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A Predictive Study on the Adoption of Active Learning at HBCUs among Engineering Faculty

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Identifying Barriers towards Adoption of Active Learning at HBCUs among STEM Faculty: A Preliminary Study

Abstract

Higher education's promotion of diversity and inclusivity is greatly helped by historically black colleges and universities (HBCUs). Active learning pedagogy which places students at the epicenter of learning has been reported to aid in student engagement, retention, and workforce development. Also, the adoption of active learning strategies has grown in significance as a means of improving undergraduate STEM students' educational experiences and academic success. Moreso, this pedagogical approach attempts to increase involvement, foster self-efficacy, and inspire students in STEM fields. The experience during the adoption and implementation of an innovative active learning pedagogy by instructors and faculty at one of the HBCUs in the United States is the main emphasis of this study. By Examining the unique obstacles and opportunities experienced by educators, our goal is to comprehend the aspects that foster or hinder the implementation of active learning techniques in HBCUs. In this descriptive quantitative study, we adopted a validated survey instrument with 17 items that were divided into four factors: student engagement and preparation, support for instruction, teacher comfort and confidence, and institutional environment/rewards. We evaluated these elements to comprehend the challenges and lessons of instructors and faculty members at our historically black colleges and universities (HBCU) during the implementation of active learning techniques. The level of significance of the barriers towards adoption were investigated using relative importance index (RII). Confidence level for inferential statistics was set at 95.0%. The study identified the institutional environment/rewards as the most important obstacle, with a RII score of 2.55. This initial finding also indicated that to promote STEM education and foster academic success at HBCUs, a key area of focus is the use of active learning strategies by the faculty members. Our study establishes a foundation for further exploration of the specific difficulties and advantages faced by STEM faculties and instructors at HBCUs. This research can contribute to enhancing their implementation of innovative teaching methods and ultimately lead to better outcomes for the diverse student population. This study will significantly advance higher education's efforts especially HBCUs to provide a more inclusive and effective learning environment.

Introduction

Historically black colleges and universities (HBCUs) are essential to the effort to promote diversity and inclusivity in higher education. These establishments have played a pivotal role in advocating for active learning pedagogy, an innovative methodology that places learners at the core of their educational journey. Particularly in STEM (Science, Technology, Engineering, and Mathematics) education, active learning has been shown to have a positive impact on student engagement, retention, and workforce development. The use of active learning techniques in STEM fields has grown in popularity as a successful way to improve undergraduate students' educational experiences and academic performance. Active learning aims to increase student participation, foster self-efficacy, and motivate students to pursue careers in STEM fields.

Over the past few decades, active learning has grown in popularity as a set of teaching strategies in higher education. In contrast to traditional passive learning through lectures, active learning involves students directly in the learning process [1]. Active learning is a teaching strategy that involves involving students in the process of learning by using collaborations, group projects, simulations, in-class talks, problem-solving exercises, critical thinking, and practical problem-solving exercises. Active learning, in contrast to conventional lecture-based methods, promotes student participation in the learning process, leading to a deeper comprehension of the subject matter. By encouraging active student participation instead of just passive information intake, the intention is to create a more dynamic, encompassing, and interactive learning environment. When compared to more passive approaches, an increasing amount of research shows that active learning improves student outcomes like retention, engagement, and learning gains [2], [3].

However, faculty at colleges and universities continue to adopt active learning strategies gradually. Less than half of STEM professors regularly incorporate active learning into their undergraduate courses, according to surveys [4], [5]. The proliferation of active learning is hindered by certain obstacles, despite the potential support of faculty members. Faculty may not have the time or resources to devote to creating excellent active learning curricula, particularly at research-focused universities that prioritize scholarly output over instruction [6]. There seems to be a need for training in active learning pedagogy and course design as many faculty members express uncertainty about how to apply active learning in an effective manner. Furthermore, some professors worry that, in comparison to lectures, active learning will not cover as much material or be as rigorous [7].

However, research suggests that faculty professional development programs can help remove several obstacles to the adoption of active learning. Teachers' abilities, expertise, and self-assurance in implementing these strategies can be enhanced through workshops, communities of practice, and other active learning-related training [8], [9]. Adoption of active learning is also being gradually encouraged by institutional incentives for teaching excellence and changing perspectives about effective instruction [6]. Funding from agencies such as the National Science Foundation is also supporting the adoption of active learning pedagogies across diverse educational settings. In the end, clearing up misunderstandings regarding the merits and rigor of active learning over passive learning as well as providing faculty with ongoing pedagogical training will be necessary to realize the advantages of active learning in higher education.

