Original Research Paper

Increasing STEM retention: comparing the alignment of cultural viewpoints between Appalachian STEM students and faculty to effect change

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Abstract: STEM education and retention at the university level is low in high-poverty areas like West Virginia. West Virginia has higher poverty rates and lower bachelor's degree completion compared to the national average. As West Virginia transitions from labor-intensive occupations to more STEM and healthcare-driven careers it is crucial to increase the number of STEM graduates to fill these positions. This study aimed to increase STEM retention through dialogue and systemic change. The study was conducted in three parts: 1) survey STEM faculty and students in STEM courses regarding their cultural beliefs and educational backgrounds, 2) share the findings and engage in open dialogue about student struggles with both faculty and students and 3) administer a post-survey to assess students' sense of belongingness and faculty's willingness to implement changes in their courses to increase student success. Results indicate that students and faculty have similar views and backgrounds ($p = 0.97$). The dialogue session indicated that faculty and students disagreed on what the students felt their biggest struggles in STEM were; faculty felt students struggled with math while students stated time management as their largest obstacle. According to post-survey results, students felt an increase in their STEM sense of belonging after attending the dialogue. Twenty-four percent of faculty said they would make changes and 64% said they would consider making changes to their classes after the dialogue. Faculty making systemic changes to their classes based on student feedback and need should increase student success and retention in these STEM courses.

Keywords: Appalachian culture; faculty and student engagement; STEM education

Introduction

The White House Office of Science and Technology (WHOST) Policy (2024), states that science, technology, engineering, and mathematics (STEM) are crucial for careers, workplace success, and everyday life. This policy emphasizes a need for increased STEM literacy, diversity, equity, and inclusion throughout all higher education institutions in the United States (WHOST, 2024). To build a STEM-competent workforce, STEM education and retention must be improved beyond the national average success rate of 45% (Gibbons et al., 2019; Carver et al., 2017; Xu, 2015). STEM retention is considerably lower than the 68.2% national retention rate for all other undergraduate degrees (National Student Clearinghouse, 2024).

A student's likelihood of college success depends on numerous biological and cultural factors. Underrepresented students and those living in poverty are less likely to graduate with a bachelor's degree (Kinney, 2018; Cromley et al., 2016; Xu, 2015;

Laubach & Stamper, 2016; Wallace & Kiekroger, 2000). Underrepresented students' success rates in STEM fields are even lower. If success in STEM is deemed unobtainable, women and minority students are prone to pursue a different degree pathway while men are more likely to drop out of college if they feel they cannot succeed in their STEM degree (Leary & Bryner, 2021; Kinney, 2018; Xu, 2015). Once poverty and cultural variables are factored in on top of sex and gender identity, attrition rates increase even further (Morton et al., 2024; Leary & Bryner, 2021; Tashakkori et al., 2018; Cromley et al., 2016).

Students living in low socioeconomic areas, like Appalachia, face greater challenges in succeeding in STEM than those living in other regions. Rural students are 41% less likely to attend college (Morton et al., 2024). Along with poverty, Appalachians are often subjected to negative educational and success stereotypes and are less likely to obtain a bachelor's degree (Kinney, 2018; Laubach & Stamper, 2016). Because of these stereotypes, scholars state that Appalachians exhibit a passive resignation to their life situations and these life situations are influenced by family ideology, finances, and the educational system (Gibbons et al., 2020; Kinney, 2018; Maloney 2007; Wallace & Kiekroger, 2000). This study focuses on a four-year undergraduate institution in West Virginia where 90% of the students are in-state residents. West Virginia (WV) is nestled in the heart of Appalachia, and the only state entirely in Appalachia, which makes its citizens subjected to not only Appalachian hardships but WV specific ones as well.

According to the US Census (2022), 17.9% of West Virginians live in poverty compared to 12.6% of the US overall; the annual median household income in WV is $55,217 compared to $74,755 nationally, and only 22.7% of West Virginians have a bachelor's degree or higher, compared to 35.7% nationally. As employment opportunities in Appalachia follow the trends stated in the WHOST Policy (2024), these regions are shifting away from labor-intensive occupations (such as coal, agriculture, and timber), and younger generations must seek different career opportunities to remain in the region (Wallace & Kiekroger, 2000). WV's unemployment rate is higher than the national average at 4.1% with job growth in private education and health services, in which a STEM and STEM adjacent degree would be necessary (Workforce WV, 2024; WHOST, 2024). STEM and STEM adjacent degrees give these students the opportunity to decrease income gaps and increase the median household income in WV (Hansen et al., 2024).

