



Elites: A STEM Leadership Program

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Abstract

In this article, we describe the Emerging Leaders in Technology, Science and Mathematics (Elites) program developed as part of an NSF S-STEM grant awarded to Radford University's Artis College of Science and Technology. The S-STEM grant supports scholarships for meritorious students with financial need. Elites was designed to incentivize student participation in high impact activities that would help them develop their careers as they are progressing through their degree. Coupled with strong advising, the Elites program's overarching goal was to increase retention among scholarship recipients and help them continue to pursue STEM related careers. This paper presents the successes and challenges of the Elites program as measured using focus group interviews and using an academic motivational tool: MUSIC (Jones, 2009). The salient result of the assessment was that while students showed greater motivation in defining and reaching their professional goals, the program struggled to create a sense of community.

Keywords: Higher Education, Science/STEM, Leadership, Motivation

1. Introduction

NSF S-STEM scholarship grant program supports meritorious U.S citizens with financial need to pursue majors in STEM. The intent is to increase the pipeline of STEM graduates to meet national needs. Hence, retention of students in STEM during college and keeping them motivated to pursue a career in STEM after graduation is one of the most important metrics that measures the success of this grant. With this as the central goal, the co-investigators of this grant at Radford University's Artis College of Science and Technology (ACSAT) developed a new leadership program in STEM called Elites (Emerging Leaders in Technology, Science and Mathematics). Elites was designed to address a fundamental weakness in the college: very few STEM students used to acquire internships, go to graduate school, participate in undergraduate level research, or, as anecdotal evidence from faculty experiences as advisors suggests, even develop a resume by the time they reach their senior year. In fact, among the 2011-12 STEM graduates from the University, the official numbers indicate that less than 10% declared that they acquired an internship and just 11.5% were going to attend a graduate school. Elites was the leadership program tailored specifically for students majoring in a STEM field. In this paper, along with members from the office of assessment, several of the co-investigators evaluated the effectiveness of the Elites program, after implementation almost three years ago.

2. Related Work

The Elites leadership program draws on several high impact practices (e.g. student-faculty interaction via undergraduate research), which promotes student engagement (Kuh, 2001). Student engagement signifies the time and effort students dedicate to activities when institutions provide opportunities for student participation (Kuh, 2001, 2003 as cited in Kuh, 2009). Yet, we are mindful of the caution given by some researchers who claim that programs like Elites, that include high impact practices, may be categorized as having a conditional effect versus general effect on students (Pacarella

& Terenzini, 2005; Siefert, Gillig, Hanson, Pascarella, & Blaich, 2014). The general effect impact all students in the same way, while the conditional effect has a different impact on each student or subgroups of students (Siefert, et al., 2014). A large proportion of the students attending our university are members of the first generation sub-group, which research shows benefit from high impact practices (Kuh, 2009). We contend that the Elites Leadership program may have a conditional effect on the students who choose to participate in the Elites program, due to their prior experiences, knowledge, skills, and disposition. Yet, we believe this may not undermine the level of engagement shown by our STEM students. We designed the program to be student-focused.

While other universities have STEM leadership programs for undergraduates that integrate the STEM leadership component throughout the science curriculum (i.e. Reed, Aiello, Barton, Could & McCain, 2016), this program differs in that the Elites leadership program does not overlay nor impact the current instructional practices or ongoing programs (e.g. clubs) in the departments, in the college or across the university. The goal is to draw from the current STEM academic curriculum and STEM academic practices and student support services within the university (e.g. career services) that also promote student engagement. In essence, the Elites leadership program recognizes the time and effort students currently spend in academic and non-academic activities that develops their STEM leadership skills and wishes to draw on them. As a result, the Elites leadership program has the potential to improve retention and graduation rates at both ends of the academic ability spectrum –high performing students who choose not to transfer to more notable universities and struggling students who increase their effort to reach graduation due to their involvement in academic pursuits outside of the classroom (e.g. undergraduate research) and their relationships with STEM faculty.