Experiment-centric pedagogy is an innovative active learning pedagogy that has transformed learning and teaching experience in the classroom and laboratory. As described by Authors [10], experiment-centric pedagogy places students at the center of the learning process. Experiment-centric pedagogy (ECP) focuses on inexpensive and safe hands-on tools and activities to promote learning in STEM subjects. As presented by Connor et al. [5], and Authors [6], ECP engages learners and improves their comprehension, familiarity, and retention of knowledge, ultimately leading to quantifiable outcomes. This active learning pedagogy was implemented over the course of 4 years by STEM faculties and this study is poised to reveal their experiences and perception into challenges and barriers that was faced in adopting such pedagogical approach. This is an initial attempt to fill the gap about implementing innovative pedagogy among faculty and instructors at an HBCU.

Methodology

The current study adopted a descriptive quantitative approach to investigate the experience of faculty members at one of the nations' Historically Black colleges and Universities. The study participants represent instructors and professors that have been actively involved in the deployment of experiment-centric pedagogy to aid diversity and equity of access. This study is representing their voices after 4 years (2019 -2023) of implementation of an active learning pedagogy described as experiment-centric pedagogy. A total of seven STEM fields participated in their implementation of the ECP during the study period. A survey of 17-items which has been validated, was adopted from Carroll et al [4] and administered to all faculties that have participated in the 4 year program. A total of ten (10) faculty which represent diverse STEM fields are included in this study. Notably, out of the 7 STEM disciplines that the implementation of the ECP was done, only 6 fields department feedback were captured in this preliminary finding. The 17-items have 5-point Likert scales that range from strongly disagree to strongly agree. The responses were coded from 1-5 under 4 different subscales. The subscales were student preparation and engagement (5-items), instructional support (4-items), instructor comfort and confidence (4-items), and institutional environmental/rewards (4-items). The data was cleaned and analyzed using the statistical package for social scientists (IBM SPSS 25.0). The results were presented using simple frequency and percentages. A relative importance index was calculated for the factors identified using equation 1.

$$\text{RII} = \frac{\sum W}{n*A} \qquad 1$$

Where $\sum W$ represents the weighting given to each factor by the participants, A is the highest score given to the responses and n is the number of respondents. The higher the RII, the higher the importance of the factor identified by the faculty members. Prior to calculating the RII, the scores were re-coded as the 17 -items were bi-directional to ensure single direction. Also, since the subscales are unequal in terms of number of items, a normalized RII was evaluated with the modification as shown in equation 2.

$$\text{nRII} = \frac{\frac{\sum W}{m}}{n*A} \qquad 2$$

where m is the number of items in each subscale to achieve normalization of weights, $\frac{\sum W}{m}$ and then RII scores was evaluated. The nRII with the highest value represents the factor with most importance.

Results

Result presented in Table 1 shows the gender and specialty of the faculty members that participated in this study. The results indicated that seven (7) were males and three (3) were females. Among the participants of the current study, four (4) were in biology, two (2) were in chemistry, and one (1) was in each of the other departments.

Table 1: Gender and specialty of faculty participants

	Frequency (N=10)	Percentage (%)
Gender		
Male (he/him)	7	70
Female (she/her)	3	30
Specialty		
Biology	4	40
Transportation	1	10
Chemistry	2	20
Anatomy & Physiology	1	10
Environmental Engineering	1	10
Civil Engineering	1	10

Results presented in figure 1 showed the work experience of the participants. An average five (5) participants had over 10 years’ experience as faculty and three (3) had 0-3 years’ experience in the field.

