

Article

Examining the Relationships between Teacher Self-Disclosure and Emotional and Behavioral Engagement of STEM Undergraduate Research Scholars: A Structural Equation

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Abstract: Understanding the factors contributing to the persistence and retention of students in science, technology, engineering, and mathematics (STEM) is among the main issues of concern within STEM post-secondary education. The literature suggests that teacher self-disclosure and emotional and behavioral engagement play a significant positive role in the learning process across disciplines. Such factors may lead to improved academic achievements and retention in STEM disciplines. A variety of studies examined the relationship between teacher self-disclosure and emotional and behavioral engagement within the field of humanities, but less within the fields of STEM. This study used structural equation modeling (SEM) to examine the relationship between teacher self-disclosure and emotional and behavioral engagement of 208 undergraduate students enrolled in a two-year Freshman Research Immersion program. The results showed significant relationships between different aspects of teacher self-disclosure and classroom engagement. Additionally, STEM students view that high amounts of teacher self-disclosure can be related to negative aspects of classroom engagement such as emotional engagement anxiety. The study's significance lies in practical recommendations associated with the strategic use of instances of teacher self-disclosure while teaching STEM classes and ways to support STEM undergraduate students' levels of classroom engagement.

Keywords: teacher self-disclosure; emotional and behavioral engagement; teacher preparation; persistence and retention in STEM; Freshman Research Immersion STEM program



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1. Introduction

Prior studies have documented a lack of persistence as post-secondary students change majors from science, technology, engineering, and mathematics (STEM) to non-STEM majors [1–3]. This has negative outcomes such as workforce shortages [4–6], limited diversity and representation in STEM [7], and reduced innovation and technical development [8]. Among the key reasons for the lack of persistence in STEM majors is how STEM students identify themselves as STEM learners (or not) in a STEM field [9–11]. Additionally, classroom engagement is another factor to issues of persistence and retention of students within STEM spaces [12–14], specifically within STEM research programs in higher education [15–18]. Furthermore, Daempfle [19] argued that lack of classroom communication between faculty and students is among one of the contributing factors that lead to attrition within STEM fields. The researcher asserted this by stating that “students were generally interested in the sciences but were ‘turned off’ by the structure and climate of the classroom” (p. 41). Such statements suggest that less engaging classrooms taught by unapproachable faculty lead to the attrition of students from STEM fields [20–22].

In addition to the classroom environment, teacher self-disclosure also plays a significant role in the learning process across STEM disciplines [23,24]. A combination of a suitable classroom environment and instances of teacher self-disclosure aid students in

understanding the course material [25–27], develop students' participation within learning situations [28,29], and enhance their overall learning experience [26]. This, in return, has the potential to lead to retention and persistence within STEM fields [23,24]. While working with teachers across the field of communication studies, Cayanus and Martin [1] classified teacher self-disclosure in three dimensions: amount, relevance, and negativity.

This article investigates the research question: What is the direct relationship between teacher self-disclosure and the behavioral and emotional classroom engagement of undergraduate students enrolled in a STEM research program? It can be argued that instances of teacher self-disclosure have the potential to enhance or hinder levels of student engagement in the classroom. More specifically, teacher self-disclosure instances, including amount, relevance, and negativity, can significantly influence the behavioral and emotional classroom engagement of undergraduate students in a STEM research program. By carefully considering these factors, teachers can effectively utilize self-disclosure as a tool to enhance student engagement, which, in turn, can positively contribute to their persistence within STEM.

Based on the results, we illustrate the significance of specific dimensions of teacher self-disclosure in promoting or hindering levels of classroom engagement for undergraduate students enrolled in a STEM research program. The findings have the potential to generate recommendations that can contribute to the advancement of teaching and learning in STEM research programs and higher education classes. By implementing these recommendations, there is potential to enhance student engagement, improve learning outcomes, and elevate the overall quality of STEM education at the higher education level, which, in turn, can have a positive impact on student persistence and retention within STEM.

1.1. Literature Review

To ground the study, we explain the concepts of teacher self-disclosure and emotional and behavioral engagement. In addition, we also describe the relation between teacher self-disclosure and students' levels of emotional and behavioral engagement.

1.1.1. Teacher Self-Disclosure

Wheless and Grotz [30] defined self-disclosure as “any message about the self that a person communicates to another” (p. 338). Jourard [31] explained that deciding to self-disclose is based on positive feelings, such as an attitude of trust and love. For defining themselves within academic context, teachers can choose to voluntarily disclose their personal information, thoughts, and feelings to students [29]. Cayanus and Martin [1] suggested three dimensions of teacher self-disclosure—amount, relevance, and negativity. The amount of self-disclosure has to do with how much and how often teachers self-disclose their personal information. For example, a math teacher might occasionally mention their passion for hiking when discussing real-life applications of geometry. Relevance refers to the relevancy of the self-disclosure instance to the topics being discussed in the classroom and related to the course content. For instance, a science teacher might share a personal experience of conducting an experiment that aligns with the current lesson, making the self-disclosure relevant and enhancing students' understanding of the topic. Negativity deals with revealing negative experiences and feelings within the classroom context, for instance, expressing negative feelings towards a colleague, disagreements with the department, or general feelings or comments of sexism or racism towards an individual.