To gather both qualitative and quantitative feedback from current students participating in the program, students were asked to respond to questions in an annual survey that is administered at the end of each year and to participate in two focus group interviews. Results were used to answer the research questions: (1) *How do the Elites scholars perceive the Elites leadership program in helping them prepare for their futures?* (2) *How motivated are the Elite scholars to engage in the Elites leadership program?* Before, the study is described, background about the Elites leadership program and the theoretical framework that comprises the motivation model.

3. Overview of the Elites Leadership Program

Elites goals are to develop leaders in STEM and to incentivize student participation in activities used to develop leaders. It is designed based on the fundamental understanding that leaders in STEM do not fit neatly into a single category. They can be outstanding teachers, scientists, project/product managers, or individuals who perform community outreach. So, Elites focusses on incentivizing activities in four areas: (1) Research Skills, (2) Communication Skills, (3) Career Development, and (4) Management and Service Skills. Each component offers the student opportunities to hone a particular aspect of their leadership skills that is consistent within their discipline. Table 1 summarizes these four categories along with examples.

Table 1: Elites overview

Leadership component	Justification
1. Focus: Research skills to prepare future researchers.	
<i>Independent study (1-6 credits)</i>	Develops research ability: surveying latest research efforts or conducting original research.
<i>Honors contract on a course</i>	Develops leadership skills such as: leading class discussions, and engaging in research
<i>Research assistant (RA) on a STEM project</i>	Develops research skills.
<i>Attending a conference/symposium/competition in STEM</i>	Motivates students to pursue research, interact with graduate programs and meet graduate students
<i>Present/publish paper/poster or develop a product (e.g., software)</i>	Develops research skills; communication skills and team participation.
2. Focus: Communication	Reason why this is a leadership component: Develops communication skills in STEM.
<i>Presentation at a University outreach event such as an open house; bridge camps for high school</i>	These presentations can range from a course project (e.g., developing a new computer? game) to a report on college life at University to prospective high school STEM majors.
<i>LEAD contract in a course or take a LEAD certified course. LEAD is the University's leadership program</i>	Develops presentation skills in a course or group work. All majors in CSAT offer LEAD certified courses.
3. Focus: Career Development	Reason why this is a leadership component: Developing career goals and interacting with prospective employers or graduate schools shows that the student is taking charge of their career.
<i>Creating a resume and an effective professional online-profile.</i>	Based on our (informal) experience many students put this activity off until their senior year. Develops a student's ability to focus on his/her career.
<i>Participation in career focused event.</i>	Develops a student's ability to focus on his/her career. Events include: career development forum/workshop & job and internship fairs.

<i>Applying for an internship/co-op position/graduate school</i>	Such applications can be easily made through the University's career services office or in case of graduate school in consultation with the student's advisor.
<i>Acquiring an Internship/co-op during summer in STEM.</i>	Provides students with valuable experience – and makes their resumes attractive for future career in STEM.
4. Focus: Management and Service	Reason why this is a leadership component: Encourages students to organize or participate in STEM related extra-curricular events setting the trend for future such service to STEM fields.
<i>Student Peer-Mentor</i>	Students who act as mentors are showing leadership skills
<i>Officer in a STEM related academic club.</i>	Officers in these clubs organize events; enroll new members; conduct meetings.
<i>Organize/ Volunteer in a STEM- related event</i>	Develops skills such as planning, organization and interacting with others.
<i>Organize/ Volunteer in a community event</i>	Develops skills such as planning, organization, interacting with the community, communication.

The students' progress within these four categories by completing tasks. To make administering this program easier, the tasks are assessed and assigned points that were determined when the program was designed. The various activities allow for student-choice that will better suit each student's overarching career goal, either workforce or graduate school. The points earned are based on the student's level of success. Each of the four categories is capped at 10 points to encourage students to distribute their points over each of the four categories to ensure they develop a well-rounded set of leadership skills. A successful student will earn a total of 20 points by graduation and the structure of the program allows for multiple pathways to reach the 20 points mark, which indicates respect for diverse learning opportunities. At graduation, a student who earns 20 points is identified as an Elites scholar. The Elite scholar is presented with a certificate from the Dean of the college at the college level commencement.

