions, "How do you define success as a student?", and "How do you define success as an athlete?" The common theme across many participants' definition of success as either a student or an athlete was that of setting and obtaining personal goals. Four students added the clause that achieving certain goals should not come at the detriment of other areas of life. One participant defined success as

"...choosing goals that suit your abilities and your priorities, and being able to meet those goals while not adversely affecting the rest of your life". (Colin, Math, Senior)

This sentiment was shared by many of the participants in the study that believed success is a personal quality rather than an attribute relative to others. The students discussed how the goals that they are motivated to achieve fall in line with those that they believe that they are capable of achieving. This coincides with Eccles' concept of competency beliefs, and by choosing goals that suit their priorities they are choosing goals that follow their value beliefs. To reinforce this notion, one of the students with an academic average above 90% stressed the fact that

"I don't put too much weight on marks. I've always strived to do the best that I can and get good marks and I do, but that's almost just 'playing the game'. You need to get good marks to get into good grad schools, or work with good professors. So that's why I get good marks. But, I think that it's more important that I learn the material from the course, and take from it what I needed to, and I wanted to learn it." (Brett, Science, Graduate Student)

This student shows signs of intrinsic interest and utility value towards learning the course material rather than achieving a high summative assessment as motivation for taking a particular course. A positive correlation toward these subjective task values was shared by many of the top students that were interviewed, where they claimed to have an intrinsic interest in the course material, and believed that actually learning the material was more important than their final course grade. This sentiment of prioritizing deeper learning is shared by Felder et. al.[29] as an optimal learning style for long term lifelong learning.

In regard to athletic success, 14 of the 16 participants cited setting new personal best times, throws, or jumps as their measure for success. This is consistent with the participants' view of academic success being a predominately personal pursuit rather than a competition among their peers. Only four participants cited winning races, or beating an opponent as a measure of success. Three participants cited a feeling of belonging or making a positive contribution to the team as a measurement for success. This coincides with Eccles' attainment value as these students attach their athletic success to their identity as athletes.

From the interview participants' responses it is clear that there are many different definitions for what success actually means. By one definition, all of the students interviewed were successful in that they were STEM student-athletes currently passing all of their courses. By their own personal definitions, many of the students considered themselves to be successful, or near successful, in progressing toward their own set of goals. For ease of comparison within this study, cumulative academic average will be used as a key indicator for success, with some consideration for the students' life goals. This method of comparison attempts to provide a means for determining what is required to achieve varying degrees of quantitative success on the GPA scale.

Life Priorities

When asked the question, "What are the main priorities in your life right now?" 15 of the 16 participants stated that school was their number one priority, and 13 of 16 participants stated their sport (track and field, or cross country) as their number two priority. This indicates that STEM student-athletes place a tremendous amount of subjective value in these pursuits, and are willing to accept the cost of making them the top two priorities in their lives. One participant that listed school and track and field as his top two current life priorities stated,

“Academics are my career, and sports are something that I take very seriously”. (Aaron, Engineering, Graduate Student)

The other students that expressed their life goals in this same order expressed similar sentiments. The one student that did not cite school as his top priority instead cited “trying to be happy” as his top priority, track and field as his second priority, and school as his third priority. Other priorities that were listed by participants include: friends, family, social life, girlfriend, or boyfriend (9), part-time job (2), career planning (2), health (1), religion (1), travel (1), and music (1). The fact that the vast majority (over 80%) of participants indicated school and their sport as their top two life priorities provides an indication of the level of dedication and determination by STEM student-athletes to be successful concurrently in both of these areas of their lives.

Weekly Time Distribution

Throughout each interview, participants were asked to provide information regarding the amount of sleep they get on average each night and their weekly time commitments to athletics and academics (including lectures, tutorials, labs, and study time). This data is presented in Table 2 along with their weekly personal time (calculated as 168 hours minus sleep, athletic, and academic hours), GPA, and an additional column providing the sum of the weekly athletic and academic hours for each participant. It should be noted that this data was calculated by the participants as their own perceived weekly average values during their individual interviews rather than by having participants actively monitor their schedules over a period of time.