When it comes to STEM spaces, it is important to examine teacher self-disclosure, as this construct is connected with classroom engagement [29,32] and contributes to persistence in STEM spaces [33]. Rassmussen and Mishna [34], who wrote a book chapter reviewing various studies on teacher self-disclosure on different educational levels, concluded that teacher self-disclosure, especially related to math concepts, were positively received by undergraduate students as it helped them in understanding better the course content and retention of points covered in the classroom. Additionally, studies conducted at the college level within various disciplines showed that instances of teacher self-disclosure

that are occasional, not negative, and are relevant to the course content supported students in the recall and retention of the lecture material [35–38].

1.1.2. Emotional and Behavioral Engagement

Emotional engagement focuses on concerns associated with aspects of students' feelings of belongingness and feelings about the classroom environment [39]. Examples of such feelings include interest, boredom, happiness, sadness, and anxiety within learning situations. This also captures students' relationships with their classmates and instructors [32,40–44]. We followed the classification of emotional engagement, as given by Renninger and Bachrach [41], which has four distinct dimensions: interest, achievement orientation, anxiety, and frustration.

Behavioral engagement is defined as students' self-reported participation and effort during class [40], and encompasses aspects such as attentiveness, diligence, and time spent on in-class tasks [45–47]. It is linked to students' adherence to classroom norms and expectations [35], which is indicated by their active listening, as well as interactions and contributions to the learning process [48]. Behavioral engagement is directly associated with how students participate in the class, take interest in academic tasks, and respect the existing classroom rules [32,35,49,50].

There are several aspects informing the significance of studying emotional and behavioral engagement in higher education and, more specifically, within STEM. First, students' emotional and behavioral engagement is associated with the development of critical thinking [51–53] and integration of the learned information into the learning process [54]. Additionally, emotional and behavioral engagement informs the level of persistence, which is one of the main issues among undergraduate students within STEM programs [55]. Studies with undergraduate students within STEM and non-STEM disciplines showed that a sense of belonging, especially classroom belongingness, is strongly related to behavioral and emotional engagement [53,56]. Such studies argued that students who opt for STEM as their desired field of study demonstrated not only higher levels of emotional and behavioral engagement with STEM classes, but also persistence in STEM fields.

1.1.3. Relation between Teacher Self-Disclosure and Emotional and Behavioral Engagement

For emotional engagement and teacher self-disclosure, the existing literature suggested that teacher self-disclosure characterized as being positive, relevant, and moderately recurrent triggers the emotional engagement of students within the classroom setting [1,35,57]. This can be supported by the fact that such instances of teacher self-disclosure are perceived by the students as being transparent and credible, which further helps them in developing a connection with the teacher. On the contrary, studies conducted by Cayanus and Martin [1], Rosborough and colleagues [58], Frisby and Sidelinger [59], and Goodboy and colleagues [60] explained that the negative domain of teacher self-disclosure could affect the emotional aspect of students' classroom engagement negatively. For example, sharing negative opinions about the institution or negative opinions about the subject being taught might create feelings of negativity and violate students' expectations of a positive learning environment, which makes students emotionally disengaged in such learning contexts.

Skinner and Pitzer [61] and Wang and Eccles [62] also argued that positive self-disclosure and positive interactions in STEM and non-STEM disciplines, respectively, could be considered among the factors that encourage secondary and post-secondary students to maintain good attendance, which is perceived as an indicator of classroom behavioral engagement. Furthermore, studies by Kelly and Turner [63] and Kromka and Goodboy [35] suggested that undergraduate students become more behaviorally engaged in instances when they feel their teachers care about them, through positive and moderate amounts of self-disclosure.

The abovementioned studies suggest that instances of teacher self-disclosure that are positive, relevant, and moderately frequent can positively affect students' levels of emotional and behavioral engagement [64]. However, this area is still unexplored when it comes to

examining the direct relationship between teacher self-disclosure and levels of emotional and behavioral engagement. Also, the literature has not examined the relationship between emotional and behavioral engagement and specific dimensions of teacher self-disclosure within the context of STEM education. Hence, we designed this study to examine the potential direct relationship between specific factors of teacher self-disclosure and students' levels of emotional and behavioral engagement within a STEM research program.

2. Materials and Methods

2.1. Context of the Study

This study was designed for undergraduate students enrolled in a STEM research program at a research-intensive institute in the northeast region of the United States. This university provides some first-year students with the opportunity to take part in an authentic research experience in STEM disciplines called Freshman Research Immersion (FRI). This three-semester program provided first-year students with the opportunity to take part in authentic research experiences in STEM disciplines under the guidance of a research mentor. This program was based on a variety of STEM subject areas: biogeochemistry, biomedical chemistry, clean energy, community and global public health, ecological genetics, environmental visualization with drones, image and acoustic signal analysis, microbial biofilms in human health, molecular and biomedical anthropology, and neuroscience. Opting for a STEM research program allowed for examining the variables in a context that is STEM-focused and the students enrolled in this research program are likely interested in pursuing a degree and career in one of the STEM fields. We used information from these undergraduates enrolled in STEM research programs as we examined the relationship between teacher self-disclosure (i.e., amount, relevance, and negativity) and the emotional and behavioral engagement of STEM undergraduate research scholars using structural equation modeling (see Figure 1).