Each Elites student's progress is tracked in one of three ways. One, by meeting face to face with the Elites advisor twice each semester to addresses academic progress and progress in the Elites Leadership program. Two, by examining the students' transcripts at the end of each semester because some of the Elites activities will appear on the student's academic transcript (e.g. LEAD 110, a leadership course). Three, through Radford University's Desire to Learn (D2L) platform that has a course identified

as Elites, which contains information about the Elites program and allows student to submit completed tasks.

3.2 The Academic Motivation model - MUSIC

The MUSIC Model is an academic motivation model where the word MUSIC is an acronym for the five components that promotes motivation within an academic setting: eMpowerment, Usefulness, Success, Interest, and Caring (Jones, 2009). It is based on the social-cognitive theoretical framework targeting academic identity that says students have psychological needs and when met, it impacts students' perceptions and beliefs about their academic abilities (Jones, 2009). This model was originally designed for the college teacher-college student relationship. We contend it holds potential when it is modified for the Elite leadership team-student relationship. In the following paragraphs each component of this model is defined and a description of its use in the college academic classroom. This is followed by the modifications that were made to address the Elites leadership team-student relationship, in which we consulted with Dr. Brett Jones.

Empowerment

Empowerment (M) is defined as the amount of perceived control students have over their learning. In the classroom, teachers can allow students to choose their collaborative learning partners, or students can control the pace of a lesson, or co-create course policies. Empowerment is important for motivation (Jones, 2009).

Likewise, we believe the Elite students need to have control as they develop their leadership skills to suite their career goals. The students choose the general activities that allow for tailoring pathways unique to them. The students are empowered by choice.

Usefulness

Usefulness (U) is the why component. Teachers need to let students know why the content is useful to them now and in the future. In the classroom, the teacher shows usefulness by connecting the content to the real world and/or to students' everyday experiences using activities or projects (Jones, 2009).

For the Elites scholar, usefulness is linked to his or her future goal. The Elites Leadership program is designed to provide opportunities to develop the students' leadership skills in ways that are relevant to future employers and to graduate school admission boards. Usefulness, for the student, is the heart of the Elites Leadership program. The usefulness component assures the Elite scholar that time and effort engaged in this program are aligned with his or her future professional goal.

Success

Success (S) in the classroom is achieved by designing coursework so all students can experience success, if they put forth the effort to gain the knowledge and skills. For the students, believing they can be successful means they need to know the teacher's expectations, that the learning experiences are within their capabilities, and that timely

feedback is provided and useful to the student. Allowing students to modify or redo their work makes it evident to students that the teacher is learning focused (Jones, 2009).

Recently this component was addressed more explicitly by designing an Elites Leadership handbook to clarify expectations. Prior to the handbook, a chart was used to show the students the four categories and the activities associated with each. In face-to-face meetings each semester, students are given feedback on their progress in the program. The *Desire2Learn* (D2L) learning management platform allows students to upload completed activities and currently to a limited extent, track their progress. The feedback component continues to be under development.

Interest

Interest (I) is sparked in the classroom when the teacher designs lessons so that student interest, or a genuine liking, for the content can naturally develop. There are two kinds of interest: situational and individual. Situational interest is short term and it describes the interest a student may have for the duration of the activity or lesson. Individual interest is longer term. It describes the positive feelings that a student develops with respect to a topic and indicates a willingness to seek additional opportunities to interact with the topic outside of the classroom setting. A way to foster interest is to connect the lessons or activities to students' out of school life experiences and background. Interest is promoted when emotions are sparked. Students demonstrating negative emotions can, at times, be used as the devil's advocate or critic. Students also respond positively to a teacher's use of his or her personal interests and enthusiasm in the topic (Jones, 2009).

Elites Leadership program requires development for each students' unique interest within their major. Specifically, the goal of the mentorship provided by the Elites advisor is to guide students to identify areas of interest. This is accomplished by engaging in brainstorming sessions in the face-to-face meetings with the Elites advisor and/or with a particular professor within the student's major. The focus is to help students identify and nurture their individual interest.

Caring

Caring(C) is demonstrated by teachers in one of two ways: (1) student learning and (2) personally. Teachers show caring when they are concerned about student's failures, provide reassurance for struggling students, and celebrate student's successes. Designing engaging lessons so that students can develop content knowledge and knowledge about their classmates demonstrates personal caring within the classroom (Jones, 2009).

