Middle School Students' Conceptions of Failure in Rural Communities

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Abstract— **This work in progress paper in the research to practice category identifies trends in how middle school youth from rural schools conceptualize failure after engaging in engineering-related learning activities. These trends inform better strategies that can be used in the PEERS, Partnering with Educators and Engineers in Rural Schools, program to ensure the goals of the program are met. The PEERS program moves beyond single exposure activities by engaging students in approximately six engineering-related learning activities throughout the year. This program partners researchers, teachers and local industry representatives aiming to (1) challenge misperceptions and create relevant conceptions of engineering; (2) maintain and expand situational interest; and, (3) integrate with individual interests, values, and social identities. Since failure is an integral part of the learning experience, students' conceptions of failure can influence the way students interact in these activities and the outcomes they experience from this program. Interviews were conducted with 38 students across the three rural communities involved in the PEERS program on their perceptions of failure. This paper presents two themes that emerged from initial coding of the interviews and explains how these themes will be used to inform future decisions for PEERS.**

Keywords—partnerships, failure, engineering outreach

I. Introduction

Throughout history, failure has maintained a negative connotation, especially within academic domains [1]. Within the traditional confines of the classroom, students fear failure and look for less challenging routes to completing a task [2]. Despite the plethora of inspirational quotes around failure, students still perceive failure as a negative event that is a set-back to progress [1]. On the other hand, many researchers have identified failure as an integral part of the learning experience [3, 4, 5, 6]. Additionally, not feeling comfortable with or knowing how to cope with failure can have negative effects on students. For example, fear of failure has been linked to antisocial behavior in college students and failure avoidance has been shown to be negatively correlated with self-efficacy, goal commitment, and task performance [7].

One of our broad goals in the PEERS program is to challenge misperceptions and create relevant conceptions of engineering for the participants. Failure is not only a natural part of life, but also a necessary and inherent part of engineering that invites subsequent improved designs [8, 9]. Therefore, it is important that students understand the role of failure in engineering, which uses an iterative design process that emphasizes the idea that failures are opportunities to learn [9]. PEERS hopes to develop student aptitude for failure by renegotiating the meaning of failure to the students in our study and emphasizing the value of failure within the learning process. PEERS builds on the ideas of Autin and Croizet [10] that if parents and teachers communicated to students the importance of failure in the learning process then they may perform better in school.

II. Failure

In the academic context failure has been defined as "lack of success in education" referring to receiving a grade below a passing level or simply to a performance below expectations [11, 12]. PEERS similarly defines failure as not meeting ones expected outcomes, or falling short of what one expected for success. Since PEERS doesn't assign grades to students, the role of grades on students understanding of failure will not be considered. Instead, PEERS focuses on the role of failures in the engineering context where 'failures' or shortcomings are used to learn and make subsequent designs better [9]. PEERS represents failure as a productive and crucial aspect of engineering which can be liberating for many students, especially low-achieving students [13]. Based on our definition of failure in the academic context of engineering, our program finds the term struggle to be synonymous with our definition of failure and more accessible for students.

III. Methods

This work in progress paper uses the lens of failure to discuss initial findings in response to the following research question: How do youth in rural schools who are engaging in engineering-related learning activities conceptualize failure?

A. Context

The participants in this study are 6th grade students that are currently part of a larger initiative where they engage in monthly engineering activities. PEERS is an NSF funded program where volunteers from local industry, engineering graduate students, other university affiliates and teachers of middle school science courses collaborate to create and implement these activities during students' regularly scheduled science class. These engineering activities are intentionally designed by all participants mentioned above to

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be culturally relevant, hands-on and align with Virginia Standards of Learning for science. The activities are implemented monthly across three different rural communities in a mid-Atlantic state. Two of the activities discussed in this paper include fixing mountain roads and taking apart cell phones. In fixing mountain roads, students are given a prototype of an unsafe road and are tasked with fixing the necessary elements to make it safe (filling potholes, adding guardrail, adjusting the grade, etc.). In taking the cell phone apart students use tools to access the inside of the cell phone and identify the elements that are present in the phone.

The National Center for Education Statistics, NCES, classifies schools into four categories (rural, town, urban, city) based on their proximity to an urbanized location. Data for this study was collected from three schools, one in each community involved in PEERS. Two of these schools are classified as distant towns and one is classified as rural [14]. All of the schools involved in this program share similar characteristics and challenges as other rural communities, therefore we have clumped distant town and rural locations under the larger umbrella of rural, not urban, communities.