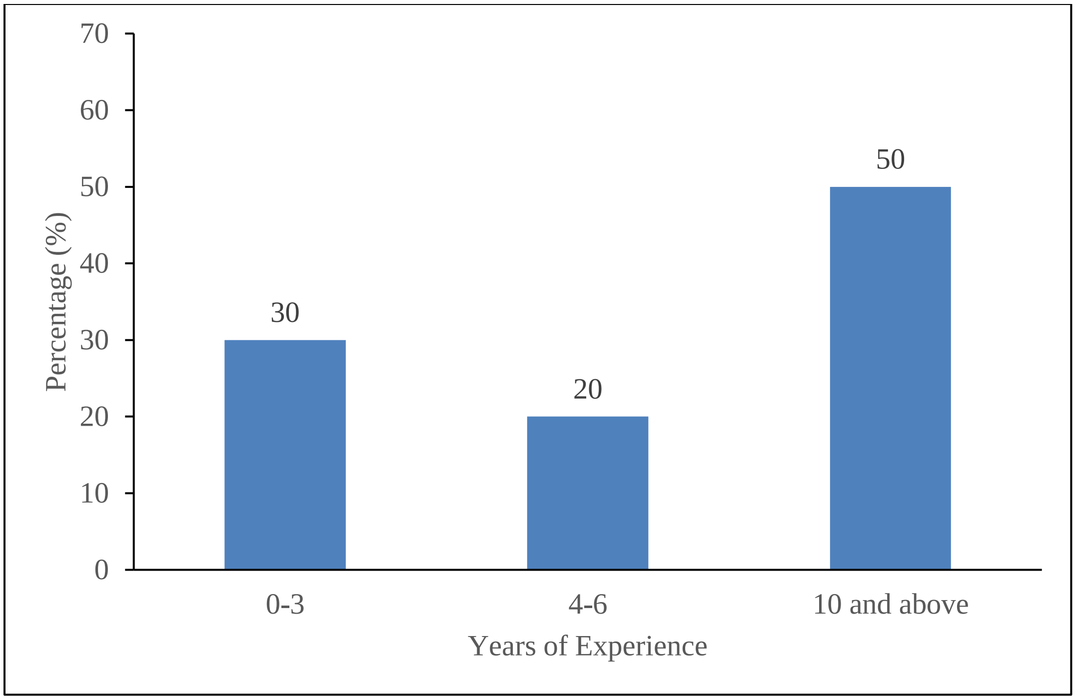

Figure 1: Years of experience of Faculty members

The big five personality traits were considered in the present study. Among the five, only three were common among the faculty participants. The self-identified personality of the participants was presented in Figure 2. The study defined conscientiousness as "reflecting the tendency to be accountable, structured, diligent, goal-oriented, and to adhere to norms and rules" for a faculty member who self-identified as such. This is one of the big -five traits of an individual and it is noteworthy to have it highly reflected among the participants as well as other two personality traits considered. The result showed that eight (8) academics self-identified as conscientious and have openness to experience while 7 mentioned that they are agreeable.