To meet the demand for STEM jobs, universities in rural Appalachia must address STEM retention rates and find ways to increase student success. STEM retention rates in Appalachia are 20% lower than the national average of 45% (Leary & Bryner, 2021; Gibbons et al., 2019; Sithole et al., 2017; Xu, 2015). These students are more likely to graduate from less rigorous, under-resourced schools creating an impossible situation for student success (Morton et al., 2024). Focusing solely on content competency is insufficient, as sociocultural variables directly influence an Appalachian student's likelihood of attending, succeeding, and completing their bachelor's degree (Laubach and Stamper, 2016). Given the demanding nature of STEM coursework compared to non-STEM majors, these fields should be examined separately (Xu, 2015). The literature indicates that student success at the university level can be achieved by integrating students into the academic and social fabric of the institution through peer and faculty interaction (Stover et al., 2024; Leary & Bryner, 2021; Wu, 2015).

Faculty and student interaction can increase a student's sense of belonging which has been positively correlated to STEM retention and success (Hansen et al., 2024; Rainey et al., 2018). A student's sense of belonging in STEM indicates that the student feels encouraged, accepted, and has academic support at the institution (Hansen et al., 2024). Underrepresented groups feel less supported and accepted in STEM and are less likely to persist (Rainey et al., 2018).

The purpose of this study was to compare the alignment of cultural viewpoints between STEM students and faculty at a comprehensive university in north central West Virginia to effect change through discourse. This exploration is essential for identifying and addressing disparities in STEM education and implementing vital support mechanisms for STEM students to increase STEM retention

Materials and Methods

Survey Adaptation and Administration

Laubach and Stamper's (2016) Appalachian Cultures survey was adapted with permission from the authors to focus on STEM students and faculty. The survey included questions about family values, high school STEM education, college preparedness, socioeconomic status, cultural variables, and basic demographic information. The survey asked about statements of agreement using an eight range Likert scale. Laubach and Stamper (2016) used Cronbach α and Heise-Bohrnstedt reliability for survey validation. The survey was administered in person via Qualtrics (LLC Qualtrics, Provo, UT) during the 2023-2024 school year. Students were instructed to answer questions in the present tense and faculty were instructed to respond to university-related questions in the past tense, reflecting on their experiences in college. The survey targeted 50 STEM courses (n = 447; 75.9% of STEM students) and three STEM faculty meetings (n = 43; 78.2% of STEM faculty).

Data Analysis

The survey results were transcribed into a numerical code Likert scale (1 strongly disagree to 8 strongly agree) and analyzed. Percentages and F-test for means were used to determine if faculty and students had differing cultural viewpoints or upbringings that may have influenced their views on higher education and STEM. Following the data analysis, meetings between faculty and students were scheduled to discuss the findings.

Dialogue Session and anonymous discuss

All STEM students and faculty were invited to two student-run club meetings and two department/college meetings, respectively. These meetings were advertised through Blackboard course announcements, emails to students and faculty, and flyers posted in the science buildings. The dialogue sessions lasted one hour during the University's meeting hour (Tuesday and Thursday 12:30 – 1:30). To encourage attendance, food was provided during the student meetings. During these sessions, average responses from the survey were shared, and faculty and students learned about the viewpoints, struggles, and beliefs of their peers.

Following the 20-minute presentation of survey results, faculty and students participated in a live anonymous discussion using Nearpod. Three questions were posed to both groups (Table 1). Students and faculty could post multiple responses and like ones in which they agreed. Once responses were collected, there was an open discussion about why students and faculty may have put these responses.

Table 1. Nearpod discussion questions

Students	Faculty
What is your biggest challenge in college?	What are your students' biggest challenges in college?
What is your biggest challenge in your STEM courses?	What are your students' biggest challenges in their STEM courses?
Give an example of a class or activity you'd like to see changed	Give an example of a class or activity you'd like to see changed.