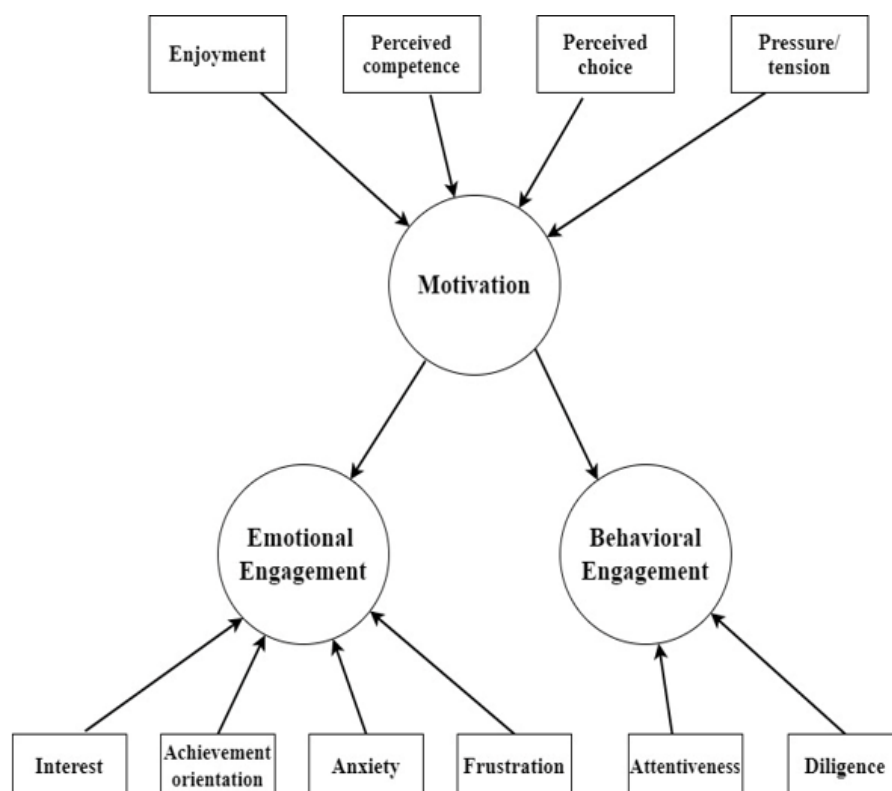


Figure 1. Hypothesized model to examine relation between teacher self-disclosure and emotional and behavioral engagement.

2.2. Participants

IRB approval was obtained prior to the study and the students voluntarily participated. We used convenience sampling and the participation in the study was voluntary. Invitation emails were sent from the director of the program to the 560 students enrolled in the program. The final sample included data from 208 participants. About half of the participants self-identified as white (56%). There were more females (62.5%) than males (36%). The participants were almost equally distributed across different FRI streams, with a majority from Community and Global Public Health (14%) and Biomedical Chemistry (13%) (see Table 1).

Table 1. Demographic characteristics ($N = 208$).

Variable	N
Gender	
Female	130
Male	75
Prefer not to say	1
Ethnicity	
Black or African American	19
Asian	43
Hispanic, Latino or Spanish Origin	32
Middle Eastern or North African	6
White	106
Some other race (e.g., South Asian, Ashkenazi)	2
American Indian or Alaska Native	0
Native Hawaiian or Other Pacific Islander	0
I prefer not to answer	0
Status in the Program	
Freshman	53
Sophomore	81
Junior	54
Senior	20
STEM Specialization	
Biogeochemistry	18
Biomedical Chemistry	26
Clean Energy	19
Community and Global Public Health	28
Ecological Genetics	23
Environmental Visualization with Drones	22
Image and Acoustic Signal Analysis	12
Microbial Biofilms in Human Health	19
Microbial Biofilms in Human Health	19
Neuroscience	22

2.3. Data Source

The participants completed an online questionnaire in Qualtrics after the end of the Fall 2020 semester with items on their perception of teacher self-disclosure and emotional and behavioral engagement specific to their experiences in the STEM research programs. One reminder was sent to the participants after a two-week period. Table 2 demonstrates example items used to measure each of these constructs.

Table 2. Example items used to measure each sub-construct and coefficient alpha associated with each construct.