Table 2: Participants' weekly time distribution

Participant	Sleep Hours	Athletic Hours	Academic Hours	Personal Hours	Athletic + Academic Hours	GPA
Angela	9	20	35	50	55	95-100
Aaron	7.5	21	37.5	57	58.5	95-100
Colin	7.5	7	25	83.5	32	95-100
Brett	6.5	22.5	42.5	57.5	65	90-94
Elliot	9	15	40	50	55	90-94
Kevin	9	15	50	40	65	90-94
Danielle	7.5	6	45	64.5	51	90-94
Freddie	7.5	20	45	50.5	65	85-89
Greg	7	20	50	49	70	80-84
David	6.3	20	32.5	71.4	52.5	75-79
Jason	7.5	12	50	53.5	62	75-79
Becky	6	9	20	97	29	70-74
Harrison	7	13.5	32.5	73	46	70-74
Ivan	6	8	25	93	33	70-74
Liam	7.5	16	30	69.5	46	65-69
Cathrine	8	8	15	89	23	55-59

The table has been sorted by self-declared GPA range and program year. Cells have been highlighted for participants that average nine hours of sleep each night, dedicate 20+ hours weekly to athletics, or 35+ hours weekly to academics. An interesting point to note is that 8 of the 10 students with GPA's over 75% dedicate at least 35 hours per week to academics, and 9 of these 10 students dedicate at least 50 hours per week to a combination of athletics and academics. All five of the students with GPA's less than 75% spend less than 35 hours per week committed to academics and less than 50 hours per week between athletics and academics. Additionally, 3 of the 7 students with GPA's over 90% were graduate students, and all three of the graduate students in the study claim to commit over 20 hours per week to athletics and over 35 hours per week to academics. Further investigation into the participant Colin, with a GPA in the 95-100% range and only 32 athletic plus academic hours, revealed that by taking freshman level courses as his junior and senior level elective courses, he was able to artificially increase his GPA, a practice not undertaken by other participants. To normalize for this advantage, his dataset will not be considered for this portion of the analysis. Figure 5 provides a graphical representation of the weekly hour utilization of a subset of the participants across the GPA spectrum.