All middle schools in these communities are involved in PEERS which allows all 6th graders to be involved in the program for a total of 757 students. While PEERS aims to (1) challenge misperceptions and create relevant conceptions of engineering; (2) maintain and expand situational interest; and, (3) integrate with individual interests, values, and social identities this paper focuses on how student perceptions of failure is influencing these outcomes.

B. Data Collection

Semi-structured interviews were conducted with 38 students across the three different communities: 12 in Springfield County, 15 in New County, and 11 in South County. In total there were 21 boys in the sample and 17 girls. Interviews at each school were conducted during the same school day when students were engaging in their monthly engineering-related learning activity. All students that were interviewed had engaged in 5 engineering-related activities facilitated by the PEERS program at the time of the interview.

Individuals were quickly pulled out by the teacher and/or researcher to discuss program-related impressions as part of a brief semi-structured interview. Only data from students who had parental consent and student assent to the research study were included in this analysis. This pull-out strategy was used to minimize the amount of distractions occurring from people entering and exiting the room during the engineering-related activity. Since student consent did not include the ability to record students, interview responses were typed in real-time as the interviewee responded to the question and were read through after the interview to fill in any gaps that were missing. Strategies used when recording interview responses were adapted from Coso [15] and follow suggestions made by Miles, Huberman and Saldana [16] that a formal-write up conducted after the interview will be useful in adding in any missing details from the original interview notes. While many of the responses aren't verbatim, we feel that the transcripts were a strong representation of the message that participants were trying to portray.

C. Interview Protocol

This paper focuses on the following questions:

1. Thinking about the VT PEERS activities that you have engaged in (list the activities for the specific school), can you tell me about a time that you struggled?
3. Thinking again about the VT PEERS activities, can you tell me about a time that you were successful?
4. Did you learn anything through either of these experiences (the two they mentioned in # 1 and # 3)?
5. Do you think you learn more when you successfully complete a task or when you struggle during a task?
8. When you struggle during an activity, do you normally quit the activity or continue? If you quit, why do you quit? If you continue, why do you continue?
9. What were you thinking about when you answered that questions? Can you give me an example?

D. Data Analysis

All interviews were coded using a combination of in-vivo and deductive coding strategies. Due to the nature of some of the interview questions that asked students to respond to binary questions (4,5,8), such as a question asking students if they think failure is a positive or negative thing, deductive codes were created to classify students based on their responses to these binary questions. Students were also asked to provide explanations to their binary answers and were asked some completely open- ended questions which were coded using in-vivo codes which uses words or short phrases from participants' own language to describe a chunk of code [16]. The following chart details how some interview questions were coded. The deductive codes list the codes used to classify the students and in-vivo codes show the category of codes researchers were looking for within student responses.

TABLE I. CODING STRATEGIES

Question	Deductive Codes	In-vivo codes
Thinking about the VT PEERS activities that you have engaged in (list the activities for the specific school), can you tell me about a time that you struggled?	Activity title - 'Flashlights' - 'Build Roads' - 'Fix Roads' - 'Cell Phones' - 'Water Filter' - 'Ecosystems'	Characteristics of what it means for a student to struggle in something.
When you struggle during an activity, do you normally quit the activity or continue? Why?	-'quit the activity' -'continue activity'	Reasons why students discontinue or continue a task
What were you thinking about when you answered? Can you give me an example?		Title of example that was given.

To understand this coding strategy better, let's look at Liam's response whether failure is positive or negative:

Liam: *it can be a positive; I think it's positive because you learn from your mistakes.*

This response was coded using the deductive code 'failure is positive' and the in-vivo code 'learn from your mistakes.' Similar strategies were used for the other questions.

To begin looking for themes or patterns in these interviews, the first cycle of coding strategies was applied to 2 interviews (1 boy and 1 girl) from each of the three schools in this study. Initial results from the 6 interviews led to interesting emerging themes especially around the responses to questions 4,5 and 9. The second coding cycle further developed these themes by coding the remaining 32 interviews looking specifically at the student's responses to these questions and using the same coding strategies previously shown. The themes discussed in this paper will be drawn from all 38 student's responses to the identified questions: 4,5 and 9. This is supported by Miles, Huberman and Saldana [24] who state that "not every portion of the field notes or interview transcripts must be coded."