The Elites Leadership program team promotes caring for the students academically and as they progress through the program and on a personal level. This is demonstrated by the face-to-face meetings with each student individually and the action plans that are initiated when a student first shows signs of struggling academically. We believe it is important to address the poor academic performance in a timely, positive, and professional manner. In doing so, we believe we show caring about student learning but also on a personal level as we care about each student reaching their career goals. Likewise, celebrating success with the students throughout the program and at graduation also shows caring on both levels. Many students experience caring from their discipline specific mentors.

Ultimately, we believe the MUSIC model allows us to effectively engage with the Elites scholars. We can evaluate our level of effectiveness for each of these components, by analysing the results of the motivation survey. The Elites Leadership program is closing out its third year, in which all stakeholders are familiar with the program to formally evaluate its effectiveness. Specifically, the following research questions are asked:

- (1) *How do the Elites scholars perceive the Elites leadership program in helping them prepare for their futures?*
- (2) *How motivated are the Elite scholars to engage in the Elites leadership program?*

Method

The research design used a multi-phase mixed methods design (Creswell & Plano-Clark, 2011). The qualitative and quantitative data were collected sequentially and both were equally valued (Creswell & Plano-Clark, 2011). The qualitative data was collected from the focus group interviews and the quantitative data was collected using the motivation survey instrument and the Elites management tool.

Participants

The participants include the scholarship recipients in cohort one through three, one cohort for each year of the program. Six to seven students in each cohort. Further, 7 non-scholarship recipient students who joined the Elites program in fall 2015. There are 16 males and 10 females in the Elites program. The scholarship recipients are predominantly White with two African Americans.

Procedures

Three sets of instruments were used in this study: the Elites program management tool, focus group interviews, and the MUSIC Model Inventory.

Elites Program Management Tool. The first instrument is the management tool used by the Elites advisor to track the leadership skill development for each student. The Elite program management tool is presented in Table 2.

Table 2

Elites Program Management Tool				
Student Name	ID Number	Year	Major	Points Earned
		Research	Tasks	Possible points
			Independent study	5 points/credit hour
			Honors contract course	1 points/course
			Research Assistant (RA) on STEM project	10 points/semester

	Attend conference/symposium/competition in STEM	5 point/event
Communication	Tasks	
	Present, publish paper/poster or develop product	1 - 10 points
	Present at an outreach event (Open house, Summer Bridge Program)	2 - 5 points with a talk
	Lead contract in a course or take a LEAD certified course	2 points/credit hour
Career Development	Tasks	
	Creating a resume and an effective professional online profile	2 point, mandatory
	Participation in career focused event	3 points/forum
	Applying for an internship/co-op position/graduate school	1 - 4 points to activity
	Acquiring a STEM internship/co-op during the summer	5 - 10 points
Management & Service	Tasks	
	Student peer mentor	1 - 10 points/semester
	Officer in a STEM related academic club	1 - 5 points
	Organize/volunteer in a STEM related event	1 - 3 points/event
	Organize/volunteer in a community related event	Max 2 points/event

Focus Group Interviews. The focus group interviews were conducted over several days with a total of seventeen students participating during spring 2016. Seven questions were created collaboratively by the grant team. The questions concentrated on how the scholarship did or did not influence the students' decision to attend Radford University, the components of the Elites leadership program that attracted their attention, and improvements to the Elites leadership program. During the sessions, students were asked to respond to each question individually, then the floor was open for additional comments. Not all students answered each question and some students addressed questions with multiple answers. At the end of each session, students were encouraged to comment on other aspects of the program, positive or negative that were not addressed earlier.