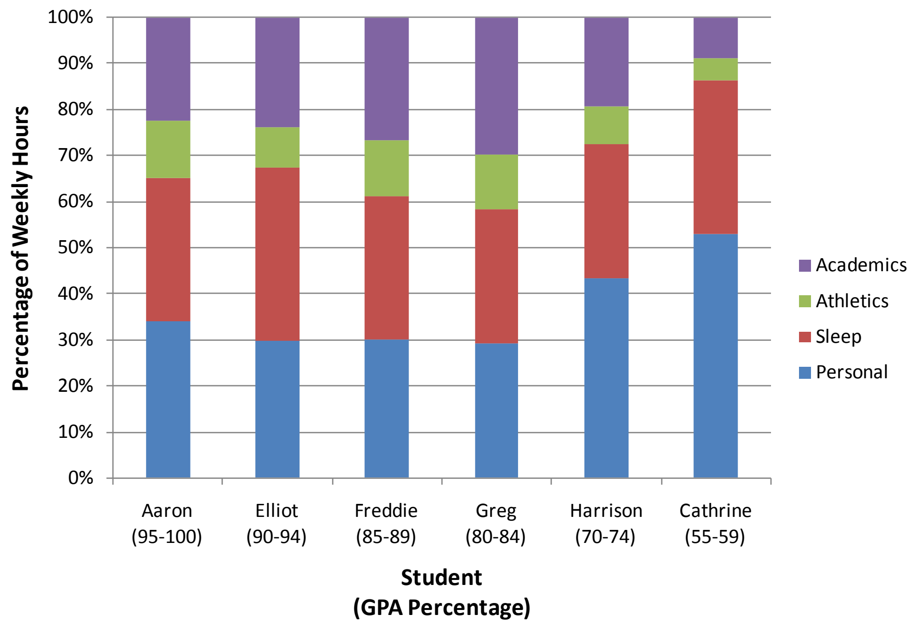

Figure 5: Percentage-base weekly hour distribution for six participants

In this figure, the weekly hour distributions of six participants are shown. The first four participants have grades greater than 80%, and each represent one grade category between 80-100%. Of the other two participants, one has a GPA between 70-74% and the other between 55-59%. One point that becomes immediately clear is that the student-athletes with higher GPA scores simply invest more time into their academic and athletic pursuits than those students with lower GPA scores. This time investment strategy appears to saturate however for those students above the 75% threshold. Those students in the top 20% of the grade range appear to invest similar amounts of time into their sleep, athletics, and academics each with varying results. This would suggest that for grade improvements below the 75% threshold, a greater time investment is all that is required, whereas a different set of strategies are needed for grade improvements above the 75% threshold.

Time Management

In regard to time management, participants presented many strategies for making an effective use of their time. Topics discussed included time scheduling, reviewing course material, pulling "all-nighters", procrastination, and attending study skills workshops.

Participants discussed many time management aids such as planners, calendars, to-do lists, and mental checklists as their main tools for scheduling their time; however, no one aid in particular appeared to have a definitive correlation to student grades. The general consensus was that it is important to be prepared, know what activities and due dates are coming up, and to be able to gauge how long a particular task will take to complete. These views are consistent with those presented by Ulfa[21] and Repak[22]; however, the optimal method for managing these matters is left to individual preference.

When asked about how often participants review their course material, 2 of the 16 participants said that they review their course notes on a daily basis, 10 of the 16 participants said they review either weekly or while doing assignments, and the remaining four students said that they only review course material before midterm and final exams. Three of the four students that claimed to only review material before exams had GPA's below 75%, while the fourth student was the same outlier (Colin) as mentioned earlier. This suggests that although "cramming" may have potential to result in a passing grade, a more significant academic commitment is required throughout the term to breach the 75% threshold. Additionally, the two students that reviewed their course material daily were both freshman (Liam GPA 65-69%, Danielle GPA 90-94%). This suggests that students have a tendency to change their review habits as they progress through their academic careers.

Four students admitted to recently, within the last year, foregoing an entire night of sleep to complete an assignment or study for a test (otherwise known as "pulling an all-nighter"). Additionally, three more students admitted to previously engaging in such behaviour. The remaining 11 students claimed to have never pulled an "all-nighter". One of the students that frequently forwent sleep to study for her exams (Becky GPA 70-74%) said that she "works well under pressures", whereas all three of the students that no longer do so feel that it's not worth it. One stated,

"[Staying up] doesn't work as well, and [school work] takes much longer [to complete]". (Greg, Math, Junior)

One student, adamant against such behaviour, went so far as to say

"I find sleep deprivation has such a big impact on every aspect of my life that there's never any situation where it's justifiable". (Elliot, Engineering, Junior)

Three of the four students that had recently pulled all-nighters had GPA's in the 70%'s, whereas the fourth student, who admitted to this behaviour only about once per term, has a GPA in the 85-89% range. Two of the students that no longer pull all-nighters are now graduate students with GPA's in the 90-94% range. These finding are in agreement with Thacher's which show that engagement in single night total sleep deprivation can lead to lower grade scores and a decrease in student motivation[30]. Sleep deprivation can impact the productivity factor in the procrastination feedback model shown in Figure 2.

Of those students interviewed, only 2 of the 16 admitted to having taken a formal study skills workshop, and only another two of them had read material given to them by either a coach or a faculty member. Of the 14 student that had not taken a formal study skills workshop, five expressed varying degrees of interest in taking a workshop, while the remaining participants stated that they were comfortable with their current study habits.

Procrastination

The amount a student procrastinates appears to have a significant influence on his or her academic performance. Of the 16 students interviewed, five common responses were given when asked if procrastination was something they had a problem with. These responses included: a definitive “yes”, “sometimes”, “a little bit”, “not really”, and a definitive “no”. A scatter plot of these responses compared to GPA is shown in Figure 6.

