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Awareness and Adoption of Evidence-Based Instructional Practices by STEM Faculty in the UAE and USA

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Abstract: There has been a widespread call for improvement in undergraduate STEM education, leading to what are known as evidence-based instructional practices (EBIPs). However, EBIP usage in STEM is a more recent phenomenon in the United Arab Emirates, which is historically known for its passive teaching practices but is now taking strides to transform its educational system. This study sought to assess (i) STEM faculty EBIP awareness, adoption, and ease-of-implementation perceptions from STEM faculty at a leading university in the United Arab Emirates and the demographic factors correlated with faculty responses, and (ii) the contextual factors that influence faculty EBIP adoption. Data was compared to that of STEM faculty at a top-tier research and teaching university in the United States of America. Finally, this study sought to provide a snapshot of current STEM faculty teaching practices when both a leader (United States of America) and a newcomer (United Arab Emirates) in STEM EBIPs were considered. A survey containing 16 teaching practices—3 traditional, 13 EBIPs—along with 20 contextual factors was developed and completed by faculty. EBIP awareness and usage were positively affected by time spent on teaching, teaching experience, and teaching workshop participation, and negatively affected by more class time spent lecturing. Significant contextual factors point to potential factors for consideration in efforts to improve EBIP adoption.

Keywords: student-centered teaching; STEM faculty; evidence-based instructional practices; active learning; awareness; adoption

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1. Introduction

There has been a call for widespread improvement in undergraduate science, technology, engineering, and mathematics (STEM) education, with tremendous effort being put into building a strong knowledge base about learning and most-effective teaching practices [1–8]. The result of these efforts has led to what are known as evidence-based instructional practices (EBIPs) for STEM, which are "practices that have been empirically demonstrated to promote students' conceptual understanding and attitudes toward STEM" [9], having a well-established association with improved student course grades, feedback, and course-driven goals [10–14]. EBIPs are "active" by nature, meaning that they encourage students' active engagement in the learning process and involve building their knowledge through inquiry-based learning, open-ended problems, group work, discussion, and reflection [10]. EBIPs include various specific teaching practices, such as Cooperative Learning, Problem-Based Learning, Peer Instruction, Think-Pair-Share, Just-in-Time Teaching, and Service Learning, to name a few [2,9]. However, despite ample evidence for the effectiveness of EBIPs in STEM, didactic teaching practices (i.e., lecturing and other passive, teacher-centered behaviors) are still prevalent throughout STEM undergraduate courses [15–18]. Moreover, when STEM faculty do adopt an EBIP, they often do so at the expense of critical elements of the practice, rendering it ineffective [9,17,19–23]. It is common for instructors to take some of the basic ideas of an EBIP but not implement it in the way described by the developer [17]. Peer Instruction, for example, consists of the following critical elements: (1) the instructor poses a multiple-choice concept test to students, (2) students individually vote on an answer (by a show of hands, flash cards, or a classroom response system known as "Clickers"), (3) students discuss their answers with neighboring students, and (4) students vote again [20]. If one of these essential elements is lacking, the practice is not being utilized and its established benefits are not applicable [17].

Research regarding STEM faculty awareness and adoption of EBIPs has taken place, especially in the United States of America (USA) [10,18]. USA-based science and government organizations continue to push for improvements in STEM, such as the American Society for Engineering Education [24], National Academy of Engineering [7,25], Association of American Universities [26,27], National Research Council [5], National Science Board [28], American Association for the Advancement in Science [29], and the President's Council of Advisors on Science and Technology [8]. The USA has also seen a rise in STEM education centers, which add resources and incentives for the implementation of EBIPs and STEM education research [30]. Along with STEM faculty EBIP awareness and adoption, research aiming to understand the factors that influence faculty EBIP adoption choices, such as barriers [31–34] and supports [10,26,35,36], has continued to grow in the USA context. However, the call for improved undergraduate STEM education is a more recent phenomenon in other international contexts, such as the region of the Gulf Cooperation Council (GCC).

Given the GCC's later start to building modern educational systems and its historical reliance on passive, teacher-centered teaching methods [37–41], research in the GCC pertaining to newer, student-centered pedagogies (e.g., active learning, EBIPs) is only a recent phenomenon. The United Arab Emirates (UAE) in particular is one of the GCC countries that has taken strides to transform its educational system into one that matches global standards [42]. In recent years, the UAE has responded to the widespread call for improved, more-effective education, focusing more on active learning strategies characteristic of 21st century skills such as critical thinking, analyzing, and problem-solving [43–47]. In order to achieve this transformation, the UAE has created various initiatives. The UAE's Vision 2021, for example, set out to make the UAE "among the best countries in the world" by creating a competitive knowledge economy and a first-rate, restructured education system [48]. Now the UAE's Vision 2030 and National Strategy for Higher Education 2030 both continue this work, striving to develop a highly-skilled, highly-productive workforce, as well as to "build and achieve the highest scientific and professional education standards" [49].

Meanwhile, studies regarding the UAE and its transition to more active, student-centered teaching practices are increasing but, unfortunately, they remain limited. The studies often focus on a single learning approach such as Problem-Based Learning [50], or on how university-level Emirati students who are female or studying English are beginning to adapt to active learning strategies [38,51–54]. One recent study outlined the challenges and possibilities of STEM education in the UAE [55], and another reported pedagogical practices utilized among UAE university faculty [56]. However, these studies do not focus on EBIPs nor on STEM faculty. Moreover, while the UAE has been included in STEM studies involving the GCC [57] and Middle East and North African (MENA) regions [58], the authors of this study are unaware of its inclusion in STEM studies involving countries outside of these regions, particularly those that have a history in emphasizing EBIP awareness and usage, such as the USA.

Overall, assessing STEM faculty EBIP awareness and adoption is relevant and needed in order to remain current on the state of STEM education in countries that have joined the call for its improvement. The USA and the UAE have both joined this call, with the USA being a forerunner and a country whose STEM education practices can be seen as high in the global context, and the UAE being a recent addition and a novice in this pursuit. An assessment of STEM faculty teaching practices from both countries then, one a leader and the other a newcomer, is useful in providing not only a potential gauge of both contexts, but also a snapshot of current STEM faculty practices in general given that countries from both ends of the spectrum are being taken into account. Furthermore, given the lack of (1) any known studies to date that measure STEM faculty EBIP awareness and adoption in the context of the UAE, (2) any known studies to date that include the UAE in their assessment of STEM faculty practices in contexts outside of the GCC and MENA regions, and (3) the potential usefulness of assessing faculty teaching practices from both a leader and a recent recruit in STEM EBIPs, the current study was undertaken. Finally, not only may such research prove useful in helping the UAE assess its progress given its 2030 goals, but it may also add beneficial data toward assessments of current STEM faculty practices both in the USA and GCC contexts.

