

Benefits of Informal Learning Environments: A Focused Examination of STEM-based Program Environments

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Abstract

This paper examines STEM-based informal learning environments for underrepresented students and reports on the aspects of these programs that are beneficial to students. This qualitative study provides a nuanced look into informal learning environments and determines what is unique about these experiences and makes them beneficial for students. We provide results of a qualitative research study conducted with the Mathematics, Engineering, Science Achievement (MESA) program, an informal learning environment that has proven to be effective in recruiting, retaining and encouraging underrepresented students to pursue STEM careers. Using a grounded theory approach, focus group interviews were conducted with five student groups throughout the state of California in an effort to “unpack the activity” variables of the informal learning environment. Results of this study should inform formal learning environments and other informal learning environments as to the components that make these learning environments effective and appealing to underrepresented students populations.

Introduction

Education in the Science, Technology, Engineering, and Mathematics (STEM) fields has several implications for economic and national security, making the issue of STEM education *reform* and *access* one of national concern (Kuenzi, 2008). The need for reform in STEM education is spurred by the inability of STEM fields to attract a diverse workforce. Chubin, May, and Babco (2005) contend that to thrive in a globally competitive, technological world, it is incumbent upon the nation to develop a STEM workforce that takes advantage of the nation's diverse population. Moreover, the nation's demand for world-class talent in STEM has ramifications that extend beyond national security and productivity. Benefits of a diverse student population extend to learning environments and educational experiences of all students as well. More than a matter of equity and social justice, the inability to attract a diverse population to STEM careers impacts the level of creativity, innovation and quality of STEM products and services (Watson & Froyd, 2007). According to Burke and

Mattis (2007) diversity makes the university educational and learning experience richer and more valuable for all students.

The challenge of meeting the nation's demands for increased diversity in the STEM workforce is exacerbated by the inability of many formal learning environments to introduce underrepresented students to STEM professions (Denson, Austin, & Hailey, 2013). Turning to informal learning environments as a vehicle to introduce STEM related concepts to students might provide new pathways toward STEM careers for students. Martin (2004) offers that researchers have long recognized the importance of informal learning environments and suggests that informal education will be instrumental in the reform of STEM education. There have been reports of success for recruiting and increasing the number of underrepresented students progressing to STEM programs through informal learning environments such as the Math, Engineering, and Science Achievement (MESA) program (MESA, 2008). However, there is a paucity of research that articulates why programs such as MESA have been successful and beneficial for students from underrepresented populations. Research on informal learning programs such as MESA and their impact on students may benefit *all* students and help reform STEM education. In order to modify formal learning environments to reflect successful practices of informal learning environments, it is important to understand the instructional strategies and activities that appeal to a diverse range of students.

Informal learning environments

It is estimated that during their schooling years 86.7% of students' time will be spent outside of a classroom (Gerber, Cavallo, & Edmund, 2001). This illustrates the importance of providing opportunities for learning that are outside of the traditional classroom environment. Informal learning environments provide these opportunities and have been an integral part of education for years (Martin, 2004). The continued study of informal learning environments may provide insight into ways the nation can begin to attract a STEM workforce that is more diverse. The merits of informal learning environments are known, yet the research is not clear on how such

experiences are beneficial to students (Gerber, Cavallo, & Edmund, 2001). Beyond anecdotal reporting on informal learning environments, there is a lack of research that documents the ability of informal learning environments to influence learning and student development.

When examining the benefits of informal learning environments it is important to identify characteristics of *effective* learning environments. In order to establish a standard of excellence for successful informal learning environment, we will provide a set of characteristics as identified by the literature. In a review of engineering focused informal learning environments, Chubin et al. (2005) postulated that an effective informal learning environment must: (1) promote awareness of the engineering (2) provide academic enrichment, (3) have trained and competent instructors and (4) be supported by the educational system of the student participants. MESA is an afterschool program that meets the above criteria for effective informal learning environments in STEM.

Informal learning environments can be categorized into three major settings: 1) everyday experiences, 2) designed settings, and 3) programmed settings (Kotys-Schwartz, Besterfield-Sacre, & Shuman, 2011). The MESA program is categorically identified as a programmed setting. Program settings are characterized by structures that emulate or complement formal school settings, planned curriculum, facilitators, and a group of students who continuously participate in the program (Kotys-Schwartz, Besterfield-Sacre, & Shuman, 2011). Due to MESA's reported success as an informal learning environment and ability to recruit and retain students from underrepresented populations to STEM fields, we sought to investigate the unique aspects of this program to inform instrument development and further our research efforts.