Construct	Sub-Construct (# of Items)	Example Item	Coefficient Alpha
Teacher self-disclosure	Amount (4)	My research mentor often gives their opinions about current events.	0.78
	Relevance (5)	My research mentor uses personal examples to show the importance of concept.	0.92
	Negativity (5)	My research mentor's disclosures, on the whole, are more negative than positive.	0.81
Emotional engagement	Interest (6)	In my research classes I find the knowledge interesting.	0.86
	Achievement orientation (6)	Though learning about research is tough, I feel happy when I can finish the tasks.	0.94
	Anxiety (5)	I find myself very nervous during research activities.	0.84
	Frustration (5)	I feel uncomfortable when the research mentor starts a new research topic.	0.78
Behavioral engagement	Attentiveness (6)	I listen to the research mentor's instructions attentively.	0.93
	Diligence (6)	For difficult problems/concepts, I would study hard until I understand them.	0.81

2.3.1. Teacher Self-Disclosure

We used the Teacher Self-Disclosure Scale by Cayanus and Martin [65] to measure three aspects of self-disclosure—amount, relevance, and negativity—using 14 Likert-type items. The items captured responses on a seven-point scale (1 = completely disagree, 7 = completely agree). The first aspect, amount, describes how often instances of self-disclosure are used by a teacher in the classroom. Relevance refers to the instance of teacher self-disclosure relating to the topic of classroom discussion and course content (e.g., telling a story about how a math concept was learned as a student when introducing a new math concept). Finally, negativity refers to disclosing “bad” things in the classroom and messages that are of a negative nature (e.g., expressing bad feelings towards the department or some general rules).

Some items were reworded to fit the nature of the program. For example, “My instructor reveals undesirable things about him/herself” was changed to “My research mentor reveals undesirable things about themselves.” The Cronbach alpha for the three sub-constructs ranged between 0.78 and 0.92, showing an acceptable to good reliability index (see Table 2). The descriptive statistics for each item used to measure teacher self-disclosure are given in Table 3. An acceptable level of the skewness and kurtosis of the items indicated that the data were considered normally distributed.

Table 3. Descriptive statistics for teacher self-disclosure ($N = 208$).

	<i>M</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>
Amount				
My research mentor often gives their opinions about current events.	3.26	1.6	0.55	−0.77
My research mentor often shares their dislikes and likes.	3.99	1.54	0.14	−0.91
My research mentor often presents their attitudes toward events occurring on campus.	3.39	1.32	0.72	−0.43
My research mentor often gives their opinions about events in the community.	3.58	1.38	0.20	−0.66

Table 3. Cont.

	<i>M</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>
Relevance				
My research mentor uses personal examples to show the importance of concept.	5.66	1.2	−1.21	1.53
My research mentor uses their own experiences to introduce a concept.	5.77	1.21	−1.30	1.79
My research mentor provides personal explanations that make the content more relevant.	5.73	1.22	−1.35	1.87
My research mentor provides personal examples which help me understand the importance of the content.	5.65	1.31	−1.45	1.94
My research mentor links current course content to other areas of content through the use of personal examples.	5.62	1.25	−1.37	1.93
Negativity				
My research mentor’s disclosures, on the whole, are more negative than positive.	1.86	0.88	1.34	2.26
My research mentor normally reveals “bad” feelings they have about themselves.	1.89	0.94	1.31	2.18
My research mentor reveals undesirable things about themselves.	1.86	0.87	1.15	1.73
My research mentor usually discloses negative things about themselves.	1.95	0.90	1.21	2.37
My research mentor has told some unflattering stories about themselves.	1.92	0.93	1.2	1.57

2.3.2. Engagement Instrument

We used a version of the Student Engagement in the Mathematics Classroom Scale (SEMCS) developed by Kong et al. [66] to examine the levels of emotional and behavioral engagement. The data were gathered on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). There were four aspects of emotional engagement—interest, achievement orientation, anxiety, and frustration. Interest referred to the student’s attraction to the applicability of the learning task [66]. Achievement orientation referred to the students’ capability of optimizing learning aspects (e.g., time and effort) with the goal of meeting some level of achievement (e.g., high marks). Anxiety referred to students’ perceived feelings of nervousness and unease that they might experience in some situations (e.g., taking tests) and the way they perceive this to affect their learning. Finally, frustration refers to students’ feelings of being tired of some learning tasks, which might lead to losing interest in the learning activity. Some items were reworded to fit the nature of the courses taken by the participants. For instance, “I find the math knowledge interesting and math learning enjoyable” was changed to “In my research classes, I find the knowledge interesting and research learning enjoyable.” The Cronbach alpha for the four aspects of emotional engagement ranged between 0.78 and 0.94, showing an acceptable to good reliability index (see Table 2). The descriptive statistics are given in Table 4.

For behavioral engagement, we used 12 items with two sub-constructs as attentiveness and diligence, with six items in each. Attentiveness includes instances when students are paying attention and are focused on the learning activities and related learning tasks [67]. Diligence refers to the students working persistently and in a careful manner to achieve a given learning task. Some items were reworded to fit the nature of the courses taken by participants. For instance, “I really make an effort in the math classes” was changed to “I really make an effort in the research classes.” The Cronbach alpha for attentiveness and diligence was 0.93 and 0.81, showing a good reliability index (see Table 2). The descriptive statistics are given in Table 5. An acceptable level of the skewness and kurtosis of the items indicated that the data were considered normally distributed.

Table 4. Descriptive statistics for emotional engagement.