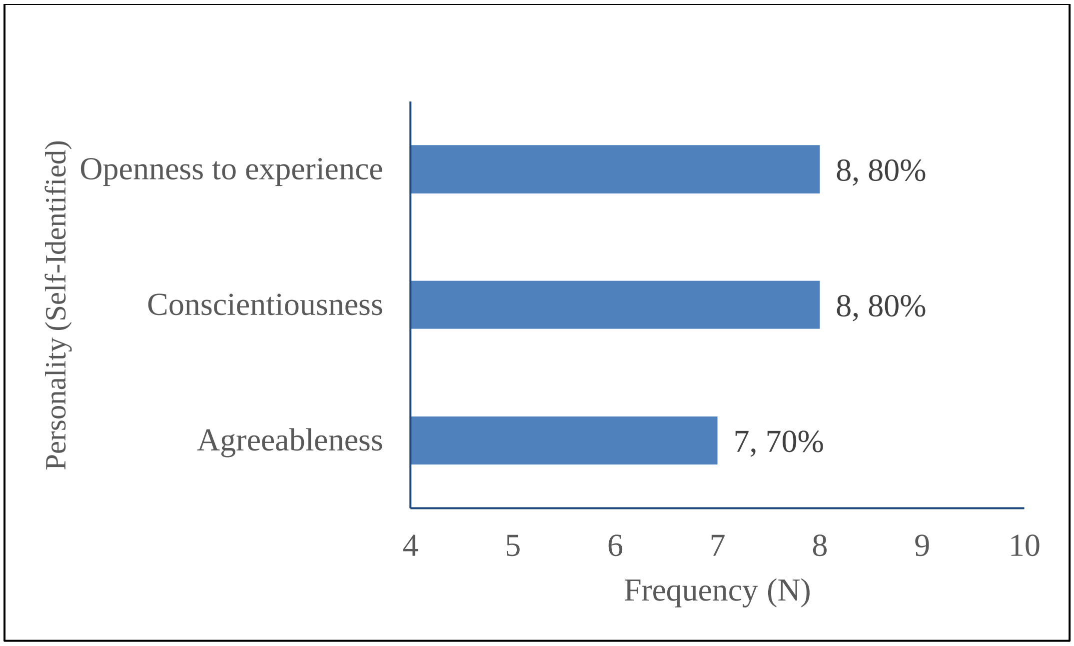

Figure 2: Self-identified personality traits of faculty

Responses indicated moderate concerns about student preparation and engagement. From the result, six (6) of the faculties disagreed that students lacked knowledge of how to engage in active learning, though two (2) agreed this was a barrier. Three (3) agreed that their students do not come prepared for in-class activities and that they do not expect to engage in active learning during lecture. In addition, nine (9) disagreed that "students were resistant."

With regards to instructional resources and support, four (4) agreed that classes do not have the teaching assistant support necessary for active learning. However, seven (7) disagreed there were enough accessible active learning materials and tech support. All the participants agreed that they were comfortable teaching in ways other than lecturing. A high proportion of participants, eight (8) affirmed that they were confident that they have adequate skills to use active learning in their classes and five (5) were more comfortable as facilitators rather than being lecturers. Notably, five (5) agreed that their colleagues were encouraging towards adopting active learning, and seven (7) participants agreed that the institutional policies do support active learning. In addition, seven (7) agreed that their colleagues were supportive towards a curriculum change and four (4) participants agreed that there were no incentives for implementing innovative pedagogy.

Table 2: Barriers towards adoption

Items	Strongly Disagree (N)	Disagree (N)	Undecided (N)	Agree (N)	Strongly Agree (N)
Student Preparation and Engagement					
My students do not know how to engage in active learning.	2	4	2	2	0
My students do not come prepared for in-class activities.	1	1	5	3	0
My students play the system to circumvent learning objectives.	1	4	3	2	0
My students are resistant to engage in active learning.	1	8	0	1	0
My students do not expect to engage in active learning during lecture	2	5	0	3	0
Instructional Support					
Educational support staff do not provide enough personalized support for me to make changes in my classes.	3	4	1	1	1
There is not enough easily accessible material to use active learning in my course.	3	4	1	0	2
There is insufficient technological support to ensure active learning works in my classroom.	1	6	1	1	1
My classes do not have the teaching assistant support necessary for active learning.	4	1	1	2	2
Instructor Comfort and Confidence					
I get anxious when trying active learning in class.	6	3	0	1	0
I am uncomfortable teaching differently than the norm of lecturing.	7	3	0	0	0
I am not confident that I have adequate skills to use active learning in my classes.	5	3	1	0	1
I am more comfortable in the role of a lecturer rather than a facilitator.	1	4	4	0	1
Institutional Environment/Rewards					
The teaching policies at my institution do not support active learning.	6	1	3	0	0
My colleagues are generally encouraging about using active learning.	0	3	2	2	3

My colleagues are not supportive of changing to a curriculum that uses active learning.	3	4	3	0	0
There is no incentive to innovate in my teaching.	1	4	1	2	2

The normalized relative importance indices (nRII) (Table 3) rank result indicates that instructional support was the most significant barrier faced by faculties in this study in adopting and implementing experiment-centric pedagogy (nRII = 0.57) The second most rank factor was Instructional Support (RII = 0.54) which is higher than Institutional Environment/Rewards (RII= 0.51) and the least rank factor was Student Preparation and Engagement (nRII = 0.48).

Table 3: Relative Importance Index of Barrier towards adoption

Factors	Weight	Normalized weights	Normalized Relative Important Indices (RII)	Rank
Instructional Support	91	23	0.57	1
Instructor Comfort and Confidence	86	22	0.54	2
Institutional Environment/Rewards	82	21	0.51	3
Student Preparation and Engagement	95	19	0.48	4