Math, Engineering, and Science Achievement

The MESA program is a co-curricular program that supports educationally disadvantaged students by providing pathways for minority students to succeed in science, mathematics and engineering disciplines (Kane, Beals, Valeau, & Johnson, 2004). MESA was started in 1970 as an inter-segmental program, administered

through the California Public School System, Community College System, and California College System. After initial success in California, MESA has expanded to eight other states. MESA USA is now a partnership of MESA programs in nine states: Arizona, California, Colorado, Maryland, New Mexico, Oregon, Utah, Washington, and Pennsylvania. MESA USA programs are based on the academic enrichment model originating in California. Each MESA site includes many of the following elements: SAT/ACT preparation, study skills training, hands-on activities, competitions, career and college exploration through field trips and guest speakers, parent leadership development, individual academic plans, and teacher training opportunities. Students in MESA USA programs participate in an annual national engineering design competition (MESA, 2012). Students who go through the MESA program outperform public high school students in completion of advanced mathematics and physics courses, course grades and college entrance exam scores (Kotys-Schwartz et al., 2011).

Due to the success of MESA, we sought to work with the program and its facilitators in an effort to investigate the reasons why the MESA experience was beneficial to students. Initially, a Likert-type scale was developed to measure the influence that MESA's activities had on participants' self-efficacy, interests, and perceptions of engineering. The instrument was pilot tested with 166 students from MESA programs in California and Utah (Hailey et al., 2011). After statistical analyses and consultation with experts in survey development, we decided that the initial instrument failed to adequately "unpack the activity" components of the MESA program. The instrument was not sensitive enough to identify the subtle nuances of the "MESA experience" that appealed to their student populations. Subsequently, we decided to conduct focus group interviews in an effort to determine why MESA's informal learning environment was beneficial to students.

Methodology

Our research team used a focus group protocol to guide the interview sessions. Focus groups are used to gather opinions. They consist of a series of interviews, conducted with five to ten participants, wherein the researcher attempts to gain a certain perspective from a particular group (Krueger, 2009). Focus group interviews are well suited for qualitative studies including grounded theory (Webb & Kevern, 2001). In a focus group the participants are able to increase the trustworthiness of the data through member checking, expounding upon participant responses, and adding clarity to group responses. Focus groups typically have five characteristics including: (1) people who (2) possess certain characteristics, (3) provide qualitative data (4) in a focused discussion and (5) help understand the topic of interest (Krueger, 2009). In order to ascertain a perspective that was reflective of the

MESA program it was important to establish a "consensus" among group members.

Participant Selection

The participants for this study were all members of MESA who provided us with qualitative data during a focused discussion in an effort to inform us as to the aspects of MESA that were particularly beneficial to their experience.

Participants were selected for this study using purposeful sampling. Purposeful sampling is an effective strategy of sampling that allows for the collection of "information rich" data (Glesne, 2006). Advisors for each MESA chapter participating in the study selected participants for the focus groups based on student attendance, achievement and overall participation in the MESA program. Participants were provided with food and refreshments as remuneration for their participation. A total of 28 MESA students from five different schools in the California area participated in the five focus group. The student members of the focus groups are entitled "participants" in this paper.

Research Ethics

Researchers conducting research in educational contexts need to be conscious of ethical responsibilities when working with students and teachers. In the world of research, students represent a particularly vulnerable group due to their youth and subjugated roles in school systems (Hatch, 2002). It is the researcher's responsibility to ensure that students are informed on their rights and what their participation will entail (Denson, Avery & Schell, 2010). Minor assent and parental consent were obtained before students were allowed to participate in any part of the study. IRB approval was obtained before the onset of the study.

Data Gathering

Two researchers were responsible for conducting alternating focus group interviews. One researcher served as facilitator and the other researcher served as note taker with this responsibility alternating between site visits. This was made possible due to the fact that both researchers were well versed in conducting qualitative research. The focus group interviews were audio recorded. Notes were taken to ensure that data could be cross-checked with the audio recording.

The interviews took approximately one hour to complete for each focus group. The facilitator posed the two open-ended questions:

1. Can you think of one of the best times you have had in MESA?
2. What do you think you are gaining by participating in MESA?