2. Materials and Methods

2.1. Research Questions

This study aims to answer the following questions:

1. What are the United Arab Emirates University (UAEU) STEM faculty levels of awareness, adoption, and ease-of-implementation perceptions regarding specific EBIPs?
2. What factors (such as gender, department, number of years teaching, job responsibilities, exposure to teaching workshops) are correlated with UAEU STEM faculty responses?
3. What contextual factors influence UAEU STEM faculty adoption of EBIPs?
4. How does the collected data compare to that of STEM faculty at a top-tier research and teaching university in the USA?
5. What findings emerge for research questions 1–3 when taking into consideration STEM faculty teaching practices from top universities representing countries at both ends of the STEM-EBIP-focus spectrum, with one being a historical leader (USA) and the other a newcomer (UAE)?

2.2. Participants

UAEU was selected as the UAE university for the present study as (1) two of the authors have experience as UAEU faculty members and another as a student and research assistant, and (2) it is the UAE's flagship university, being the UAE's first and foremost comprehensive national university [59]. It is also equipped with modern classroom and laboratory facilities, as well as current technology. As such, UAEU likely provides a good snapshot of the UAE's STEM faculty.

In winter 2021, the authors conducted an online survey which invited every faculty member (313 total) from the following UAEU STEM departments to participate: Biology, Chemistry, Geology, Mathematical Sciences, Physics, Architectural Engineering, Chemical and Petroleum Engineering, Civil and Environmental Engineering, Electrical Engineering, Mechanical Engineering, Computer and Network Engineering, Computer Science and Software Engineering, and Information Systems and Security. Eighty-five total faculty members began the online survey, with 66 faculty members fully completing it—a response rate of 21%.

The University of Nebraska-Lincoln (UNL) was selected as the USA university for the comparison (fourth research question) and combined assessment (last research question) purposes of this study, as (1) it consistently ranks in the top tier of USA research universities and is considered to be a lead teaching institution in the USA [60], (2) it is classified within the Carnegie "R1: Doctoral Universities—Highest Research Activity" category [60], and (3) two of the authors have experience working at UNL. Similar to UAEU, it is also equipped with modern classroom and laboratory facilities, as well as current technology. Interestingly, UNL was also the university chosen for Lund & Stains' 2015 study of STEM faculty EBIP awareness and adoption [9].

In summer 2021, the authors conducted an online survey which invited every faculty member (679 total) from the following UNL STEM departments to participate: Agronomy and Horticulture, Biological Sciences, Biochemistry, Center for Plant Science Innovation, Chemistry, Earth and Atmospheric Sciences, Microbiology, Plant Pathology, Physics and

Astronomy, Mathematics, Statistics, Architectural Engineering, Biological Systems Engineering, Chemical and Biomolecular Engineering, Civil and Environmental Engineering, Computer Science and Engineering, Construction Engineering, Electrical and Computer Engineering, and Mechanical and Materials Engineering. Ninety-six total faculty members began the online survey, with 81 faculty members fully completing it—a response rate of about 12%.

All participants provided informed consent to participate. The study was approved by both UAEU's and UNL's boards for research.

2.3. Survey Instrument

A literature review was conducted regarding EBIPs in STEM with a focus on instruments utilized to measure faculty awareness and adoption of EBIPs. There are various available instruments to measure STEM teaching practices (not limited to EBIPs), including several self-report surveys [61]; however, the existing surveys do not fully match the objectives of this study. The authors identified three articles in particular [2,9,62] as a basis on which to build the current study due to their (1) focus on STEM faculty awareness and adoption of EBIPs with the inclusion of barriers and/or contextual factors, (2) extensive lists of referenced EBIPs, and (3) survey formats that aligned with the purposes of the current study. The authors' prominence in the field of STEM research was also a factor when utilizing the Prince et al. article [2], as well as that of Lund & Stains [9].

While these three surveys (referenced as "the three key surveys" going forward) provided a helpful foundation upon which to build this study's survey, the authors created a new survey in order to best suit its purposes. This current study's survey was broken down into three parts with questions regarding (1) contextual factors that influence faculty teaching practice choices, (2) faculty teaching practices, including faculty awareness, adoption, and perceived ease-of-implementation for each practice, and (3) faculty demographics. The following adaptions were made from the three key studies:

1. Chosen EBIPs and their descriptions: The authors of this study developed a list of 16 teaching practices, comprising 13 EBIPs and three traditional, teacher-centered practices. The EBIPs were chosen based on the following, with the second being influenced by Sturtevant & Wheeler's work [62] and the third by Froyd's work [63]: (1) consistent representation in STEM literature, (2) varied ease-of-implementation levels (authors wanted both simple and more complex EBIPs to be represented), and (3) varied types (e.g., in-class activities, small group work, formative assessment, scenario-based content). The EBIPs included in the three key surveys were also utilized as a helpful gauge in that they provided some of the largest lists of EBIPs when compared to other surveys of similar nature. The three teacher-centered practices included in this current study were added with the intent of ensuring that even participants who were unaware of EBIPs would be able to likely confirm recognizing and/or utilizing at least three of the included teaching practices, which in turn might help them answer honestly about not recognizing the other 13 EBIPs. A similar approach of including three traditional, teacher-centered teaching practices in the midst of student-centered teaching practices was utilized by Marbach-Ad et al. [64]. Concise, straight-forward descriptions for each teaching practice were adapted from the literature. The selected teaching practices were then grouped according to their type, as influenced by Froyd's work [63], as well as by their perceived effort to implement, based on Sturtevant and Wheeler's work [62], as shown in Table 1 below. The method section of Table 1 lists each EBIP's critical elements.
2. Barriers and contextual factors: The authors adapted the barriers and contextual factors included in the three key surveys, specifically rewording for clarity and succinctness, as well as removing items that were not applicable in the UAEU context (i.e., tenure).
3. Likert scales: Likert scales were utilized in both the contextual factors and teaching practices sections of this current study.

a. In the contextual factors section, the authors utilized the following Likert scale: 1 = Never true, 2 = Seldom true, 3 = True some of the time, 4 = True most of the time, 5 = True all of the time, which was also utilized in the Statistics Teaching Inventory [65].
b. In the teaching practices section, the authors asked three questions, each with its own Likert scale. The first question, "How familiar are you with this strategy?", utilized the following Likert scale: 1 = Never heard of it, 2 = Heard of it but don't know much else, 3 = Familiar with it but have never used it, 4 = Currently use/have used but don't plan to use anymore, 5 = Currently use/have used and plan to use in the future. The Likert scales found in the Lund & Stains [9] and Sturtevant & Wheeler [62] surveys were utilized as a basis for the selected scale and were modified for clarity, succinctness, and the objectives of this study. It is important to note that only faculty who selected options 4 or 5 were considered to be EBIP users, and as such, only they were directed to answer the following second and third questions in the section. The second question, "How often did you/do you utilize this strategy?", utilized a modified version of a Likert scale found in Sturtevant & Wheeler's survey [62], with the final version in this survey being 1 = Use(d) it once or twice/term, 2 = Use(d) it multiple times/term, 3 = Use(d) it about once/week, and 4 = Use(d) it multiple times/week. Finally, the third question, "How difficult is it for you to use this strategy?", utilized the following Likert scale: 1 = Very easy, 2 = Easy, 3 = Somewhat difficult, 4 = Difficult, 5 = Very difficult. All Likert scales utilized in this study were 5-point scales in order to maximize variance in responses [66,67], except for the second question regarding frequency of use.