Discussion of findings

Faculty perceptions of obstacles to the implementation of active learning are the subject of several noteworthy findings uncovered by the survey. The findings correspond with prior studies indicating varied perceptions of student resistance in terms of student preparation and engagement. In this study, a majority of faculty (60%) expressed disagreement regarding students' lack of knowledge on how to engage, whereas only a minority (20%) considered this to be a barrier. Michael [13] also discovered that faculty held contrasting perspectives regarding student capabilities and motivation for engaging in active learning. Nevertheless, 30% concurred that students do not anticipate active learning during lectures. This supports the findings of studies that have identified challenges arising from students' expectations of passive roles in lecture classes [7]. Regarding instructional support, 40% of respondents identified inadequate teaching assistant support as a hindrance. The significance of sufficient support personnel in promoting the adoption of active learning is highlighted in various studies [14], [15]. The fact that 70% of respondents reported a shortage of materials and technology highlights the necessity for adequate instructional resources. This finding is consistent with Michael's [13] research, which identified a lack of resources as a major obstacle.

All faculty members expressed comfort with teaching methods that extended beyond traditional lecturing. Brownell and Tanner [6] argue that conflicts between active learning and instructors' perception of themselves as authoritative knowledge providers can hinder progress. Self-efficacy additionally impacts the inclination to adopt novel teaching methodologies [8]. Enhancing pedagogical assistance and instruction can potentially foster self-assurance in alternative teaching approaches. Additionally, a high proportion of faculty reported having colleagues who were supportive. According to Henderson and Dancy [16], the absence of support from departments and institutions poses substantial challenges to implementing instructional changes. It is crucial to tackle the systemic disincentives to achieve wider implementation.

The current study found that institution support with normalized values above average indicating it to be a significant factor. This finding is consistent with prior research that identifies institutional factors as significant barriers to implementing instructional change. The academic culture and incentive systems frequently discourage pedagogical innovation and fail to sufficiently recognize evidence-based teaching [6], [16]. Our findings indicate that focusing on institutional policies and cultures could have a substantial influence on the acceptance and implementation of active learning. The highly ranked significance of instructional support as an obstacle is also consistent with previous studies. Faculty often identify insufficient resources, materials, training, and support staff as obstacles to active learning [13], [15]. Enhancing the availability of support resources and networks can facilitate the process of adoption.

Notably, factors related to students were ranked lower in comparison to barriers related to institutions and support. In contrast to previous studies that identified student resistance as a significant barrier, Seidel and Tanner [7] found a different result. In their findings, they uncovered that student resistance to the implemented active learning pedagogy is mostly not related to the pedagogy but the personality and delivery style of the pedagogy by the instructors which they termed as teacher misbehavior. Further investigation could provide additional clarity on the correlation between student engagement and the implementation of active learning.

Furthermore, the finding of lack of instructor confidence is consistent with existing research that connects self-efficacy beliefs to the willingness to adopt new teaching [8]. Offering faculty training and fostering communities of practice has the potential to enhance both confidence and skills. To encourage widespread adoption of active learning, it will probably be necessary to employ a comprehensive strategy that addresses obstacles at the institutional, individual, and support levels.

Conclusion

This study investigated the perspectives of faculties that participated in a 4-year funded research where experiment-centric pedagogy was implemented across seven (7) STEM disciplines on their experiences and obstacles faced in the implementation of the pedagogy. Using a quantitative approach, the study surveyed their experiences and presented the findings. The findings indicate institutional factors present the most prominent barriers. Alongside, the findings of this preliminary study discovered that insufficient instructional support and challenges related to student engagement are also high rated factors by the faculty based on their experiences. The barrier with the lowest rating was the lack of instructor comfort and confidence indicating that the faculty members had the least resistance or personality barrier towards adopting and implementing the pedagogy. These initial findings indicate that implementing active learning will necessitate the development of a comprehensive strategy that can possibly address systemic, resource-related, and individual obstacles in higher STEM education. To fully comprehend the extent of the institutional barriers towards the adoption and implementation of active learning, the study suggests an institution wide survey among STEM educators especially at historically black colleges and universities. This can further enlighten us and strengthen the need to develop institutionally focused innovative strategies that can aid increase student motivation, curiosity, and retention. Findings from broader and larger surveys will also help to ascertain faculty perceptions on the usage of active learning strategies in their classroom rather than laboratories. Future research should persist in examining the intricate interplay among these factors in diverse educational settings among which are not limited to cultural diversity, student-to-teacher ratio, and STEM curriculum. Given their longstanding dedication to inclusive and engaging education, Historically Black Colleges and Universities have a distinct advantage in spearheading the adoption of active learning.

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