Post-Session Surveys

At the end of the dialogue session, faculty completed a six-question survey about potential changes to their courses (n = 34), and students completed a six-question survey about whether the session increased their STEM sense of belonging (n = 9). These data were analyzed via percentages to determine the overall view of the group, but the responses were too few for any meaningful data analysis. Subheading

Results

Survey results

A total of 520 survey responses were collected, with 94% of participants completing more than 20% of the survey (students: n = 447; faculty: n = 43). The demographics of the participants are presented in Table 2. Surprisingly there was an equal number of men and women students and more women faculty than men. Population affinity results were consistent with the WV population with 92% of the students identifying as white and 87% of faculty.

Table 2. Demographic results.

	Students			Faculty	
Social race	**Men**	**Women**	**Non-binary**	**Men**	**Women**
American Indian	5	0	0	0	0
Asian	5	0	0	3	0
Black	17	0	0	0	0
Latino	11	0	0	0	0
Middle eastern	4	0	0	0	0
Pacific islander	1	0	0	0	0
White	178	212	3	13	20
Mix	12	0	0	0	0
Did not answer	2	0	1	0	0
Self-identify	0	0	0	2	0
Total	**212**	**212**	**4**	**18**	**20**

Eighty-seven percent of the students were from West Virginia (90% from Appalachia). Seventy-two percent of faculty are from West Virginia (76% from

Appalachia). These percentages are consistent with Fairmont State's overall demographics. Among the students, 93% grew up in a small town or rural environment. Socioeconomic status distribution was 82% middle class, 13% working class, and 4% on assistance. Regarding family structure, 61% of students grew up in a 'typical' family (including nuclear and stepparents), 13% in single-parent households, and 25% with non-family members or grandparents (Table 3). The survey also examined students' work hours while being full-time students: 27% did not work, 41% worked full-time or more, and 31% worked part-time. Faculty data are detailed in Table 4. Note that some faculty responses may reflect their current situations or their experiences during graduate school, which could explain discrepancies in family dynamics and working hours.

Table 3. Student and faculty self-reported socioeconomic status. Individuals who did not answer these questions were included in the percentages but not listed.

	Students	Faculty
Community	Small town/rural: 93% Large city: 2.5%	Small town/rural: 97% Large city: 3%
Economic Status	Middle class: 82% Working class: 13% On assistance: 4%	Middle class: 71% Working class: 18% On assistance: 3%
Family dynamic	Normal: 61% Single parent: 13% Non-family/grandparents: 25% None: 1%	Normal: 24% Single parent: 4% Other family(children): 16% Non-family: 4% None: 32%
Hours worked while attending school	Did not work: 27% Part-time hours: 31% Full-time hours: 41%	Did not work: 24% Part-time hours: 35% Full-time hours: 41%

The student participants were further categorized by major: Natural Sciences (biology, chemistry, and forensic science) made up 25.3%, Technology (mathematics, computer science, and engineering) 33.4%, Exercise Science 17.8%, and non-STEM students (including nursing, business, art, architecture, etc.) 23.5%. Among the faculty surveyed, 42.5% taught in Natural Sciences, 42.5% in Technology, and 15% in Art and Architecture. The student cohort was composed of 36.9% freshmen, 25.7% sophomores, 22.6% juniors, 12.8% seniors, and 2% non-degree seeking or returning students. Additionally, 31.8% of students and 48.6% of faculty were first-generation college students.

Faculty and students were asked several questions about college preparedness, family support, and enjoyment of science and math (Table 4). The average responses from faculty and students were compared using a F-test, (p = 0.97; 95% CI 2.9, 3.9; var 2.5) indicating that cultural beliefs between students and faculty were not significantly significant. While there were few differences between students and faculty, there were notable variations in the degree of agreement or disagreement. Students placed higher importance on familial responsibilities over academics and were less inclined to move away from WV after graduation. Differences also emerged in perceptions of high school preparedness; students felt their high schools did not adequately prepare them for college or educate them on financing their education.

Overall, students enjoyed science and their science teachers but did not enjoy math. Another notable difference was that students felt their academic performance was directly linked to their teacher's teaching ability, though it is unclear whether this referred to high school or college instructors (Table 5). At the college level, students were satisfied with their major and did not feel the desire to change it, but they were strongly opposed to taking courses outside their major. It is not clear whether this sentiment was directed at general studies courses or other science courses, such as math or chemistry for biology and forensic science majors, for example.