4. Perceived ease-of-implementation questions: The authors chose to add the third question in the teaching practices section, "How difficult is it for you to use this strategy?", which was not present in the three key surveys.
5. Participant background/demographics: The authors modified demographic questions from various surveys, including the three key surveys, the Faculty Survey of Student Engagement [68], the National Survey of Geoscience Teaching Practices [69], and the Higher Education Research Institute (HERI) Faculty Survey [70]. Examined demographics included faculty gender, academic rank, department, university teaching experience (i.e., number of years), research activity, teaching load, typical time spent lecturing, graduate student supervision, and teaching workshops/programs/courses participation.

Table 1. Selected Teaching Practices Grouped According to Type and Effort to Implement.

Practice Type	Effort to Implement	#	Method
Traditional (Not EBIPs)	Low	1	Instructor-Led Lecture: Students listen while instructor explains course content.
	Low	2	Instructor-Led Problem Solving: Students observe instructor solve problems during class.
	Low	3	Individual Student Response: Students are invited to respond to instructor questions individually during a lecture.

Table 1. *Cont.*

Practice Type	Effort to Implement	#	Method
In-Class Activities	Moderate	4	Interactive Lecture Demonstration: Students: (i) hypothesize the outcome of a demonstration, (ii) watch the demonstration, and (iii) reflect on it.
	Moderate	5	Teaching with Simulations: Students/instructor use computer simulations.
	Low	6	Clickers/Personal Response Systems: Students' responses/data are collected in real-time through an interactive classroom response system.
Small Group Work	Low	7	Collaborative Learning: Students perform group-work toward a common goal.
	Low	8	Think-Pair-Share: Students are: (i) given "think time" to internalize content, (ii) asked to discuss ideas with a peer partner, and (iii) asked to share thinking with the rest of the class.
	Low	9	Peer Instruction: Students: (i) vote on an answer (often with "Clickers") to an instructor-posed concept test question, (ii) see the answer distribution, (iii) form pairs and discuss answers, and (iv) vote again.
Formative Assessment	Low	10	Concept Maps: Students diagram the relationships that exist between concepts.
	Low	11	Minute Paper: Students briefly write their answers to questions at the end of class: What was the most important thing you learned in class today? What point remains unclear/unanswered?
	Moderate	12	Concept Tests/Inventories: Students respond to short, multiple-choice questions regarding a concept. Common wrong answers/misunderstandings are part of the answer choices.
	Moderate	13	Just-in-Time Teaching: Students: (i) complete a set of Web-based activities outside of class, and (ii) submit these to the instructor who identifies misunderstandings and adjusts the lesson.
	Low	14	Student Presentations: Students present their work orally and/or in the form of a poster.
Scenario-Based Content Organization	High	15	Problem-Based Learning: Students are given a complex, real-world problem and are asked to apply their knowledge and direct their own learning in order to solve it.
	High	16	Service Learning: Students are integrated into community service experiences that help reinforce course content (e.g., students work on a project with a real, not-for-profit client in the community).

An online survey was then created via SurveyMonkey, comprising three parts: (1) participant awareness, adoption, and ease-of-implementation perceptions regarding specific EBIPs (first research question), (2) contextual factors that influence participant adoption of EBIPs (third research question), and (3) participant background (second research question). The authors' last two questions were addressed through the administration of the same online survey to STEM faculty at UNL in the USA.

2.4. Data Analysis

Descriptive statistics, Chi-square tests, and Kruskal-Wallis tests were used to help answer this study's research questions. However, given the small sample size of faculty responses from UAEU and UNL—66 and 81, respectively—the authors utilized Chi-square tests when analyzing the combined university faculty data (research question 5) only. The Kruskal-Wallis test was also utilized in assessing significant relationships between the independent variables of faculty awareness, adoption, and perceived ease-of-implementation of the selected teaching practices and the continuous variables of percent faculty time spent on teaching, research, and service. Both the Chi-square and Kruskal-Wallis tests were conducted using Minitab Statistical Software 19. Descriptive statistics alone were adopted to help answer the first four research questions.

For research question 5, the authors combined UAEU and UNL data and analyzed it utilizing Chi-square tests to determine if significant relationships exist between the following:

1. STEM faculty levels of awareness, adoption, and ease-of-implementation perceptions and the selected 16 teaching practices as a whole;
2. Specific demographic factors (such as gender, department, number of years teaching, job responsibilities, exposure to teaching workshops) and STEM faculty levels of awareness, adoption, and ease-of-implementation perceptions for:
    a. All 16 teaching practices in general (e.g., faculty EBIP awareness versus rank), and
    b. Each specific teaching practice (e.g., faculty adoption of Student Presentations versus rank);
3. Awareness versus adoption levels, as well as adoption versus perceived ease-of-implementation levels regarding all 16 teaching practices as a whole; and finally,
4. STEM faculty identification with specific contextual factors and their adoption levels of:
    c All 16 teaching practices as a whole, and
    d Each specific teaching practice.

3. Results

3.1. Research Question 2: Characteristics of Participating Faculty

An overview of the participants' demographics in terms of rank, gender, and colleges is shown in Table 2 below. Close to half of all UNL faculty participants (43%) are Full Professors, compared to 18% of surveyed UAEU faculty. Furthermore, when looking at the total surveyed faculty, nearly three-quarters are men (73%), with both Engineering and Science colleges represented almost equally (45% and 55%, respectively).

Table 2. Overview of Participant Demographics.