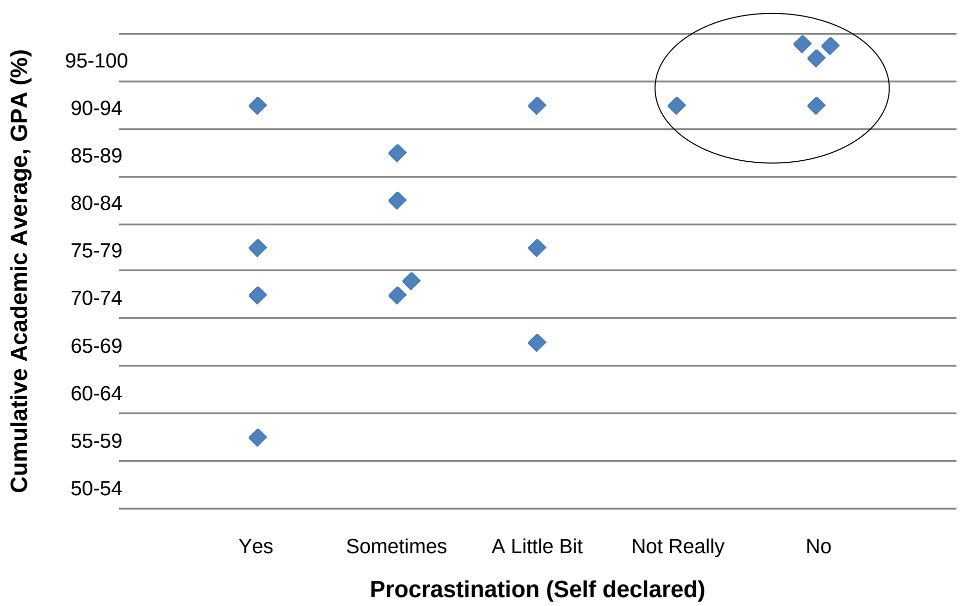

Figure 6: Procrastination response compared to GPA

It can be seen in the figure that all five participants that answered in the negative (either “No”, or “Not Really”), have a GPA score above 90%, with an average of 95.5%, these data points have been circled for clarity. For the 12 students that answered in the affirmative (either yes, sometimes, or a little bit), the GPA range is much broader from 55-59% to 90-94%, with an average of 77.5%. The response to this question can be used to determine the system input procrastination factor described in Figure 2.

Transferrable Skills and Coping Mechanisms

In terms of making connections between what is learned in the classroom and what is learned from sports, many students felt being an athlete made them a better student, but few saw connections between how being a student could make them a better athlete. When asked what the participant had learned from their sport that helped him or her academically, many students cited qualities such as time management, work ethic, expectations from older athletes, dedication, leadership, responsibility for one's self, responsibility for a group, focus, determination, and discipline. One student had a unique perspective on understanding how sleep and rest improves athletic performance allowed him to see the benefit of taking brakes when working. During the interview, he stated,

"The whole balance of track is about not hurting yourself. You have to balance sometimes with studying. You can't just crush things. Like with [computer] programming, if you're just going at it for a long time, sometimes you need to take a break and come back. You can't just absolutely crush yourself." (Freddie, Math, Junior)

Another student felt that being involved in sports allowed him to have a more holistic view of his academic career, stating that,

"Training for running is a humongous exercise in delayed gratification, so it's important not to get caught up in the little day-to-day ups and downs, good runs, bad runs. I try to focus on establishing the little habits that will stack up over time and pay off later. Having a long-term perspective like this helps me a lot in the classroom." (Elliot, Engineering, Junior)

Additionally, another student commented on sporting accomplishments improving his self-esteem which led to him being happier while studying. He stated,

"I think that you get a self-esteem improvement from doing athletics. By being consistent at track practice you can see steady improvements, and that makes you feel better not only physically, but mentally because you know that you've accomplished these things, and that puts me in a better mood when I'm working academically." (Aaron, Engineering, Graduate Student)

Also, by having a highly physically demanding sport integrated into a student's schedule it allows the student to put the difficulties of his or her academic program into perspective. One student stated during his interview that,

"When I'm running tough workouts, it's hard to call anything else in my life tiring with a straight face". (Elliot, Engineering, Junior)

By successfully completing challenging workouts, these students are exhibiting increases in not only their athletic competency belief, but their academic competency belief as well. This shows that success in one area can influence success in the other, and ultimately in both as a STEM student-athlete.