After the first question was introduced, the facilitator asked additional probing questions for the purpose

of clarification and confirmation. This allowed the participants to answer a multitude of questions with minimal probing from the facilitator. After a number of supplementary questions, the second main question was then posed as a concluding question. Again the process was repeated with the facilitator listening carefully to answers and asking additional or follow-on questions from answers given. The themes formed are the result of four recorded interviews and notes taken from a fifth interview. Technical difficulties prevented transcription of the fifth focus group recordings.

Analysis

To build toward a theory of impact and influence relative to MESA activities and underrepresented students, we employed a ground theory approach to analyze the focus group results. Grounded theory is an inductive, comparative iterative method that is used primarily as a method of data analysis. This strategy is useful when striving to render a conceptual understanding from the data (Charmaz & Belgrave, 2002, Dey, 2004). The grounded theory approach yields themes that are formed from the grouping of codes according to conceptual categories that reflect commonalities among coded data (Glaser & Strauss, 1967).

In this study, we looked for emergent themes formed from the focus group participants' responses. This was accomplished by looking at the transcribed recordings and notes that were taken during each interview session. Initial data examination was done independently by each researcher prior to coming together to discuss the themes that were prevalent. Individual researchers reviewed collected responses and gradually went from coding to categories, and eventually theory building, which lead to the development of activity components (Harry, Sturges, & Klingner, 2005). After individual analysis, the researchers came together to identify themes and correlate results in order to establish inter-rater reliability.

Results and Discussion

The results of the grounded theory approach to analyzing the focus group responses produced eight themes. They were: (a) informal mentoring, (b) makes learning fun (c) time management (d) application of math and science, (e) feelings of accomplishment, (f) builds confidence, (g) camaraderie, and (h) exposure to new opportunities. Each emergent theme is discussed in more detail below.

A. Informal Mentoring

In the analysis of data from the focus group interviews a surprising theme emerged. Participants talked more about their roles as mentors in informal mentoring settings as opposed to the informal mentoring they received from

MESA teachers and advisors. Participants spoke about mentoring not only their fellow underclassmen but also volunteering with local middle and elementary schools:

... instead of doing the competition and competing, we get to volunteer -- we get to help with the um middle schools and um help them make their projects and give them advice. (Group One)

We tutor elementary schools too, so there's a lot of elementary schools around. (Group Three)

Also prevalent was the tutoring and mentoring of other MESA students by returning MESA members who took it upon themselves to assist their fellow underclassman duly noted in this excerpt from Group Four:

... but we've done enough projects between us that we've probably done whatever project the freshman, and juniors, and sophomores are doing, so we can help them. That's kind of what we do. (Group Four)

Informal mentoring from the MESA advisors and teachers was also mentioned:

This is a club that like wants people, us, all of us, to succeed in life going into college, succeeding in that, all the advisors, all the teachers, just want to see you achieve, to your best quality. So they're going to help you out and to be the best you can be in succeeding. (Group Two)

B. Makes Learning Fun

Participants seemed to agree that making learning fun was a key component of MESA's success. They not only spoke of the MESA experiences in reference to learning but also voiced the importance of MESA experiences in changing their perceptions of STEM fields:

It is actually really fun, you don't fall asleep. Um yeah, you don't fall asleep. It's amazing. (Group One)

If we didn't have the fundamental of math -- I mean fun, in between there -- it would be really boring. (Group Two)

That's something that MESA shows you at hand. You actually see people -- actually see engineers and they're just out there doing their thing, and they're just having fun and they're enjoying it. (Group Three)

C. Time Management

Organization and time management emerged as a prevalent theme among the focus groups. When speaking about the benefits of MESA, a participant spoke about the impact of the program stating:

Like MESA, like kind of helped me like I used to be something like get on time, and something like that do some other stuff with MESA and taught me that I should be doing stuff earlier than doing it at the last second. . . (Group Four)

The competitions also aided in developing time management skills:

You learn that time is of the essence because we're there working, and then once we get to Saturday academics, or regionals, everything has to be on schedule, or we're running late, you have to turn in project at the certain time, so you're running. (Group Two)

MESA advisors helped participants with the organization necessary for application to college programs, as noted:

(MESA helps) when, there's so many deadlines and applications you have to turn in as a senior for college. (Group One)