	<i>M</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>
Interest				
In my research classes, I find the knowledge interesting and research learning enjoyable.	4.17	0.70	−0.84	1.87
I find learning about research pleasurable and I am interested in research activities.	4.19	0.66	−0.94	2.92
I feel a sense of satisfaction when I do research activities in research classes.	4.18	0.69	−0.96	1.94
I feel excited when we start a new topic in research.	4.13	0.70	−0.85	1.90
I am always curious to learn new things in research and I find learning research is enjoyable.	4.14	0.71	−0.60	0.52
I am very interested to know how to deal with new research issues.	4.10	0.84	−0.73	0.01
Research always gives me pleasure.				
Achievement Orientation				
Though learning about research is tough, I feel happy when I can finish the tasks.	4.26	0.59	−0.56	1.75
Though learning about research is boring, I am happy when I get good results.	2.95	1.10	0.36	−0.77
Learning about research is tough, but to get good results, the effort is worthwhile.	4.37	0.53	0.04	−1.00
Learning about research is tough, but I am happy as long as I can get good results.	3.85	1.00	−0.60	−0.42
Learning research is tough, but I am satisfied when I get good results after making an effort.	3.95	0.96	−0.81	0.20
Though learning research is tough, I get a sense of satisfaction when I get good results.	3.70	0.92	−0.38	−0.29
Anxiety				
I find myself very nervous during research activities.	2.55	0.95	0.86	−0.13
I am worried in research activities.	2.29	0.83	1.00	0.82
During research activities, when I come across problems/ideas/ knowledge that I cannot comprehend, I feel very nervous.	2.77	1.00	0.32	−0.98
I am always afraid that I will get poor results in my research classes.	2.45	0.97	0.95	0.26
During research classes, when I come across problems that I cannot solve, I feel very anxious.	2.63	1.00	0.51	−0.40
Frustration				
I feel uncomfortable when the research mentor starts a new research topic.	2.13	0.73	0.88	1.91
I am tired of learning a new topic in research classes.	1.84	0.56	0.14	0.71
I do not like attending research classes.	1.87	0.65	0.24	−0.22
I dislike doing research.	1.87	0.65	0.24	−0.29
I am tired of being involved in research classes.	1.79	0.71	0.73	0.67
Interest				
In my research classes, I find the knowledge interesting and research learning enjoyable.	4.17	0.70	−0.84	1.87
I find learning about research pleasurable and I am interested in research activities.	4.19	0.66	−0.94	2.92
I feel a sense of satisfaction when I do research activities in research classes.	4.18	0.69	−0.96	1.94
I feel excited when we start a new topic in research.	4.13	0.70	−0.85	1.90
I am always curious to learn new things in research and I find learning research is enjoyable.	4.14	0.71	−0.60	0.52
I am very interested to know how to deal with new research issues.	4.10	0.84	−0.73	0.01
Research always gives me pleasure.				

Table 4. *Cont.*

	<i>M</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>
Achievement Orientation				
Though learning about research is tough, I feel happy when I can finish the tasks.	4.26	0.59	−0.56	1.75
Though learning about research is boring, I am happy when I get good results.	2.95	1.10	0.36	−0.77
Learning about research is tough, but to get good results, the effort is worthwhile.	4.37	0.53	0.04	−1.00
Learning about research is tough, but I am happy as long as I can get good results.	3.85	1.00	−0.6	−0.42
Learning research is tough, but I am satisfied when I get good results after making an effort.	3.95	0.96	−0.81	0.20
Though learning research is tough, I get a sense of satisfaction when I get good results.	3.70	0.92	−0.38	−0.29
Anxiety				
I find myself very nervous during research activities.	2.55	0.95	0.86	−0.13
I am worried in research activities.	2.29	0.83	1.00	0.82
During research activities, when I come across problems/ideas/knowledge that I cannot comprehend, I feel very nervous.	2.77	1.00	0.32	−0.98
I am always afraid that I will get poor results in my research classes.	2.45	0.97	0.95	0.26
During research classes, when I come across problems that I cannot solve, I feel very anxious.	2.63	1.00	0.51	−0.40
Frustration				
I feel uncomfortable when the research mentor starts a new research topic.	2.13	0.73	0.88	1.91
I am tired of learning a new topic in research classes.	1.84	0.56	0.14	0.71
I do not like attending research classes.	1.87	0.65	0.24	−0.22
I dislike doing research.	1.87	0.65	0.24	−0.29
I am tired of being involved in research classes.	1.79	0.71	0.73	0.67

Table 5. Descriptive statistics of behavioral engagement.