In terms of making connections from the classroom to sports, the interview participants made fewer connections than from their sport to the classroom. Some cited the bi-directional nature of time management, while others mentioned simple things such as the reinforcement of basic math skills from having to calculate target interval run times. Those students taking physiology or health courses talked about the application of course material for injury prevention and nutrition. Only two students discussed stronger connections between applying what he or she had learned from academics to their sport. One student discussed the application of planning and problem solving skills to optimize his workouts, while one of the graduate students provided a more involved answer. He stated,

"I originally thought that the two were pretty mutually exclusive, and track was just a break from academics, but I'm starting to see more links between the two of them now. One thing as a grad student you learn a lot about is research, and wanting to know why things are the way that they are. So that's really gotten me interested in not just working hard, but working smart at track. So I ask lots of questions at track, and I research sports science as well. Having a general interest in research and learning, I've been able to apply those skills to track, and just become a more knowledgeable athlete." (Aaron, Engineering, Graduate Student)

As students become more involved in their academic and athletic careers, there is a potential for them to become more self-aware and draw deeper connections between these two components of their lives increasing the utility value of their interdisciplinary lifestyle. Being able to synthesize connections that other students may not have the opportunity to experience can allow STEM student-athletes to provide a unique perspective on certain situations, and facilitate for them to be more well-rounded individuals.

Motivation to Study for Exams

When asked how participants motivate themselves to study for exams, interestingly half of the interview participants (8 of 16) replied that their main motivation for studying was either a fear of doing poorly or not wanting to fail to meet the expectations of others. This sentiment was expressed by students across all years of study from freshman through to graduate student, all major discipline categories (science, engineering, and mathematics), and across the entire GPA range from 55-59% to 95-100%. This fear of failure can be viewed as a high subjective task cost value that must be overcome to elicit successful STEM student-athlete motivation. Conversely, four participants claimed that they were self-motivated, and their motivation to study was either "intrinsic" or "built-in". Of these four "intrinsically" motivated students, all of them had GPA's above 90%, and two of them (both graduate students) claimed that they don't accept anything less than the best from themselves. One went so far as to quote the famous American runner Steve Prefontaine stating,

"To do anything less than your best is to sacrifice the gift". (Aaron, Engineering, Graduate Student)

This level of confidence and determination speaks to these students' competency beliefs for their own success. By having a heightened sense of faith in one's own ability, the student may be creating a self-fulfilling prophecy and increasing the probability of their own success. These students show a higher level of drive toward achieving their goals that is not necessarily present in the other participants. Although it may not be a quality that is necessary to be successful, having this level of determination toward a goal appears to be beneficially based on these four students' academic standings.

Advice for First Year Students

When asked about what advice they had for incoming freshmen STEM student-athletes, the interview participants had much to say on a variety of different topics. The major points included tips on studying, sleep and nutrition, warnings about procrastination, comments regarding personal desires and priorities, as well as overall philosophical viewpoints from the upperclassman perspective. The common themes were best expressed by the three graduate students that said,

"Make sure you love your program and make sure you love your sport or it's not possible". (Angela, Math, Graduate Student)

"Prioritize your tasks to figure out what's really important to you and just work on that stuff everyday". (Aaron, Engineering, Graduate Student)

"You can't change how many hours there are in a day, so why worry about it? Just focus on using [those hours] the best that you can, and everything will work out as it's supposed to." (Brett, Science, Graduate Student)

Five separate participants all made the comment that student-athletes must enjoy what they do for their lifestyle to be possible. As well, six students discussed the significances of prioritizing tasks based on what was most important to them. Three of these six students also emphasized the necessity to prioritize school over other aspects of their lives. Four participants claimed that time management was essential to success as a student; understanding how many hours a specific task required, and allocating the appropriate number of hours to complete it. Three students mentioned the importance of avoiding procrastination and spending time on meaningless or empty tasks. Finally, three students mentioned the importance of sleep and nutrition. According to these participants, sleep and nutrition are vital to the success of a student-athlete. One student summarized the importance of sleep by stating,

"Don't let anything compromise bedtime. If you're not sleeping well, you're probably not doing anything else as well as you could be." (Elliot, Engineering, Junior)

Discussion

Within this section, comments are made regarding a top-ten set of best practices for students, commonalities and differences across program year and discipline, as well as further investigation into one particular student's loss of interest in her program major. Each of these topics is discussed in turn.