D. Application of Math and Science

The focus group participants expressed an understanding of the importance of having opportunities to apply math and science learned in formal learning environments. One participant explained the integration of the formal and informal learning environments:

So as I would do MESA, I would get more encouraged and be wait, this is what I was learning in class. So where I would learn something in class, I would use it in MESA, and when I would learn something in MESA I would use it back in my class. You're realizing that this isn't just something you're doing for pointless reasons, but you're doing something with it. (Group Two)

Several participants commented on learning the importance of math and science and also the opportunity for transference of knowledge by stating:

Well the best experience I've had in MESA has been just overall learning the value and importance of math and science. Because we -- we put math and science into like -- into all these projects we do. (Group Three)

And MESA really brings out -- really tells you like -- it really gives you an experience of what it's used for. Like here we're doing physics in class, and I'm like what am I going to use this for? You know, how does this apply to me? But then once you do the windmill or something like that. . . (Group One)

E. Feelings of Accomplishment

MESA provided opportunities for participants to achieve outcomes that seemed to be key components in the program. Below participants voiced feelings about competing and winning competition, stating:

One thing you get is just this immense sense of accomplishment, that you did something and it's not something that you just can't fabricate. (Group Two)

I get an award, I get this medal on to show that I put that much effort into it. And that's something that MESA does for us. Well to me, it makes me feel accomplished like I actually did something, that I put my work into, and I got something out of it. (Group Three)

We were doing team math, and when we won first place I

was, like yes. So it was a good time for me. . . (Group Four)

F. Builds Confidence

Participants commented on gaining and building confidence from winning competitions and seeing others like them succeed:

I think I've gained a lot of confidence in myself from MESA, because you do a project, or you give a speech, or you take a math test and you kind of think, I don't know I kind of did okay on that. (Group Four)

Well now that I've done it since 7th grade, it's been more easier. Like I'm more calm I know what I'm doing it's just as I go through it I just learned from 7th grade don't be as nervous, just do the best, and just have a little mental power that, you know, I can do it and I can. (Group Two)

Like it make a difference for me because like all my dad, um a lot of his friends from college became engineers, so it's kind of cool because you may of his friends that I've met have been male engineers, and like I go to their companies and it's all like guys working there. So it was kind of cool because like not only was she an engineer, but she was like in charge of many projects. And so like it showed like how it didn't matter so anybody could do -- be in charge. (Group One)

G. Camaraderie

Although the participants spoke often about participation and placing in various competitions, these activities were oftentimes not what kept them coming back. One of the prevalent themes we heard was the camaraderie formed by working on projects and visiting different schools while participating in different events. Below are a couple of examples from different groups expressing such thoughts:

... like if you're at prelims you just kind of cheer for your school if they win, but when you go to regionals, if your center wins, then you're cheering for them. But it's not like that serious, like at competitions like you want to win of course, that's what you're doing it for but like everyone is kind of you know relaxed, and everything like everyone talks to everyone. It's not like, you know, you don't talk to them because they're your competitor or whatever. It's kind of like oh, you're here too, how did you do this year? (Group One)

And when we're doing the trebuchet, we spent countless hours. We would go to our advisors house, stay there from like eight in the morning, and it would be eight at night. And we'd be trying to build it. It would be all the groups and we help each other. (Group Two)

We interact with other schools, and we're -- and well, you get to meet new people when you're doing the same project as they are, and they get to give you like what Martha said, and everybody else they get to give you hints on what to do on the project, and then besides that, even though you're competing against them, you make new friends that will

help you. (Group Two)

The relationships formed among the groups were paramount to why a number of students stay in MESA:

Well, I stayed with people I didn't really know during MESA that year that well, because they were juniors and I was just a sophomore. It was kind of fun I stayed with them, got to know each other better, got closer for this year. So that was really fun to like, you know, all hang out there together. (Group One)

... I liked being in a group with them and working, because it was always fun. And I think it helped with like our friendship and bonding and stuff. (Group Four)

It's like a good time to learn from our other older students. If you have troubles in any subject, math, science, or English, anything, they'll help you out, and it's great because if you have no one else in all your other classes that will help you. It's a great place to go to help others if you don't need help, or if you need it back, that's my experience. (Group Three)