	<i>M</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>
Attentiveness				
I listen to the research mentor's instructions attentively.	4.21	0.81	−1.26	2.43
In the discussion of new topics, I take an active part and raise my points.	4.04	0.83	−0.98	1.33
I really make an effort in the research classes.	4.30	0.62	−0.57	0.56
I concentrate very hard when the research mentor introduces new research related topics.	4.08	0.74	−1.06	2.62
I will use every means to understand what the research mentor teaches in the research classes.	4.11	0.68	−1.04	2.91
I always take part in the discussion in the research class.	3.89	0.87	−1.00	1.41
Diligence				
For difficult problems/concepts, I would study hard until I understand them.	4.09	0.66	−0.78	1.70
If I cannot arrive at the right answer straight away, I will try again later.	3.78	0.88	−0.99	1.25
If I make mistakes in solving problems in the research classes, I will work until I have corrected them.	4.04	0.69	−0.76	1.40
If I work on problems persistently, I am sure that I will get the right answer.	4.06	0.69	−0.60	0.83
If I cannot solve a problem right away, I will persist in trying different methods until I get the solution.	4.18	0.54	−0.10	0.86

2.4. Data Analysis

We first used Confirmatory Factor Analysis (CFA) to assess the structure of the constructs and then used structural equation modeling to examine the relationships between

the proposed constructs using the lavaan package version 3.5.1 in R. We used the maximum likelihood estimation as it assumes that the observed variables follow a continuous and multivariate normal distribution [68]. This study used the criterion given by Hu and Bentler [69] as non-significant Chi-square tests of model fit in addition to other model fit indices, like the root mean square error of approximation (RMSEA) ≤ 0.06 , comparative fit index (CFI) ≥ 0.96 , and Tucker–Lewis index (TLI) ≥ 0.95 . Any possible chances of the model misspecification were examined by the modification index based on theoretical considerations.

3. Results

Before running the SEM analysis, we tested the factor structure of each of the proposed constructs in this study. While calculating the CFA structure for the teacher self-disclosure survey, we assessed the fit of the competing models. Based on the fit indices, as stated by Hu and Bentler [69], we decided to follow the three-factor correlated model as it was more suitable in this study since it resulted in better fit indices ($\chi^2 (74) = 98.79$, $p = 0.029$; CFI = 0.981, TLI = 0.977, RMSEA = 0.040 ($p = 0.780$) with 90% confidence interval of [0.014, 0.060], SRMR = 0.052).

For emotional engagement, we took guidance from Kong et al. [66] and found that a first-order four-factor correlated model had an acceptable fit ($\chi^2 (202) = 399.807$, $p < 0.001$; CFI = 0.924, TLI = 0.913, RMSEA = 0.069 ($p = 0.001$) with 90% confidence interval of [0.059, 0.078], SRMR = 0.066), after correlating the error terms of two items “Learning about research is tough, but I am happy as long as I can get good results” and “Learning research is tough, but I am satisfied when I get good results after making an effort” for the achievement sub-construct.

For behavioral engagement, a two-factor correlated model with the factors of diligence and attentiveness showed an acceptable model fit ($\chi^2 (53) = 137.260$, $p < 0.001$; CFI = 0.942, TLI = 0.927, RMSEA = 0.087 ($p = 0.001$) with 90% confidence interval of [0.070, 0.106], SRMR = 0.059). A lower correlation between attentiveness and diligence ($r = 0.28$, $p < 0.05$) suggested that these constructs can be treated as separate first-order constructs.

Relation between Teacher Self-Disclosure and Emotional and Behavioral Engagement

To understand the direct relationship between teacher self-disclosure and behavioral and emotional classroom engagement, we examined the structural parameters of the structural model, as given in Figure 2.

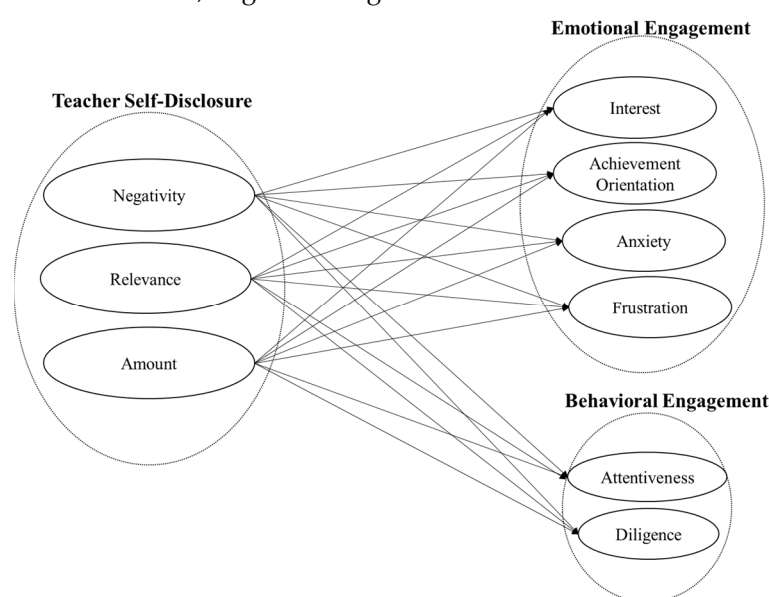


Figure 2. Relation between teacher self-disclosure and emotional and behavioral engagement.