Best Practices

By considering the interview data, a set of ten time management and coping best practices is proposed to help students improve their GPA scores while maintaining their status as STEM student-athletes. These attributes and ideals were possessed by many, although not necessarily all, of the interviewed STEM student-athletes with GPA's over 90%. This information can also be used by coaches, faculty, and administrators to help STEM student-athletes and regular students alike along their individual roads to success. The main purpose of these best practices is to increase students' productivity while reducing their procrastination levels. This is intended to boost students' competency belief in their own abilities and increase their perceived value in completing the task of being a STEM student-athlete. The proposed best practices are,

1). Genuinely enjoy the academic program that you are in and the sport that you play.

2). Make academics and athletics the top two priorities in your life.

3). Investing at least 35 hours per week into academics and at least 50 hours per week into the combination of athletics and academics.

4). Find a system for managing and organizing your time that works for you and stick with it.

5). Procrastination can be avoided by seeing value in what you are working on, so seek it out if it is not immediately clear.

6). There are only a finite number of hours in a day, so focus on using those hours the best that you can.

7). If possible, schedule your classes around your sport's practice schedule.

8). Make sleep a priority.

9). Eat a healthy, well balanced diet.

10). Take responsibility for yourself, and for your own successes and failures.

The key motivating factors for being a successful STEM student-athlete expressed by all of the participants interviewed in this study was that the student must first believe in his or her ability to be a STEM student-athlete and secondly, possess the desire to make it a reality. This fact was made clear by the amount of dedication and determination expressed by all of the participants throughout the interview process. All of the students with GPA's over 90% showed considerable signs of agreement with Eccles' subjective task values including, identifying themselves with their particular STEM program and their sport, showing signs of genuine enjoyment and utility in both, while associating little personal cost in participating in them. These ideals were reinforced by many students citing academics and athletics as the top two priorities in their lives.

One of the most quantitatively clear strategies employed by the highly achieving students in this study was their shear time commitment to both their athletics and academics. Those students that committed over 50 hours per week between the two commitments (with at least 30 of those hours going toward academics) possessed cumulative academic averages over 75%, whereas those students under this time commitment had averages under 75%. Committing more than 50 hours per week to athletics and academics combined had little effect on academic average. Beyond this 50 hour-75% average threshold a different strategy must be employed. One suggested strategy is to consider the student's mindset. Those students with averages above 90% expressed a considerable amount of emphasis on their personal enjoyment of their course material, whereas those students with grades less than 90% expressed more focus on working hard to achieve a particular grade than seeking interest in the course.

When comparing time management, organization, and planning strategies employed by interview participants to those suggested in the literature, no one particular strategy stood out from the other; in fact some students' strategies even contradicted one another. Using a planner to section off time for certain tasks was a strategy Aaron (GPA 95-100%) swore by, but Danielle (GPA 90-94%) discouraged strongly against. Additionally, of the top students interviewed, some of them claimed to not use any written organization methods (planners, calendars, or to-do lists), and only maintained mental checklists for keeping track of the tasks they needed to accomplish (Greg, GPA 80-84%), whereas, some of the students with the lowest academic averages use all of these time management devices, and still produced low grades (Cathrine GPA 55-59%). Each student with GPA's above 90% had each developed a unique system for organizing their lives that worked for them, and were open to modifying them when necessary.

Procrastination can happen for a variety of different reasons, but it can lead to a severe academic backlog if left unattended. This can cause students to run the risk of academic burnout before the end of the semester. Procrastination can be naturally minimized if the student enjoys the work that he or she is working on, or if they can see utility in the completion of their tasks. As an instructor, this provides motivation for presenting students with the purpose behind each exercise, and as a student, the knowledge that seeking an activity's learning objective can add value to the task. In the event that procrastination does arise, taking a break or doing something relaxing for a brief period of time can allow the student to refocus on the task and regain their motivation. Additionally, since time is a limited resource, utilizing it effectively can help to mitigate overwhelming academic backlog. Completing at least one major task done a day, can provide a tangible sense of accomplishment, and prevent tasks from accumulating, or becoming too daunting.