H. Exposure to New Opportunities

A number of the participants came from backgrounds that do not afford them opportunities to visit college campuses or to work on projects outside of their classrooms. MESA provided a bridge to those participants that do not go unnoticed or unappreciated:

MESA, it gives you so many opportunities, that a person like me, would never have had. Like my parents were always -- like they complain about the hours I put in for like my projects, you know, but they're like oh, you should -- you should do that because it gives you the opportunity -- like gives you an opportunity to like see things that we'll never -- that you'll never get to see with us, you know. Because my parents they're not really, like um -- they don't know any English so they can't go anywhere, so they never take me anywhere and they're just like yeah, so you should just like do your best. And join things that would allow you to see others things, you know, give you opportunities. And MESA really does that. (Group One)

And like one thing is like with engineering and stuff, that it -- there's not a club on campus that would allow you to explore that option. There's some for writing and reading, the obvious subjects, but sometimes like engineering is kind of like pushed back because it's math and science, the two most unpopular subjects at a school. And then on top of that, you're asked to do a lot of different projects. And without MESA not a lot of teachers would be willing to have just the fun option of trying this. (Group Two)

-- just this last weekend they took some of us juniors to Chico -- Chico University and this took us Sunday night and we slept over there at an apartment that these girls share. And so it's not just the fact that you're there, but you get this feeling like you belong. And it's um -- you're part of the college. And you get to -- you get to experience that even

before you go to college. And it was really nice we were just -- and then we got to visit the dorms we got to visit around school. We saw students, ex-MESA students from this school and they're really happy they say their classes are super hard, but they're loving it. And it's just really nice. And just MESA we're just like -- we're really united when it comes to. (Group Three)

Conclusion

The goal of this study was to identify aspects of a STEM-based informal learning environment that benefited students, with particular focus on underrepresented student populations. To accomplish our goal, focus group interviews were used to gather data while using a grounded theory approach to analysis to develop our themes. Five student groups from across the state of California participated in focus group interviews with the purpose of identifying activity variables within the MESA program that impacted students. The results of this study provided eight emergent themes that illustrate the benefits of informal learning environments: (a) informal mentoring, (b) makes learning fun, (c) time management, (d) application of math and science, (e) feelings of accomplishment, (f) builds confidence, (g) camaraderie, and (f) exposure to new opportunities.

The results of this study speak to the role of informal learning environments. Operating outside the constraints of standards-based testing and statewide curriculums, the MESA program seems to be effective in impacting students' knowledge, skills, and affective abilities. This comprehensive approach to teaching and learning may be at the heart of what makes some informal learning environments effective. More empirical research is needed to better understand the role informal learning environments play in advancing learning in STEM. Our study was limited in that it only investigated one model of an informal learning environment. However, we contend that our results are applicable to a myriad of environments including other informal learning environments and even formal learning environments.

Implications

The themes presented are particularly useful for programs interested in increasing the participation of underrepresented students. Based on the results of the study, it is our contention that the teaching of STEM content to *all* students can be enhanced by the emphasizing themes presented in this study. To combat the growing sentiment that the nation is failing to prepare an adequate number of students, teachers, and practitioners for careers in STEM fields (Kuenzi, et al., 2006), it behooves educators in STEM-based formal and informal learning environments to examine the themes presented in this paper. Whether evaluating the impact of their learning environment or attempting to revise

the teaching of STEM content, the themes presented here offer a window into ways that STEM education can be reformed. It was our intent to provide some insight into the aspects of informal learning environments that may influence students and are particularly attractive to underrepresented student populations. We believe the results of this study help accomplish this goal, in addition to their contribution to instrument development.

The aforementioned eight themes were utilized in the development of a survey instrument to support focused work with MESA. The Engineering Self-Efficacy, Interests, and Perceptions Survey (ESIPS) instrument is currently being administered to MESA students in four states: California, Utah, Maryland, and Washington. With an anticipated goal of 1500 participants, the study will provide data on the impact of MESA activities on underrepresented students' engineering self-efficacy, interests and perceptions. Findings from this study will add to the growing literature on informal learning environments and their influence on students.

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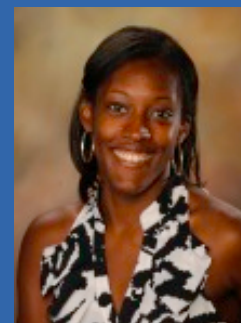
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