	UAEU Faculty (66)	UNL Faculty (81)	Total Surveyed Faculty (147)
Rank			
Instructor/Lecturer	17%	14%	15%
Assistant Professor	29%	23%	26%
Associate Professor	36%	20%	27%
Full Professor	18%	43%	32%
Gender			
Men	85%	64%	73%
Women	12%	31%	22%
Prefer Not to Respond	3%	5%	4%
Colleges			
Engineering	59%	33%	45%
Science	41%	67%	55%

An overview of participating faculty's teaching and research demographics is shown in Table 3 below, highlighting faculty years of college/university teaching experience, number of courses taught per academic year, number of published research papers per academic year, percent of typical class time spent lecturing, and teaching workshops/programs/courses participation. In terms of teaching experience, over half of all participating faculty (57%) have 11+ years teaching experience in the college/university setting. In terms of course load, 20% of UAEU faculty versus 5% of UNL faculty teach 7–8 courses per academic year, along with 8% of UAEU faculty versus 1% of UNL faculty teaching more than 8 courses per academic year. Furthermore, though many UAEU faculty teach more courses per academic year, 50% are publishing 3–4 research papers per academic year compared to 30% of UNL faculty, along with 8% of UAEU faculty publishing 5–6 research papers per academic year versus 5% of UNL faculty publishing the same. In terms of class time spent lecturing, the amount of UAEU faculty who spend 81–100% class time lecturing is over two times that of UNL faculty (30% versus 14%, respectively). Moreover, 50% of all surveyed faculty are spending 61–100% of class time lecturing—an amount of time that can be seen as high for academic settings aiming for higher active, student-centered learning environments. Finally, both UAEU and UNL staff participation in teaching workshops/programs/courses can be seen as low with nearly half (49%) having only attended 0–3. However, UAEU faculty participation is lower than that of UNL faculty. Sixty-seven percent of UAEU faculty have attended 0–3 workshops versus 34% of UNL faculty. Moreover, 47% of UNL faculty have attended more than 6 teaching workshops/programs/courses compared to 21% of UAEU faculty, and 56% of UAEU faculty have attended only 1–3 versus 28% of UNL faculty.

Table 3. Overview of Participant Teaching and Research Demographics.

	UAEU Faculty (66)	UNL Faculty (81)	Total Surveyed Faculty (147)
Years Teaching Experience			
First year teaching	6%	0%	3%
1	0%	1%	1%
2–5	23%	11%	16%
6–10	20%	26%	23%
11+	52%	62%	57%
Average # of Courses Taught/Academic Year			
Up to 4	42%	74%	60%
5–6	30%	20%	24%
7–8	20%	5%	12%
More than 8	8%	1%	4%
Average # of Research Papers Published/Academic Year			
Up to 2	36%	58%	48%
3–4	50%	30%	39%
5–6	8%	5%	6%
More than 6	6%	7%	7%
Percent of Typical Class Time Spent Lecturing			
0–20%	6%	14%	10%
21–40%	12%	15%	14%
41–60%	17%	35%	27%
61–80%	35%	23%	29%
81–100%	30%	14%	21%
# of Attended Teaching Workshops, Programs, Courses			
None	11%	6%	8%
1–3	56%	28%	41%
4–5	12%	19%	16%
More than 6	21%	47%	35%

3.2. Research Questions 1 and 4: UAEU versus UNL Faculty—Awareness and Adoption of Selected Teaching Practices

First, faculty awareness and adoption levels of all the selected teaching practices (includes the first three practices which are not EBIPs) were calculated and compared between UAEU and UNL faculty, as shown in Table 4 below. Teaching practices are listed according to Table 1. Awareness results are displayed as the percent of faculty selecting option 3 (i.e., "Familiar with it but have never used it") and higher, and users are displayed as the percent of faculty selecting Option 4 (i.e., "Currently use/have used but don't plan to use anymore") and higher. The first three practices, which are traditional and teacher-centered (i.e., not EBIPs), have the highest faculty awareness and adoption levels, along with Collaborative Learning for both UAEU and UNL faculty. Both universities also have similar awareness and usage levels of the first five practices, along with Just-in-Time Teaching, Collaborative Learning, Student Presentations, and Problem-Based Learning. Larger differences (i.e., 25% or higher) in EBIP awareness of Clickers/Personal Response Systems and Peer Instruction for both UAEU and UNL faculty are bolded and shown in Table 4 below. UNL faculty present higher awareness levels for all practices, but many are very comparable. UNL faculty adoption levels are also higher than those of UAEU faculty, except for Student Presentations, Problem-Based Learning, and Service Learning, but, overall, they are very comparable. The least adopted practice for UAEU faculty is Minute Paper (16% are users), characterized with a low effort-to-implement rating as shown in Table 1, while UNL faculty least adopt Service Learning (15% are users), which is characterized with a high effort-to-implement rating. Both UAEU and UNL faculty have similarly high awareness and adoption levels of Problem-Based Learning, a high-effort-to-implement teaching practice.

Table 4. UAEU and UNL Faculty Awareness and Adoption Levels of All 16 Practices.

	Teaching Practices	UAEU Faculty		UNL Faculty	
		Total Aware (%)	Total Users (%)	Total Aware (%)	Total Users (%)
1	Instructor-Led Lecture	94	90	100	98
2	Instructor-Led Problem Solving	96	86	99	93
3	Individual Student Response	94	88	100	98
4	Interactive Lecture Demonstration	86	62	89	61
5	Teaching with Simulations	81	64	88	61
6	Clickers/Personal Response Systems	**66**	34	**95**	57
7	Concept Maps	66	21	74	35
8	Minute Paper	66	16	79	39
9	Concept Tests/Inventories	79	55	90	61
10	Just-in-Time Teaching	67	39	79	41
11	Collaborative Learning	93	81	99	85
12	Peer Instruction	**63**	37	**90**	55
13	Think-Pair-Share	76	55	93	63
14	Student Presentations	96	82	98	76
15	Problem-Based Learning	94	78	98	77
16	Service Learning	64	25	72	15

Larger differences (i.e., 25% or higher) are in bold.

Next, the authors considered only the awareness and adoption levels of the 13 EBIPs (excludes the first three teaching practices). On average, UAEU faculty are aware of 9.9 EBIPs and adopt 6.5 EBIPs, as compared to 11.4 and 7.3 for UNL faculty, respectively. Figure 1 below provides the percentages of both UAEU and UNL faculty who are aware of X or more EBIPs. Nearly every participating UNL faculty member (99%) professed awareness of at least 7 EBIPs, compared to only 87% of participating UAEU faculty for the same. The lines most diverge at awareness of at least 10 EBIPs, with 84% of UNL faculty professing awareness versus 63% of UAEU faculty. Furthermore, 44% of UNL faculty are aware of all 13 EBIPs, as compared to 31% of UAEU faculty. Figure 2 below provides percentages of both UAEU and UNL faculty who utilize X or more EBIPs, showing similar percentages between the faculty groups. The lines most diverge at 7, 8, and 9 EBIPs, with UNL faculty professing 12–13% higher usage for each compared to UAEU faculty. However, the lines merge again at 12 and 13 EBIPs.