For those students that have the option to choose their own courses, scheduling classes around the team's practice schedule can help to minimize the amount of structured scheduling conflicts and allow a student to be able to attend all of their commitments. Showing up is always the first step toward success.

In terms of healthy living, sleep and nutrition were two significant coping mechanisms discussed by the participants. These two areas are stressed constantly within the athletic community, but many of their effects can carry over to the academic domain. If a student is hungry or sleep deprived, he or she may not be able to work as efficiently or effectively as they have potential to and can become more susceptible to injury or illness. Comments on healthy eating and sleeping habits are outside the scope of this study; however, 6 of the 7 students with 90%+ averages claimed to maintain on average 7.5 to 9 hours of sleep per night, and many of the interview participants claimed to either minimize alcohol consumption, or abstain from it entirely either during the competitive season, or year round.

Finally, time management is ultimately a continuous exercise in self management. Although planning a schedule may at first feel limiting and rigid, it allows the student to take responsibility for his or her own time, priorities, and actions. Since, one of the defining features of post-secondary education is providing students with the opportunity to learn responsibility and autonomy, by making the student's performance his or her own responsibility, he or she can take credit for their own path in life.

Commonalities and Differences across Program Year

Regarding GPA score as a function of program year, a number of key observations can be made from the interview participants' dataset. Firstly, the two lowest grades belong to a freshman and a sophomore student. All junior, senior, and graduate students possess GPA scores of at least 70%. Although the sample size is small, this may provide an indication that at an academically oriented post-secondary institution, a STEM student's persistence in collegiate-level athletics may diminish if he or she is not achieving a minimum academic average by a certain semester. If the cost associated with being a STEM student-athlete exceeds that of its perceived value, students will naturally remove themselves from the system. Within this sample, this threshold appears to be a 70% average by the student's junior year. By this point, students are either able to improve their academic standing, or choose to leave their sport to focus more on their academics commitments.

It should also be noted that the highest student grades are distributed across the program year spectrum, meaning both freshmen and upper-year students are capable of achieving top grades while being a STEM student-athlete. Finally, all three of the graduate students within this study obtained GPA's greater than 90%. This may be influenced by the small sample size and the nature of the students that volunteered to participate in the study, but it is hypothesized that since undertaking a STEM program at the graduate level is a considerably more serious academic commitment than at the undergraduate level, only those graduate students that are capable of handling both athletic and academic commitments choose to do so. Additionally, by graduate school, many students have already established a solid academic fundamental skill set, and are sufficiently self-motivated. Further research however, including a larger sample size would be necessary to confirm this initial speculation.

Commonalities and Differences across Program Discipline

Program discipline had no noticeable influence on the response to interview questions or students' GPA scores. The only noticeable difference was that students enrolled in science or biology programs were more predisposed to seeing connections between what they observed in the classroom and in their sport. These connections were limited to physiological connections relating mainly to injury prevention and rehabilitation.

Becky's Loss of Interest

Of the 16 participants, only one student indicated that she were no longer interested in her STEM program. This change occurred gradually throughout the duration of her program, and as a senior at the time of her interview, she took very little interest in the courses she was taking, did not identify with others in her program, and knew that she would not be exploring a career path based on her major. Since she was so close to finishing her program however, she still saw merit in completing her current STEM degree. She stated that she plans to complete a second undergrad degree in the liberal arts degree program that she is currently minoring in, and expresses a considerably greater degree of interest in.

These feelings of disinterest and lack of identity with her STEM program were noticeable in her lower grade scores, lower academic time commitment, and increased level of procrastination, and were contrasted by her higher grades, commitment, and reduced level of procrastination towards her liberal arts courses. Even though these feelings of discontent first emerged at the end of her second year, it is hypothesized that if these feelings of disconnectedness had presented themselves sooner, Becky would have likely transferred programs completely from science to liberal arts sooner before the cost (loss of time) of transferring programs became too great.