MUSIC Model Inventory. The MUSIC academic motivation inventory contains twenty-five questions using a six point Likert scale to identify differing levels of agreement/disagreement

for each statement. On the lower end of the scale, number one is associated with a person who *strongly disagrees* with the statement and six is associated with a person who *strongly agrees* with the statement. The numbers in between represent the agreement or disagreement to each statement from *disagree* (2), *somewhat disagree* (3) to *somewhat agree* (4) to *agree* (5). Each question is linked to one of the five MUSIC model components. The MUSIC model questions were modified for this study to reflect the program team-student relationship rather than a teacher-student relationship. The revised questions were reviewed by Dr. Jones to ensure the theoretical integrity was not compromised. The modified Elites MUSIC motivation survey instrument was administered, online using QUALTRICS, during the fall of 2016 with 14 (70%) of the Elite scholars responding.

Data Analysis

There were three sets of data that was analysed: data from the Elites program management tool, the focus group interviews, and the motivation survey. Descriptive statistics summarized the responses for each leadership component identified in the Elites Management Tool: (1) research skills, (2) communication skills, (3) career development, and (4) management and service. The focus group interview data were analysed using thematic analysis (Braun & Clarke, 2006) to identify overarching themes. The Elites MUSIC motivational model was analysed using the scoring rubric developed by Jones (2014), which did not require modification.

Results

The results of the data analysis are presented in the following sections beginning with the summarized participation in the leadership activities. This is followed by the focus group results and then by the MUSIC motivation results.

Leadership Activities

The leadership activities are identified per the Elites leadership program. In Table 3 below contains the summarized results that show the number of students or number of activities completed tasks for each section in the Elites leadership program. This list reflects cohorts 1 and 2. Cohort 3 is in their first year in the program. They are encouraged to focus on their academics and become aware of leadership opportunities that may interest them. Students become actively engaged during their second year in the program.

Table 3
Number of Elite Activities by Category

Elites Leadership Section	Number of Times or Students Engaged
Research	10
Communication	7
Career Development	6
Management and Service	6

The average number of times our students involved within each component is 7. This represents approximately 56% of the students.

Under the research category, there were 10 times that students engaged in the activities. Most the students were research assistants or teaching assistants. Independent studies were also included in this component.

Under, the communication section shows most that students engaged in presentations through on-campus forums (i.e. undergraduate research) or presenting at a professional conference. Some of the students presented more than once.

Finally, in Career Development activities showed students participating in internships and completing a professional resume or shadowing professionals. The Management and Service section shows most of the students taking an active role as a club officer in a STEM club. Other activities include planning and implementing STEM related community events either on or off campus that were sponsored by the STEM club, by department clubs, or other college level events.

Focus Group

For this study the two most important questions of the focus group were:

1. How has the Elites leadership program prepared you for your future?
2. If you were not receiving a scholarship, would you still be involved with Elites, why or why not?

The most common themes for each question are shown in Table 4.

Table 4
Common Themes for Focus Group Questions

Question	Themes
How has the Elites Leadership program prepared you for your future?	. Research experience (60%) . Career planning/Internship (40%) . Extracurricular activities (30%) . Leadership (27%)
If you were not receiving a scholarship, would you still be involved with Elites? Why or why not?	. No, lack of awareness of the program (67%) . No, lack motivation to do the activities in the program without the scholarship (44%) . No, lacks a sense of community (30%)

As can be seen from the table: many students claimed the research experience and the career planning component were the two categories most beneficial as they prepare for their future.

For the second question, most the students responded that they would not have been involved in Elites if they did not receive a scholarship.

The two main criticisms were:

1. Most students claimed the program is not adequately advertised.

2. Several students claimed that the Elites leadership program had a weak sense of community among Elites students and the faculty team, which was important to them.

MUSIC Model Inventory

The Elites MUSIC Inventory was analysed using the scoring system developed by Jones (2014). Each component of the Elites MUSIC model is addressed by several questions interspersed throughout the questionnaire (Jones, 2014). For example, eMpowerment is addressed in questions 2, 8, 12, 17, and 26. The mean scores for all participants linked to these items are averaged to calculate the mean score for eMpowerment, 5.1. This process is used for each component. The mean scores for each component are presented in Table 5.

Table 5
Mean Scores for MUSIC Components

Component	Description	Score
eMpowerment	Students feel they have control over learning	5.1
Usefulness	Students feel the activities are useful	5.2
Success	Students feel the activities prepare them for success	5.0
Interest	Students develop interest in the subject	4.9
Caring	Students feel cared for	5.3

The data shows the mean score for the components range from a low of 4.9 for Interest, to a high of 5.3 for Caring. The overall mean score for all the components when each component mean score is weighted equally, is 5.1, which is linked to the response *agree*.