Table 4. Average survey responses of students and faculty compared. Scale > 5 Agree; 4 - 4.99 Neither agree nor disagree; < 3.99 disagree. * Disagreement between student and faculty.

	Students	Faculty
I enjoy science.	6.1 (SD 2.0)	6.7 (SD 2.3)
I had a good science teacher in high school.	6.1 (SD 2.2)	5.9 (SD 2.7)
I am happy with my major and doubt I will change it.	6.0 (SD 2.1)	6.0 (SD 2.6)
My parents are willing to sacrifice for me to go to college.	5.8 (SD 2.3)	5.2 (SD 2.6)
I would rather not take classes that are not part of my major.*	5.7 (SD 2.4)	3.7 (SD 2.6)
I had a good math teacher in high school.	5.6 (SD 2.4)	5.6 (SD 2.7)
I was afraid I would get lost or overwhelmed in college.*	5.6 (SD 2.2)	3.6 (SD 2.4)
I try to go home on the weekends as often as I can.*	5.2 (SD 2.6)	4.3 (SD 2.5)
I would get better grades if	5.0 (SD 2.0)	3.4 (SD 2.2)

teachers did a better job of teaching.*		
Helping out my family is more important than school.*	5.0 (SD 2.0)	4 (SD 2.2)
I enjoy math.*	4.9 (SD 2.4)	6.2 (SD 2.7)
I am going to college because that is what my family expects	4.6 (SD 2.2)	4.1 (SD 2.3)
My school taught me how to get scholarships and loans for college.*	4.0 (SD 2.4)	3.4 (SD 2.2)
West Virginians really don't need outsiders coming in trying to "fix" us.*	4.0 (SD 2.1)	3.4 (SD 2.3)
I felt my high school experience prepared me for college.*	4.0 (SD 2.2)	5.3 (SD 2.4)
I will have to move away from WV for a job that requires a college degree.*	3.9 (SD 2.0)	4.1 (SD 2.3)
I would have done better in high school if I had more attention from teachers.	3.8 (SD 2.1)	3.1 (SD 1.9)
I have been told that I am not smart enough for college.	2.7 (SD 2.1)	1.9 (SD 1.9)
I have to hide my interest in college from my family.	2.0 (SD 1.6)	1.7 (SD 1.5)

To examine college preparedness, participants were asked about math preparation, STEM course availability, and college prep courses available at their high schools (Table 5). The highest math most students had was trigonometry (36%) while faculty completed calculus (46%). Biology (87%) was the most common natural science course taken followed by chemistry (67%). Forensics, environmental science, anatomy, physics, and computer science were not available at all high schools. While most students took AP or dual enrollment courses, 27% did not take any college preparation courses. The faculty results were comparable.

Table 5. STEM courses taken in high school by faculty and student survey participants.

Students	**Highest math**	**%**	**Sciences**	**%**	**College prep, AP, dual credit courses**	**%**
	Trigonometry	36%	Biology	87%	4+	31%
	Algebra (I, II, III)	26%	Chemistry	67%	0	27%
	Calculus	25%	Anatomy	46%	2	15%
	Other	7%	Physics	29%	1	14%
	Math (1, 2, 3)	6%	Forensics	20%	3	12%
			Computer science	15%		
			Other	8%		
			Environmental science	1%		
Faculty	**Highest math**	**%**	**Sciences**	**%**	**College prep, AP, dual credit courses**	**%**
	Calculus	46%	Biology	32%	4+	33%
	Trigonometry	24%	Chemistry	32%	1	21%
	Algebra (I, II, III)	24%	Physics	21%	0	21%
	Other	6%	Environmental science	8%	2	12.5%
			Computer science	4%	3	12.5%
			Other	2%		
			Anatomy	1%		

Dialogue results

After the 20-minute presentation going over the survey results with the attendees, they participated in an anonymous discussion answering the questions in Table 1. When asked what the students' biggest challenges in college were, the main themes consisted of motivation, time management, and finances (Table 6). These responses were not surprising as faculty and students posted similar responses. Student and faculty results varied when asked about students' biggest challenges in STEM. Students believed their challenges were time management, study skills, and test anxiety. In comparison, faculty believed time management, math competency/anxiety, motivation, and not asking for help (Table 6). This discrepancy led to a discussion about student schedules, homework, and course expectations in a STEM. Full-time STEM students normally take a 16-hour course load which typically includes four STEM courses (12 hours of lecture each week), four labs (12 hours of lab each week), and usually 1-2 test labs (3 hours weekly for exams, but not factored into the course load). Students highlighted the challenge of balancing this with part-time work and finding time to study.