The initial fit of the model was not in the acceptable range, as proposed by Hu and Bentler ($\chi^2 (1042) = 1609.201, p < 0.001$; CFI = 0.900, TLI = 0.894, RMSEA = 0.051 ($p = 0.345$) with 90% confidence interval of [0.046, 0.056], SRMR = 0.061). Based on the modification indices, as well as being guided by the item wording, we correlated the error terms for two of the items for the diligence sub-construct “If I work on problems persistently, I am sure that I will get the right answer” and “If I cannot solve a problem right away, I will persist in trying different methods until I get the solution” as well as for the two items in the achievement orientation sub-construct “Though learning about research is tough, I feel happy when I can finish the tasks” and “Though learning about research is boring, I am happy when I get good results”. These modifications improved the model fit substantially, as $\chi^2 (1040) = 1548.510, p < 0.001$; CFI = 0.913, TLI = 0.905, RMSEA = 0.048 ($p = 0.687$) with 90% confidence interval of [0.043, 0.053], SRMR = 0.061. The parameter estimates of this structural model are given in Table 6.

Table 6. Standardized parameters for teacher self-disclosure and behavioral engagement.

		Γ	SE	p
Amount -->	Interest	0.081	0.032	0.309
	Achievement Orientation	0.145	0.055	0.064
	Anxiety	0.284	0.028	0.001 **1
	Frustration	−0.030	0.031	0.727
	Attentiveness	0.084	0.041	0.289
	Diligence	0.014	0.038	0.860
Relevance -->	Interest	0.302	0.045	0.000 **
	Achievement Orientation	0.002	0.073	0.978
	Anxiety	−0.483	0.049	0.000 **
	Frustration	−0.269	0.044	0.002 **
	Attentiveness	0.236	0.057	0.002 **
	Diligence	0.377	0.054	0.000 **
Negativity -->	Interest	−0.081	0.065	0.305
	Achievement Orientation	−0.117	0.111	0.135
	Anxiety	−0.145	0.051	0.062
	Frustration	−0.025	0.063	0.767
	Attentiveness	0.084	0.083	0.286
	Diligence	0.114	0.077	0.143

¹ Note: SE refers to standard error; ** shows significant at 0.01 level.

The findings suggest that the sub-construct for teacher self-disclosure, amount, had a positive significant relation with the sub-construct anxiety ($\Gamma = 0.284, p < 0.001$). This suggests that for each unit increase in amount, there is a 0.284 unit increase in emotional engagement anxiety.

For relevance, we found a significant positive relation with one of the sub constructs of emotional engagement—interest ($\Gamma = 0.302, p < 0.001$)—indicating that for each unit increase in relevance, there is a 0.302 increase in emotional engagement interest. In addition, relevance had a negative relationship with other sub-constructs of emotional engagement, i.e., anxiety ($\Gamma = -0.483, p < 0.001$) and frustration ($\Gamma = -0.269, p < 0.001$), indicating that for each unit increase in relevance, there is a 0.483 decrease in emotional engagement anxiety and a 0.269 decrease in emotional engagement frustration. For the behavioral engagement sub-constructs, relevance had a positive relationship with attentiveness ($\Gamma = 0.236, p = 0.002$) and diligence ($\Gamma = 0.377, p < 0.05$), indicating that for each unit increase in relevance, a 0.236 unit increase in behavioral engagement attentiveness and 0.377 unit increase in behavioral engagement diligence are expected. For the last sub-construct of teacher self-disclosure, negativity, none of the sub-constructs of emotional and behavioral engagement had a significant relation.

4. Discussion

The main research question guiding our research was: What is the relationship between teacher self-disclosure and emotional and behavioral engagement? The focus of this article is based on the idea that instances of teacher self-disclosure, including amount, relevance, and negativity, can either enhance or hinder levels of student engagement in the classroom. Hence, teachers can implement teacher self-disclosure instances to promote student engagement, which can, in return, have positive outcomes such as increasing students' persistence within STEM.

Firstly, the results show that there is a positive relationship between one of the dimensions of teacher self-disclosure, amount, and one of the sub-constructs of emotional engagement, anxiety. This suggests that when the teacher uses multiple instances of self-disclosure, it may lead to feelings of anxiety in STEM undergraduates, which might affect their learning process. Prior research supports the view that instances of teacher self-disclosure can have negative effects when they are used more than needed and out of context [1,60,65].

Secondly, the obtained results also showed a positive relationship between another dimension of teacher self-disclosure, relevance, and one of the sub-constructs of emotional engagement—interest. This relation demonstrates that instances of teacher self-disclosure that are relevant in nature to the course content increase students' levels of interest in the course and the learning experience. Based on that, by incorporating relevant self-disclosure instances, educators can effectively cultivate students' interest that can directly contribute to their long-term commitment and persistence within STEM disciplines. The findings resonate with the inferences deduced by Cayanus et al. [65], who showed that relevance correlates with students' interest in the course within general contexts. The researchers highlighted that relevant examples provided by the teacher increase levels of interest, which can result in positive outcomes such as encouraging students to provide similar or counter examples, which result in more student–teacher interaction during sessions [1,70]. Finally, in addition to the studies that were conducted in the field of communication and humanities [1,60], the results showed that the relation between teacher self-disclosure, relevance, and emotional engagement, interest, is also applicable within the specific context of this study: STEM research programs.