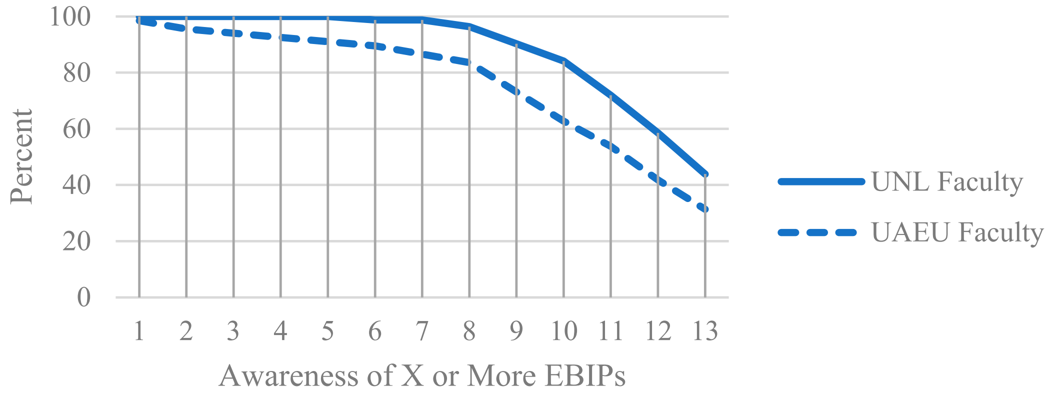

Figure 1. Number of EBIPs UNL and UAEU faculty are aware of.

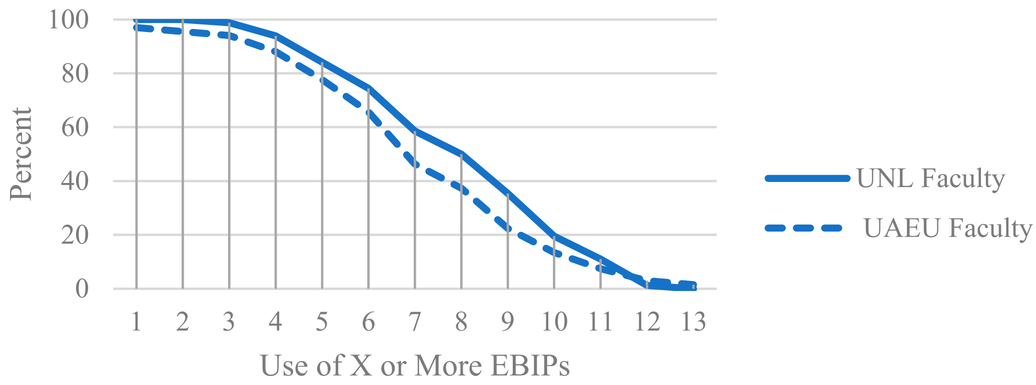

Figure 2. Number of EBIPs UNL and UAEU faculty utilize.

Next, faculty frequency of adoption for the selected teaching practices was calculated and compared between UAEU and UNL faculty, as shown in Table 5 below, considering only those faculty who are considered to be "users" (i.e., those that selected option 4 "Currently use/have used but don't plan to use anymore" and higher). Faculty responses of "use/d once or twice per term" and "use/d multiple times per term" were combined and labeled as "utilized on a termly basis". Faculty responses of "use/d once or twice per week" and "use/d multiple times per week" were combined and labeled as "utilized on a weekly basis". Larger differences (i.e., 25% or higher) in weekly frequency of adoption are in bold, while the EBIPs characterized with "low" effort to implement levels are italicized. The first three practices (i.e., not EBIPs) have the highest frequency of adoption levels overall for both UAEU and UNL users, with Instructor-Led Lecture being most utilized by UAEU faculty and Individual Student Response being most utilized by UNL faculty.

Table 5. UAEU and UNL Faculty Users' Frequency of Adoption Levels.

	Teaching Practices	Utilized on a Termly Basis		Utilized on a Weekly Basis	
		UAEU Faculty (%)	UNL Faculty (%)	UAEU Faculty (%)	UNL Faculty (%)
1	Instructor-Led Lecture	6	11	94	89
2	Instructor-Led Problem Solving	19	17	81	83
3	Individual Student Response	18	4	82	96
4	Interactive Lecture Demonstration	33	33	67	67
5	Teaching with Simulations	50	59	50	41
6	*Clickers/Personal Response Systems*	*52*	*17*	***48***	***83***
7	*Concept Maps*	*43*	*79*	***57***	***21***
8	*Minute Paper*	*45*	*72*	***55***	***28***
9	Concept Tests/Inventories	68	52	32	48
10	Just-in-Time Teaching	67	41	**33**	**59**
11	*Collaborative Learning*	*59*	*34*	***41***	***66***
12	Peer Instruction	40	31	60	69
13	Think-Pair-Share	54	29	**46**	**71**
14	*Student Presentations*	*73*	*81*	*27*	*19*
15	Problem-Based Learning	69	54	31	46
16	Service Learning	59	75	41	25

Larger differences (i.e., 25% or higher) are in bold for weekly usage; EBIPs characterized with "low" effort-to-implement levels are italicized.

As shown in Table 5 below, larger differences (i.e., 25% or higher) between UAEU and UNL faculty EBIP usage (i.e., excludes first three practices) arise when considering EBIPs that faculty use on a weekly basis (i.e., at least one or more times per week) and are as follows: (1) 83% of UNL faculty who utilize Clickers/Personal Response Systems do so at least once/week versus 48% of UAEU faculty users of this practice; (2) 57% of UAEU faculty who utilize Concept Maps do so at least once/week versus 21% of UNL faculty users of this practice; (3) 55% of UAEU faculty who utilize Minute Papers do so at least once/week versus 28% of UNL faculty users of this practice; (4) 59% of UNL faculty who utilize Just-in-Time Teaching do so at least once/week versus 33% of UAEU faculty users of this practice; and (5) 71% of UNL faculty who utilize Think-Pair-Share do so at least once/week versus 46% of UAEU faculty users of this practice. Moreover, UNL faculty profess higher overall weekly usage of 7 out of the 13 EBIPs.

3.3. Research Questions 1 and 4: UAEU versus UNL Faculty—Ease-of-Implementation Perceptions of Selected Teaching Practices

Faculty perceived ease-of-implementation responses were first calculated and compared between UAEU and UNL faculty for all of the selected teaching practices, as shown in Table 6 below. Only those faculty who selected Option 4 "Currently use/have used but don't plan to use anymore" and higher are considered to be "users". Both UAEU and UNL users of each practice show similar ease-of-implementation perceptions when grouped as "easy" and "not easy". EBIPs that are characterized with "low" effort-to-implement levels are italicized in Table 6, and larger differences (i.e., about 25% or higher) are bolded and noted as follows: (1) Interactive Lecture Demonstration, with 86% of UAEU faculty users of this practice finding it "easy" to implement versus 54% of UNL faculty; (2) Teaching with Simulations, with 32% of UAEU faculty users finding it "easy" to implement versus 55% of UNL faculty; (3) Collaborative Learning, with 28% of UAEU faculty users finding it "easy" to implement versus 51% of UNL faculty; (4) Peer Instruction, with 84% of UAEU faculty users of this practice finding it "easy" to implement versus 58% of UNL faculty; and (5) Service Learning, with 83% of UNL faculty users of this practice finding it "not easy" to implement versus 53% of UAEU faculty. UNL users of Interactive Lecture Demonstration and Teaching with Simulations are about equally split in terms of finding them "easy" or "not easy", with the same being said for UAEU users of Service Learning. Moreover, both UAEU and UNL users are about equally split in their perceived ease-of-implementation perceptions for Just-in-Time Teaching and Problem-Based Learning.