Table 6. Priority results of the dialogue between faculty and students.

	Faculty		Students	
Students' biggest challenges in college	Time management	35%	Time management	42%
	Finances	20%	Motivation	25%
	Motivation	10%	Family/friends	25%
			Motivation	8%
Students' biggest challenges in their STEM courses?	Math competency/anxiety	50%	Time management	70%
	Motivation	16%	Study skills	20%
	Time management	16%	Test anxiety	10%
	Asking for help	16%		

This led to the final question about what changes would the students suggest or would the faculty consider. Students requested changes to specific lab activities, or courses (33%), more professional development opportunities (33%), eliminated late-night test labs (8%), more online STEM options (8%), eliminated courses over lunch (8%), and having an additional 'dead hour' throughout the week to study or take part in student clubs (8%). Only three faculty members responded stating they would consider eliminating test labs, trying to upgrade lab instruments, and trying to pursue an additional 'dead hour' with the university.

Post-dialogue responses

Before students left the session, they were asked to complete a STEM belongingness survey. Only 9 students completed the belongingness survey. Six students agreed that they felt respected in the campus's STEM community (3/9 Neither agreed nor disagreed). Eight felt comfortable in their STEM classes and felt that they belonged in the campus's STEM community (1/9 disagreed). The low response rates for student post-surveys limit the reach of our conclusion. Future studies should include using broader recruitment methods to ensure more participants.

Thirty-four faculty members completed the post-dialogue survey with an even distribution of males and females. The faculty were asked if they would be implementing any change in their classroom based on the discussion, 64% said they would consider making change, 24% said yes, and 12% said no. Faculty were then asked what they would change. Faculty said they would consider the following: accommodate working students or decrease out-of-class workload to help with time management (52%), remove test labs (4%), add professional development opportunities (12%), unknown at this time (12%), and other/unrelated responses (20%). Upon a one-year follow-up, only two faculty members carried out changes based on this study.

Discussion

Universities try many methods to increase STEM persistence including peer tutors, academic support, summer bridge programs, faculty mentors, and forced grade curving, but is it enough to increase retention (Stover et al., 2024; Carver et al., 2017; Sithole et al., 2017; Cromley et al., 2016)? Compared to the national average, West Virginian students are more susceptible to disadvantages, such as poverty, inadequate high school preparation, and familial obligations, which influence their chances of obtaining a STEM degree. Socioeconomic status can predict university retention as these students have more career and educational barriers (Gibbons et al., 2020). Seventy-two percent of the surveyed students had part-time or full-time employment during the academic year meaning they have to work to afford to attend college (Tashakkori et al., 2018; Xu, 2015; Wallace & Diekroger, 2000). Unlike prior generations that were able to work to pay their way through school by working part-time summer jobs, the divide between minimum wage and tuition has grown to the extent that this is no longer a possibility in the current economic climate. Working along with being a full-time STEM student was a challenge for these students. They are not able to go below full-time hours as they would lose financial aid and be required to make payments on their student loans. Becuase of this, these students spend less time on coursework, do not attend extra study sessions, nor take part in methods of self-care (like sleeping, eating, or decompressing) which is consistent with the findings of Laubach and Stamper (2016)'s survey on Marshall University students.

Along with time constraints due to work and courseload, students are encouraged to return home as often as possible to help their families. Students mentioned they were obligated to return home and help their families when needed, even missing class. Wallace & Diekroger (2000) found that Appalachian families in Ohio and Kentucky often discouraged college attendance in favor of maintaining a normal family life. Laubach & Stamper (2016) also found that students held familial obligations higher than academic obligations. Notably, 25% of surveyed students in this study reported being raised by other family members, non-family or grandparents. With the ongoing opioid epidemic increasing the number of students raised by foster parents or grandparents in West Virginia (Mullins, 2020), these familial responsibilities are growing. These students are more likely to miss class and assignments to take care of a family member. Faculty recognized these challenges during the dialogue session and indicated in the post-survey their intention to adjust coursework and provide accommodation to better support students' needs. Two test labs have been removed for the Fall 2024 academic year (one in biology and one in chemistry).