Conclusion

Within this work, the motivation behind the success of STEM student-athletes at the post-secondary level has been investigated. Additionally, time management strategies and coping mechanisms that these students use to help them achieve their success have been considered. Eccles' expectancy-value theory was extended through propositional logic to satisfy the conjunctively connected motivated goals of obtaining a STEM degree while concurrently being a collegiate-level student-athlete. It was then applied as the motivational framework against a series of interviews conducted with set of 16 graduate and undergraduate students enrolled in STEM programs competing on the varsity track and field and cross country teams at a Canadian university. This was done in an effort to gain insight into student success and persistence from the STEM student-athlete perspective.

The interview findings lead to the development of a series of time management and coping mechanism best practices for STEM student-athletes. These best practices stress the need for STEM student-athletes to genuinely enjoy their chosen program of study and their sport to make the student's academic and athletic pursuits as manageable and successful as possible. The students also discuss their feelings regarding time commitments, organizational strategies, procrastination, healthy living, and the student ultimately taking responsibility for his or her own actions. Throughout the study it was discovered that many of the top students use a variety (and sometimes contradictory set) of student strategies. This provides evidence to suggest that there are many paths leading to success for STEM student-athletes, and according to these students, many versions for what success actually means.

This work can be used by educators to support STEM student-athlete development and retention by encouraging them to see the utility and value behind classroom activities and their chosen discipline, while leveraging their unique experience as student-athletes to draw connections between the two areas that might be missed by other students. Additionally, coaches can use this material to ensure athletes are properly motivated and staying on top of their studies while optimizing their athletic performances. Finally, students, regardless of program major, can use this information as a guide to help them with their own pursuits, whatever they may be.

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Appendix A - Interview Questions

Introduction

1. School Term
2. Program of Study
3. Walk me through a typical school week for you. (What time do you: wake up, go to school, practice, etc…) Is this different on the weekend?
4. How much sleep do you get on average per night? How much do you try to get each night?
5. What are the main priorities in your life right now?
6. What aspirations do you have after graduation in terms of work/sport?
7. How do you define success as a student?
8. How do you define success as an athlete?
9. On average, how many hours per week do you invest in your sport?
10. On average, how many hours per week do you invest in your academics (class/tutorial/lab/studying/everything)?
11. How do you feel about the amount of work you have to do as a student?
12. Do school and your sport ever conflict with one another?
13. If yes, how do you feel when you miss class for your sport, or your sport for class?

Traditional Time Management

1. In general, how do you manage your time as a student-athlete?
2. Has this changed throughout your academic/athletic career?
3. Are there any strategies that you’ve used to help you manage your time?
4. What strategies work well for you?
5. What strategies have not worked for you?
6. Are there any strategies that you would like to try?
7. Do you use a planner or organizer short term/long term? What about: to do lists, goals list, how do you prioritize your tasks?
8. Do you have a dedicated study space, where do you study?
9. Do you review what you’ve done in a day/week/class? when? Do you log it anywhere?
10. Do you ever review your notes before class, after class?
11. Do you consult with profs about game & practice schedules at all? Early in the season?
12. Have you ever pulled an all nighters, how often?
13. Have you ever taken a study skills workshop? Actively examined your own study habits?

Transferable Skills

1. What have you learned from your sport that helps you in the classroom?
2. What have you learned from the classroom that helps you with your sport?
3. Is there a difference in how you talking to students in your program vs. in your sport?

Exams / Studying

1. What do you do during exam time? How does your daily schedule/routine change?
2. How long do you study at a time? How often do you take breaks?
3. How many hours do you dedicate to studying per exam?
4. How do you study when you study? Are there any special techniques that you use?
5. Is procrastination something you have a problem with? Distractions i.e. facebook, cellphone, social networking sites, TV on, background noise (classical music, your own music)
6. How do you motivate yourself to study? (Long/short term)

Summary

1. What is your goal academic average?
2. What advice do you have for first year student-athletes?
3. Is there anything else that you think would be useful for this study?