Table 6. UAEU and UNL Faculty Users' Ease-of-Implementation Perceptions.

	Teaching Practices	Easy		Not Easy	
		UAEU Users (%)	**UNL Users (%)**	**UAEU Users (%)**	**UNL Users (%)**
1	Instructor-Led Lecture	95%	94%	5%	6%
2	Instructor-Led Problem Solving	90%	86%	10%	14%
3	Individual Student Response	80%	69%	20%	31%
4	Interactive Lecture Demonstration	**86%**	**54%**	**14%**	**46%**
5	Teaching with Simulations	**68%**	**45%**	**32%**	**55%**
6	*Clickers/Personal Response Systems*	*74%*	*70%*	*26%*	*30%*
7	*Concept Maps*	*71%*	*76%*	*29%*	*24%*
8	*Minute Paper*	*82%*	*78%*	*18%*	*22%*
9	Concept Tests/Inventories	76%	68%	24%	32%
10	Just-in-Time Teaching	50%	41%	50%	59%
11	*Collaborative Learning*	***72%***	***49%***	***28%***	***51%***
12	Peer Instruction	**84%**	**58%**	**16%**	**42%**
13	Think-Pair-Share	68%	79%	32%	21%
14	*Student Presentations*	*76%*	*60%*	*24%*	*40%*
15	Problem-Based Learning	56%	44%	44%	56%
16	Service Learning	**47%**	**17%**	**53%**	**83%**

Larger differences (i.e., about 25% or higher) are in bold; EBIPs characterized with "low" effort-to-implement levels are italicized.

Next, the authors considered only faculty-perceived ease-of-implementation levels for the 13 EBIPs. Given that only faculty who professed to utilize an EBIP were directed to the ease-of-implementation survey question, only the perceived ease-of-implementation responses of the EBIPs that faculty professed to use are considered. On average, out of the EBIPs that both UAEU and UNL faculty professed to use, both groups of faculty perceive a similar number of EBIPs as being "easy", 4.5 and 4.2, respectively. Figure 3 below provides the percentages of both UAEU and UNL faculty users of EBIPs who perceive X or more EBIPs as "easy". Both faculty groups profess very similar views in terms of how many EBIPs they utilize are "easy". Furthermore, both 91% of UAEU and UNL faculty users of EBIPs perceive at least 1 EBIP as "easy", along with only 1% and 0% perceiving all 13 EBIPs as "easy", respectively.

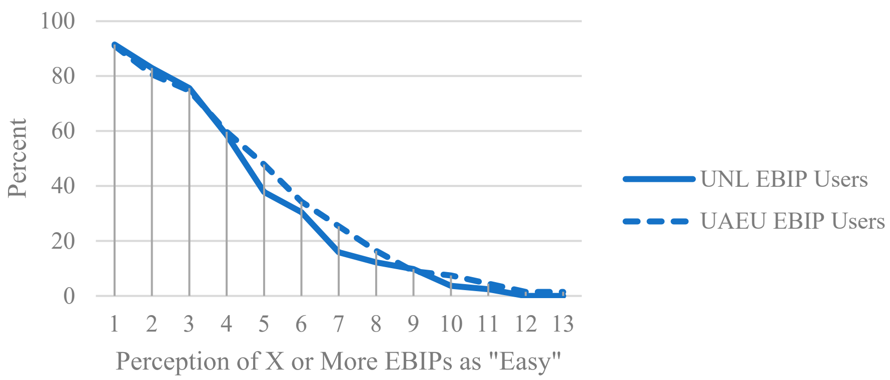

Figure 3. Number of EBIPs UAEU faculty perceive as "easy" to implement.

3.4. Research Questions 3 and 4: UAEU versus UNL—Contextual Factors That Influence Adoption of EBIPs

Lastly, the authors compared UAEU and UNL faculty affirmation/disaffirmation of specific contextual factors' influence on their teaching practices, as shown in Table 7 below, with larger differences (i.e., about 25% or higher) in bold. Specifically, more UAEU faculty agreed that the following factors influence the teaching methods they utilize most of the time: required textbooks or a syllabus planned by others (57% versus 12% of UNL faculty), time constraints due to teaching load (54% versus 31% of UNL faculty), student ability levels (94% versus 58% of UNL faculty), and teaching evaluations based on students' ratings (31% versus 8% of UNL faculty). On the other hand, more UNL faculty agreed that the number of students in a class influenced their teaching practices most of the time (57% versus 29% of UAEU faculty). Both UAEU and UNL faculty provide very similar responses for the following contextual factors: department's priority on research, department's reward system, availability of required resources, and time constraints due to research commitments.

Table 7. UAEU and UNL Faculty Agreement/Disagreement with Selected Contextual Factors that May Influence Teaching Practices.

Contextual Factors that May Influence Faculty Teaching Practices	Never True		Sometimes True		True Nearly All of the Time	
	UAEU Faculty	UNL Faculty	UAEU Faculty	UNL Faculty	UAEU Faculty	UNL Faculty
Department's priority on teaching	6%	6%	28%	45%	67%	49%
Department's priority on research	21%	24%	50%	55%	29%	21%
Department's promotion requirements	13%	23%	49%	54%	39%	24%
Department's reward system	33%	26%	47%	56%	19%	18%
Level of flexibility given by department in choosing the way a course is taught	14%	1%	15%	19%	71%	80%
Required textbooks or a syllabus planned by others	**6%**	**36%**	38%	52%	**57%**	**12%**
Textbook/s faculty choose	3%	13%	50%	56%	47%	31%
Number of students in a class	15%	1%	56%	42%	**29%**	**57%**
Physical space of the classroom	25%	6%	47%	54%	28%	40%
Availability of teaching assistants	39%	13%	38%	46%	24%	40%
Availability of required resources	7%	5%	50%	55%	43%	40%
Time constraints due to research commitments	17%	19%	47%	44%	36%	37%
Time constraints due to administrative or service commitments	17%	17%	42%	60%	42%	24%
Time constraints due to teaching load	11%	8%	35%	61%	**54%**	**31%**
Ability to cover all necessary content	18%	4%	32%	52%	50%	44%
Knowledge of appropriate instructional methods	18%	6%	38%	56%	44%	38%
Student preparation for class	8%	5%	61%	46%	53%	49%
Student ability levels	3%	4%	39%	38%	**94%**	**58%**
Student willingness to interact during class	1%	4%	50%	42%	72%	55%
Teaching evaluations based on students' ratings	21%	19%	58%	73%	**31%**	**8%**

Larger differences (i.e., about 25% or higher) are in bold.