IV. Preliminary Results

Through this initial round of coding the two themes that emerged across schools and participants involve categories of student failures and differences between student perception of and references to failure and success.

A. Student's Examples of Failure

The most consistent trend in these interviews was that students responded to question 8 about whether they would quit or continue when faced with a task that they were struggling in by explaining, with a seemingly quick rate of response, that they would continue the task. 37 of the 38 students that were interviewed explained that they would continue the task with one student noting they would quit the task because they would probably get mad. As a follow-up question to this response, the interviewer asked if the students could provide an example of a time when they struggled and continued in the task. There were many similarities in the types of examples that students were providing. Table I categorizes the examples from students.

TABLE II. Categories of Student Failures

Sports	Basketball, Dancing, Football, Golf, Gymnastics, Kickball, Soccer, Sports, Volleyball
Games	Marble Maze, Legos, Puzzle
Physical Activity	Building a treehouse, Jumping on a trampoline, Climbing a ladder, Sliding, Halter breaking a cow, Hunting / Fishing, Riding a bike
Hobbies	Choir, Drawing, Video Games
School	Science Fair Project, Science Project

In Table II above some subtle differences exist between the different categories. Sports are physical activities that are often competitive in nature while physical activities are physical in nature but not competitive and not traditionally classified as a sport. Games are activities students completed with someone else that aren't necessarily physical in nature or competitive. Hobbies are activities that students engaged in outside of school that are not collaborative, competitive or necessarily a physical activity. School refers to an activity in the classroom.

While Table II provides some insight into how the various responses were categorized, some of the examples given in Table I came up in more than one student interview, such as football that was used as an example in five student interviews. Figure I shows the number of times that the different categories were represented in the interviews. The category of no response was for students who didn't provide an example.

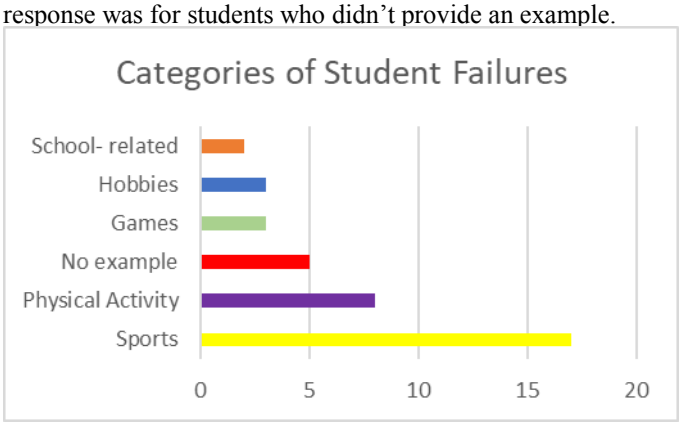

Fig. 1. Number of Occurrences for Different Student Failure Examples

Upon initial observation it may not be surprising that many students referenced sports when discussing struggling, continuing through a difficult task or failing. Life lessons, including failure, are commonly discussed and depicted as being linked to involvement in sports [17]. What is surprising is that despite being in an academic context and discussing academics for the previous 10-15 minutes students rarely referenced academics. In fact, the two students who referenced struggling in an academic context were both from the same school and were working on the exact project that they were describing when they were asked to come out for the interview. We need to reconsider if students continue through tasks they are struggling with in academics or if this is something unique to non-academic activities.

B. Disconnect Between Student Perceptions of and References to Failure & Success

The interviews suggest a disconnect between what experiences students reference when they are talking about their learning and the experiences from which they think they learn the most. Students were asked to provide examples of activities that they learned something in and they were asked to identify which types of activities they feel they learn the most from but the student responses to these didn't align. Students were giving examples from activities that didn't have the same characteristics as the activities which they seemed to think they would learn the most from. To better understand this, we will look at Tim's responses to questions one, three and four. Tim's response to question 1 (1) which asks students to identify and explain an activity they struggled in is below:

Tim: *The fixing roads was a struggle because we couldn't find most parts for ours and some people weren't doing what they were supposed to. Trying to figure out which parts we needed to fix the curves with was hardest. We ended up doing a tunnel and putting a top on the road and we ended up fixing the hole and took the tree and boulder out of the road. We added more length to it. Our road still didn't work - the marble would always fall off.*

Tim's response to question number 3 (3) asking students to identify an activity they were successful in is below:

Tim: *Cellphones, because when my group and I got it we completed it very quickly because one person knew what was going on and we all kind of figured out what was going on to a cell phone.*

After students described an activity that they struggled in (1) and an activity that they were successful in (3), which were mutually exclusive in all our student interviews, students were asked if they learned anything through either of the experiences (4). Tim's response is below:

Tim: *I learned teamwork through the cell phone activity and the importance of listening to one another.*

Since Tim referenced the cell phone activity to describe what he learned and didn't reference the fixing of the roads, he was categorized as referencing the task he was successful in. All students were categorized in a similar manner identifying whether they were referencing their successful task or the task they struggled in. After these series of questions students were asked whether they think they learn more in a task they complete successfully or one in which they struggle (5). Tim's response is below:

Tim: *When I struggle because I learn from my mistakes.*

Since Tim suggested that he learns more in a task that he struggles with he was classified as 'perceived to learn more through a task they struggled in.' There is a disconnect between what Tim references when talking about lessons learned through different activities and what he perceives to be the most valuable academic task. Many students had similar differences in their interviews. Looking across all 38 interviews, only 7 students referenced the task they struggled in when discussing what they had learned in the activities while 25 of the students explained that they think they learn more through a task that they struggle in.

Students are likely exposed to inspirational quotes about failure, sayings or stories that relate to the value of struggling and failure, so it isn't surprising that they see more value in a task that they struggle in [18]. It is surprising that students aren't as likely to reference these difficult tasks when asked what they have learned. It is possible that students know they should value failure, but they struggle to identify what they are learning through these school-related tasks they struggle in.

V. Conclusion

While the PEERS program aims to help students see failure as a positive and useful part of the learning process, initial coding and analyses suggest that students may be struggling to transfer their opinions of failure generally to go further and identify why and how it is useful in the academic context. The two themes identified above may imply that (1) students are aware of the benefits of failure generally but, (2) students are unsure how to transfer these opinions about failure to learning in the academic context and (3) students are more likely to reference or discuss how failure impacts other aspects of their lives outside academics, especially sports. We would expect that using these data collection methods in a rural context would yield similar results, given the large percentage of student responses that aligned with the findings. Within student interviews there was no shortage of inspirational phrases about failure to include things such as 'you have to fail at something to learn' or 'failure is just a challenge to learn something new.' It is likely that social desirability bias impacted student's general responses about failure and thus they are recognizing that viewing failure positively is generally viewed favorably by others, at the least by their teachers and the researchers in this program [19]. Despite this desire to view failure as a positive and productive thing, students don't necessarily understand how to transfer these opinions about failure to learning in the academic context. Applying beliefs about failure can be more difficult than just holding those beliefs.

A. Impacts on Our Program

Based on these preliminary results, there are some necessary strategies that our team will consider in next year's activities. Since students are more comfortable recognizing and persevering through struggles outside the classroom (as seen in categories of student failures), our team will intentionally use projects that idealize practice and continuous improvement, like the model used in sports, rather than projects focused on completion. One way to support this effort is to emphasize the continuous improvement aspects of engineering and that the engineering design cycle is iterative and includes a "modify and improve" step [9]. Students will be encouraged to retry activities with information learned to reach a better product as opposed to being celebrated simply for completion. Since creativity and comfort with failing are positively linked, future activities will emphasize the need for creativity and the appropriateness of failure [20].

We will also focus attention on teaching students how to transfer their opinions about failure to the academic context to get the most out of the learning experience, including how to identify what they are learning when they experienced failure, or they have struggled. Students should understand that making mistakes is a vital part of learning and being successful as one can learn from and build off those mistakes [21]. Students should accept failure as a necessary part of the learning process. In engineering "students should fail often so they can succeed sooner" [22].

B. Future Work

PEERS plans to further investigate students' opinions of failure and success by reanalyzing the interviews. Additional future work could include further analysis of the themes presented here to examine by gender differences or to analyze the impact of rural locations on the results of the study. These analyses will help us to further understand how rural youth conceptualize failure.

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