High school curriculum is also an indicator of STEM success, but universities have no control over the K-12 system and must adapt to retain these students (Leary & Bryner, 2021; Cromly et al., 2016; Laubach & Stamper, 2016). Many instructors believe students come to college with basic scientific knowledge, study strategies, and reasoning skills (Sithole et al., 2017; Cromley et al., 2016); but surveyed students believed their high school did not prepare them for college and 27% did not have access to college prep or AP courses. Balgopal et al. (2022) believe that more effort needs to be made to retain quality STEM teachers in K-12 which would increase student STEM interests. Rose & Betts (2001) found that the highest math completed in high school is correlated with the likelihood of success in college. Students who complete calculus have a higher likelihood of obtaining a bachelor's degree (Sithole et al., 2017; Rose & Betts, 2001). Only 25% of the surveyed students had calculus in high school and only 36% completed trigonometry which is the prerequisite to calculus indicating that these students again have a lower likelihood of graduating. These students need to work harder and maintain motivation to complete their degrees. Some faculty stated that to help students stay motivated they would bring in more professional development opportunities or guest speakers in their fields so they can see the relevance of obtaining their degree. Conversely, Cromley et al. (2016) stated that prior high school achievement and GPA is a poor predictor of STEM success.

STEM faculty and students in this study share similar cultural and educational beliefs, which may be beneficial, as Appalachians often resist external attempts to "fix" them or view college degrees as superior (Laubach & Stamper, 2016; Wallace & Diekroger, 2000; Gibbons et al., 2019). Though there was a low response rate, students reported an increased sense of belonging in the STEM campus community (67%), feeling more comfortable in the STEM community (89%), and feeling that they belonged in the campus's STEM community (89%). This shared cultural understanding may have facilitated open dialogue between students and faculty.

Some of the biggest faculty and student disagreements were high school preparation and enjoyment of math. More faculty completed calculus which may influence why faculty were more prepared and prone to like math (Rose & Betts, 2001). Students tended to blame the teachers for their success which is consistent with the literature. K-12 students and parents tend to blame the teachers which has carried over into higher education (Peterson et al., 2011; Gusky, 1981). Faculty countered these beliefs, like teachers, student success is the student and family's responsibility (Peterson et al., 2011; Gusky, 1981). This may also support why public schools have trouble retaining quality STEM teachers (Balgopal et al., 2022; Sithole et al., 2017). Another difference was faculty preparation for college, faculty had less anxiety and were more open to taking classes outside of their major. Students may have higher levels of anxiety as they hold high expectations for college and did not have a lot of guidance in high school (Morton et al., 2018).

The purpose of this study was to educate faculty about the challenges and perspectives of Fairmont State's STEM majors and to foster systematic change aimed at enhancing student success in STEM fields. The dialogue between students and faculty facilitated an open discussion of the students' perceived challenges, although student participation was limited. Despite the low participation in the dialogue, the feedback was valuable, with students noting that their responses represented broader concerns and issues shared among their peers. Faculty were surprised by the survey findings and engaged in discussions on potential changes to address these challenges. Although this study did not measure the impact of the changes, future research could assess the effectiveness of these adjustments by analyzing D/F/W rates before and after the implementation of changes resulting from the faculty-student dialogue.

Conclusion

West Virginian students are subjected to many variables that leave them at a disadvantage in obtaining their bachelor's degree in a STEM field. This project surveyed faculty and students, bringing commonalities to light allowing for open discussion of what students and faculty believe are the students' biggest struggles in STEM and how they can work together to increase student success. After holding the discussion students felt an increase in their sense of belonging in the STEM community and their courses. More than 80% of faculty were open to making changes in their courses to better accommodate students and in return increase STEM retention.

Availability of data: The datasets generated and analyzed during the current study are not publicly available since participants did not agree for their data to be shared publicly but are available from the corresponding author upon reasonable request.

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Ethics approval: This study was approved by the Fairmont State University Institutional Review Board (IRB) and approved for exempt status 45 CFR 46.104(d)(1) for Educational Practices. Informed consent was obtained from all participants included in the study.

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