3.5. Research Question 5: Combined UAEU and UNL Faculty Results—EBIP Awareness, Adoption, and Ease-of-Perception Levels

In order to answer research Question 5 of this study, UAEU and UNL faculty responses were combined and analyzed as one group, and Chi-square tests were utilized to determine any significant relationships. First, when all 16 teaching practices were taken combined, the relationships between these teaching practices and faculty awareness, adoption, and ease-of-implementation perceptions were found to be statistically significant with p-values of 0.000 each, indicating that there is statistical evidence that relationships between each of these three factors and the teaching practices are not independent. A summary of faculty responses regarding awareness, adoption, and ease-of-implementation is shown in Figure 4 below. Awareness results are displayed as the percent of faculty selecting Option 3 (i.e., "Familiar with it but have never used it") and higher labeled "aware". Frequency of adoption results are displayed as infrequently adopt (i.e., combined responses for once or twice/term and multiple times/term), frequently adopt (i.e., combined responses for once/week and multiple times/week), and never adopt. Perceived EBIP ease-of-implementation results are displayed as easy to implement (i.e., combined responses for very easy and easy) and not easy to implement (i.e., somewhat difficult, difficult, very difficult). As can be seen in Figure 4, surveyed faculty profess high awareness of the selected teaching practices (85.6%), with nearly 70% stating that they are easy to implement; however, only 36% of faculty are frequently adopting them. Specifically, Minute Papers, Concept Maps, and Service Learning are the practices with the highest levels of faculty never adopting them (71.4%, 71.4%, and 81%, respectively). On the other hand, faculty are most frequently adopting Instructor-Led Lecture, Individual Student Response, and Instructor-Led Problem Solving (85%, 84.4%, and 72.8%, respectively)—all non-EBIPs—on a "frequent" basis as defined above.

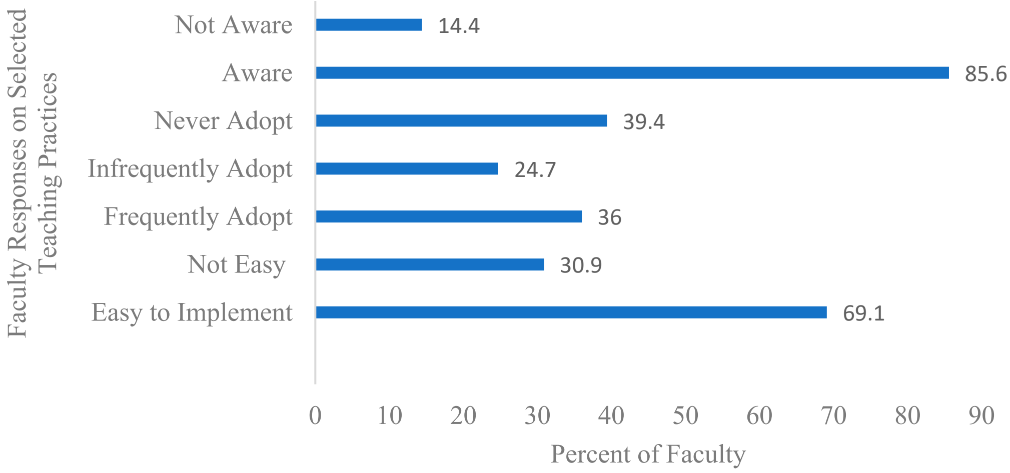

Figure 4. Summary of Combined Faculty Awareness, Adoption, and Ease-of-Implementation Responses of Selected Teaching Practices.

Next, the authors examined how participating faculty's demographics—gender, academic rank, department, university teaching experience (i.e., number of years), research activity, course load, typical time spent lecturing, graduate student supervision, and teaching workshop/program/course participation—influenced their awareness, adoption, and perceived ease-of-implementation of the selected teaching practices.

Faculty awareness of the selected teaching practices was significantly affected by percent of time spent on teaching, teaching experience, typical class time spent lecturing, and the number of teaching workshops/programs/courses attended. In terms of percent time spent on teaching, more faculty who spend 61–100% of their time teaching are more aware of the selected teaching practices ($p = 0.001$). In terms of teaching experience, more faculty with less than 6 years' teaching experience are not aware of all selected EBIPs

($p = 0.000$). By a different measure, more faculty who spend 61–100% of class time lecturing are not aware of the selected EBIPs, while more faculty who lecture 41–60% of the time are aware ($p = 0.000$).

Finally, in terms of teaching workshop/program/course attendance, more faculty who have attended up to four teaching workshops/programs/courses are not aware of the chosen EBIPs, while more faculty who have attended more than four are aware ($p = 0.000$). In particular, the following EBIPs were found to be significantly affected by teaching workshop/program/course attendance, in that more faculty who attended up to four are not aware, while more faculty who attended four or more are aware: Clickers/Personal Response System ($p = 0.022$), Minute Papers ($p = 0.000$), Peer Instruction ($p = 0.003$), Think-Pair-Share ($p = 0.000$), and Just-in-Time Teaching ($p = 0.042$).

Similar to faculty awareness, faculty adoption of the selected teaching practices was significantly influenced by percent of time spent on teaching, teaching experience, typical class time spent lecturing, and the number of teaching workshops/programs/courses attended. Frequency of adoption was categorized as follows: frequently adopt (once/week and multiple times/week), infrequently adopt (once or twice/term and multiple times/term), and never adopt. In terms of percent time teaching, faculty who spend more time teaching (i.e., 61–100%) are those who frequently adopt EBIPs in general ($p = 0.000$). Moreover, fewer faculty in their first year of teaching adopt EBIPs as compared to those with more teaching experience ($p = 0.000$). In terms of percent of typical class time spent lecturing, more faculty who spend 81–100% time lecturing never adopt EBIPs ($p = 0.000$). In addition, more faculty who spend less class time on lecture (0–40%) do not frequently adopt Instructor-Led Lecture ($p = 0.000$), a non-EBIP teaching practice.

Finally, teaching workshop/program/course participation positively affected EBIP adoption, as faculty who have attended four or more are more frequently using EBIPs ($p = 0.000$). In particular, the following EBIPs were found to be significantly affected by teaching workshop/program/course attendance, in that more faculty who attended no more than four teaching workshop/program/courses either never adopt the EBIPs or do not frequently do so, while more faculty who attended four or more teaching workshops/programs/courses do frequently adopt them: Clickers/Personal Response System ($p = 0.010$), Minute Papers ($p = 0.024$), Peer Instruction ($p = 0.001$), Think-Pair-Share ($p = 0.003$), and Just-in-Time Teaching ($p = 0.002$). These are the same EBIPs that presented significant relationships between faculty EBIP awareness and teaching workshop/program/course attendance. Furthermore, more faculty who attended more than six teaching workshops/programs/courses do not frequently use Instructor-Led Lecture, a non-EBIP teaching practice ($p = 0.088$).