Discussion

The Elites leadership program was developed to encourage STEM students to develop leadership skills. The program addresses the professional skills needed for students to excel in a STEM career. The aim of this study is to determine the effectiveness of the Elites leadership program by examining the students' participation with the leadership activities, holding focus group interviews, and administering a motivation questionnaire to answer the following research questions:

- 1) How do the Elites scholars perceive the Elites leadership program in helping them prepare for their futures?
- 2) How motivated are the Elite scholars to engage in the Elites leadership program?

To answer these questions, we examine the results from the Elites leadership management tool, then the interviews followed by the results from the survey.

Question 1: How do the Elites scholars perceive the Elites leadership program in helping them prepare for their futures?

Overall, the Elites scholars claim that the Elites leadership program helps them prepare for their futures. by providing research experiences, internship/career planning opportunities, and opportunities to hone their project management and interpersonal management skills.

Results from the Elites MUSIC Motivation model reinforce the notion that the Elites Leadership Program is useful to students, with a mean score of 5.2. This translates to *agree* leaning towards *strongly agree*. The program is useful because the Elites Leadership program positions students for success. This is evident by the mean score of 5.0, students *agree* that the program prepares them for future success.

Question 2: How motivated are the Elite scholars to engage in the Elites Leadership program?

Overall, the answer to this question is neutral. Some students were motivated to engage in the Elites program because of the scholarship monies while others were motivated to participate because of the value they perceived in the Elites Leadership program.

The focus group interviews revealed that all students would not be involved with the Elites program for one of three reasons: lack of awareness of the program, lack motivation to do the activities in the program without the scholarship, and the program lacks a sense of community.

On the other hand, the *lack of sense of community theme*, had one student claim that he or she would not engage with the program. This identifies a shortcoming in the Elites Leadership program. Although the leadership program was not designed to be a club, perhaps there are ways to increase the sense of belonging among the students. The university engages in learning communities and living-learning communities, the Elites leadership program is academically broad so that it does not align with current community structures. Therefore, the team decided to specifically omit the learning community or living-learning community structure for the Elites leadership program. The concern was forcing students to choose between the Elites learning community and a discipline specific learning community (e.g. biology learning community). Yet, the point made by the students is relevant and the team will address this shortcoming.

Interestingly, when the Elites motivation survey results are examined, overall the students *agreed* that they were motivated to achieve more when they participated in the Elites leadership program (i.e. score is 5.1). The caring component has the highest mean score followed by Usefulness, eMpowerment, Success, and Interest. These mean scores are between 4.9 and 5.3. These results show that students believed that they had control over their learning, the activities were useful, the activities helped prepare them for success, they developed interest in STEM, and they felt the faculty cared for them.

Overall, these results are consistent with the other measures indicating that the Elites program does provide STEM students with the skills and support needed to succeed and that the students were motivated to actively participate in the Elites Leadership program.

Conclusion

The Elites Leadership program was developed for our 2014 awarded National Science Foundation Scholarship STEM grant (#1356220). STEM leaders require a specific skill set because their leadership roles reside outside of the typical management leadership paradigm (e.g. leaders of research laboratories or large research projects). The Elites Leadership program provides the structure for the STEM students to hone these specific leadership skills. The program includes many of the high impact practices that motivate students to increase their academic engagement that draws on current university wide support structures (e.g. undergraduate research, career development).

Limitations

This study has limitations which includes the small sample size. This is due to the recent implementation of the Elites Leadership program and that it was recently opened to all students in the college. As more students join the program over the next couple of years, results will gain statistical significance and hopefully demonstrate the beneficial impact on next generation of STEM students.

Future Research

Our next step is to take these findings to improve the Elites Leadership program (i.e. improve the sense of community). Our future research focus will be to repeat this study to identify trends. In addition, we may modify the Elites Leadership program to improve the ways we develop future STEM leaders. We will evaluate the effect of the modifications again in the future to track the programs' effectiveness.

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