Additionally, the results showed a negative relationship between relevance and two sub-constructs of emotional engagement: anxiety and frustration. This idea is supported by Myers et al. [71], who argued that relevant instances of teacher self-disclosure are associated with more positive feelings of emotional engagement and less negative feelings of emotional engagement such as anxiety within the classroom context. The results support the idea that STEM students feel that less-relevant instances of teacher self-disclosure to the course content can cause more negative feelings of emotional engagement, ultimately impacting on their persistence within STEM disciplines.

The results also showed that one of the sub-dimensions of teacher self-disclosure, relevance, had a positive significant relation with two of the sub-constructs of behavioral engagement, which are diligence and attentiveness. When teachers share information that is applicable to the subject matter, students exhibit greater diligence, which is related to steady and energetic effort when working on classroom tasks. This increased diligence enhances their focus and task performance, and may contribute to their persistence within STEM programs. By incorporating relevant self-disclosure instances, teachers can foster an environment that cultivates student diligence, encourages active participation, and ultimately supports their long-term engagement and persistence in STEM education. The available literature supported claims about positive instances of teacher self-disclosure and behavioral engagement. For example, Imlawi and Gregg [72] and Klem and Connell [73,74] argued that teacher self-disclosure instances that are positive and relevant in nature develop students' classroom behavioral engagement that is linked to diligence and active participation during class. Furthermore, Kelly and Turner [63], Marks [75], Martin and Dowson [76], and Ryan and Patrick [77] suggested that students become behaviorally engaged, and more specifi-

cally attentive, when they receive instances of teacher self-disclosure that are relevant to the STEM content.

The study did not reveal any significant relationship between the dimensions of teacher self-disclosure amount and negativity, and the sub-construct of behavioral engagement diligence. Similarly, no significant relationship was observed between any of the dimensions of teacher self-disclosure and the sub-construct of behavioral engagement attentiveness. The available literature from the field of humanities and communications contradicts these findings, as Frisby et al. [59] suggested that negative teacher self-disclosure instances can negatively affect students' levels of behavioral engagement. Similarly, Myers and colleagues [71] suggested that positive instances of teacher self-disclosure can positively affect students' levels of behavioral engagement. There is a possibility that the specific study context, STEM research programs, might lead to these non-significant relations.

Implications

The findings of this study could serve as a basis for instructional design and curriculum development, especially within STEM higher education research programs. The findings might encourage higher education instructors or research mentors within STEM research programs and classes to include instructional methods focused on increasing classroom engagement through making strategic use of teacher self-disclosure. In addition, recommendations based on the results of this study can be used in different STEM research programs and classes as a guide to plan interventions and suitable trainings, professional development workshops, and ongoing seminars for professors, research mentors, and graduate assistants with the intention of supporting students' levels of positive emotional and behavioral engagement.

Further, findings from this study provide guidance on considering the kind of teacher self-disclosure to implement within STEM research program classes, how often it should be used, and what instances of teacher self-disclosure are considered inappropriate and should be used less often. More specifically, considering the findings, several recommendations can be made. First, it appeared that relevant instances of teacher self-disclosure can positively contribute to maintaining students' levels of classroom engagement—more specifically, emotional engagement interest and behavioral engagement diligence. Additionally, the obtained results also showed a negative relationship between relevance and emotional engagement, anxiety, and frustration. Hence, it can be recommended that STEM research mentors, STEM educators, doctoral assistants, and professional development programs make more useful and strategic use of instances of teacher self-disclosure that are relevant to the course content. As an outcome, this might support STEM students' development of positive feelings during sessions such as increased interest, fewer feelings of anxiety and frustration, and being more diligent during classes.

5. Conclusions

This research study examined the relationship between teacher self-disclosure and emotional and behavioral engagement among students in a STEM research program. The results of the study showed a significant positive relation between teacher self-disclosure relevance and positive aspects of classroom engagement such as emotional engagement (interest) and behavioral engagement (diligence and attentiveness). The results also showed that there is a negative relation between teacher self-disclosure relevance and the emotional engagement factors of anxiety and frustration. Additionally, STEM students view that high amounts of teacher self-disclosure can be related to negative aspects of classroom engagement such as anxiety. The overall results showed that STEM students favor instances of teacher self-disclosure that are relevant and not too frequent, as such disclosure contributes positively to the development of students' interest in the course content as well as supporting them to be more diligent and attentive during sessions.

The study was conducted with the intention of adding to the literature on an issue that tends to have limited studies that consider students in STEM in higher education,

and, more specifically, in a STEM research program. The obtained results showed the type of teacher-self disclosure that can be used to increase students' levels of classroom engagement. Moreover, the obtained results provided substantial evidence for the importance of strategically implementing relevant instances of teacher self-disclosure to promote classroom engagement within STEM classes.

Finally, this study's results add to the available literature on teacher self-disclosure and classroom engagement, as most of the available studies focused on the context of humanities and not STEM education [1,78,79]. Hence, this study's focus in the field of STEM and the obtained results add significantly to the available literature, and motivate more research to be conducted on teacher self-disclosure and classroom engagement within the context of STEM education.

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