Faculty ease-of-implementation perceptions of the selected teaching practices were influenced by teaching experience and the number of courses taught. In terms of teaching experience, more faculty with fewer than six years teaching experience find the selected teaching practices not easy to implement, while fewer faculty with 11+ years teaching experience find them not easy to implement ($p = 0.004$). In terms of the number of courses taught, faculty who teach more than six courses per academic year find implementing EBIPs easier as compared to faculty who teach less than six ($p = 0.041$).

Finally, authors utilized Chi-square tests to compare faculty EBIP awareness as a whole versus faculty adoption of EBIPs as a whole, as well as faculty adoption of EBIPs as a whole versus faculty perceived ease-of-implementation of EBIPs as a whole. It was confirmed that a significant relationship exists between faculty awareness and adoption ($p = 0.000$), as those faculty who are unaware of EBIPs never adopt them and those who are aware adopt them either frequently or not frequently. It was confirmed that a significant relationship also exists between faculty adoption and perceived ease-of-implementation of EBIPs ($p = 0.000$), as those faculty who say EBIPs are easy to implement are frequently adopting them and those who do not find them easy to implement are not adopting them.

3.6. Research Question 5: Combined UAEU and UNL Faculty Results—Contextual Factors That Influence Adoption of EBIPs

The authors assessed relationships between faculty affirmation/disaffirmation of specific contextual factors' influence on their teaching practices versus reported faculty adoption of the selected EBIPs as a whole. Several significant relationships were found. Namely, more frequent adopters of the selected EBIPs identify these factors as always influencing their teaching practices: (1) the level of flexibility they are given by their department in choosing the way they teach a course ($p = 0.003$); (2) the textbook/s that they choose ($p = 0.000$); (3) the number of students in a class ($p = 0.006$); and (4) the physical space of the classroom ($p = 0.003$). Finally, more infrequent adopters of the selected EBIPs identify these factors as never influencing their teaching practices: (1) their department's priority on teaching ($p = 0.064$) and (2) their knowledge of appropriate instructional methods ($p = 0.001$).

4. Discussion

In this study, the authors explored STEM faculty EBIP awareness, adoption, and ease-of-implementation perceptions in light of faculty demographic factors, along with contextual factors that influence their teaching practice selection, at one leading university in the UAE (UAEU) and, for comparison purposes, one in the USA (UNL). Furthermore, the authors explored the same STEM faculty responses when grouped as one in order to consider a current collection of faculty from both a leading country in STEM EBIPs and a newcomer in the same.

4.1. Research Questions 1–4: UAEU versus UNL Faculty

A summary of the findings comparing UAEU and UNL STEM faculty responses are listed below, beginning with faculty demographics and faculty EBIP awareness, adoption, ease-of-implementation perceptions, followed by contextual factors. Faculty EBIP awareness, adoption, and ease-of-implementation perception findings are then discussed in light of both faculty demographics and contextual factors identified as influencing faculty teaching practices.

4.1.1. Faculty Demographics

First, in terms of faculty demographics, while many (57%) of both UAEU and UNL surveyed faculty have 11+ years teaching experience in the college/university setting and similar research paper publication output, they differ in that UAEU surveyed faculty:

1. clearly have a higher teaching load (20% of UAEU faculty teach 7–8 courses per academic year versus 5% of UNL faculty; 8% of UAEU faculty teach more than 8 courses per academic year versus 1% of UNL faculty),
2. have attended fewer teaching workshops/programs/courses (67% of UAEU faculty have attended 0–3 workshops versus 34% of UNL faculty; 47% of UNL faculty have attended more than six teaching workshops/programs/courses compared to 21% of UAEU faculty), and
3. spend more time lecturing (30% of UAEU faculty spend 81–100% of class time lecturing versus 14% of UNL faculty).

4.1.2. Faculty EBIP Awareness, Adoption, Ease-of-Implementation Perceptions

Next, when comparing surveyed UAEU and UNL STEM faculty in terms of EBIP awareness, adoption, and ease-of-implementation perceptions, UAEU surveyed faculty on the whole are:

1. less aware of the selected EBIPs (nearly every UNL faculty member, 99%, are aware of at least 7 EBIPs, compared to only 87% of UAEU faculty; 84% of UNL faculty are aware of at least 10 EBIPs, compared to 63% of UAEU faculty),
2. similar in terms of their overall average EBIP adoption (6.5 versus 7.3 for UNL), but less frequent adopters of EBIPs when considering their weekly usage (UNL faculty

utilize seven out of the total 13 EBIPs more frequently on a weekly basis than UAEU faculty, as shown in Table 5), and
3. similar in terms of their perceived ease-of-EBIP-implementation levels.

When considering faculty EBIP awareness and adoption levels in light of faculty demographics, UAEU faculty responses make sense. If UAEU faculty are given a higher teaching load and attend fewer teaching workshops than UNL faculty, it follows that their awareness and adoption of EBIPs will be negatively affected. This aligns with findings that show lack of training and insufficient time as being among the most frequently cited barriers for change in faculty teaching practices [32]. Moreover, the EBIPs that showed high faculty awareness differences (bolded numbers shown in Table 4) are specific practices that are most likely to be discussed in teaching workshops/programs/courses or included in research regarding EBIPs. Furthermore, while UNL faculty showed higher overall involvement in teaching workshops/programs/courses, both UAEU and UNL surveyed faculty teaching workshop participation can be seen as low with nearly half (49%) having only attended up to three. Lastly, both UAEU and UNL surveyed faculty still most frequently utilize the first three traditional, non-EBIP teaching practices on a weekly basis and half of all surveyed faculty still spend 61–100% of their class time lecturing. This finding also aligns with other studies regarding the continued prevalence of didactic teaching practices in undergraduate STEM courses [15–18].

In terms of faculty EBIP ease-of-implementation perceptions, the similar findings in both UAEU and UNL surveyed faculty responses help to confirm the effort-to-implement levels shown in Table 1 that were based on Froyd's work [63], as well as that of Sturtevant and Wheeler [62]. Larger differences (i.e., about 25% or higher as shown in Table 6) were specifically noted for Interactive Lecture Demonstration and Peer Instruction, with UAEU faculty perceiving them as easier to implement than UNL faculty. One potential explanation for this may spring from a lack of understanding about what each practice actually entails. Given that many STEM faculty often take some of the basic ideas of an EBIP but do not implement it as described by the developer [17], respondents may wrongly believe they are adopting a practice when in fact they are utilizing only parts of it. Moreover, if respondents were not familiar with these practices and did not read the practice descriptions carefully, they could wrongly infer what they involve (e.g., one could think that Peer Instruction simple means peers teaching each other).

4.1.3. Contextual Factors

Finally, when comparing UAEU and UNL STEM faculty in terms of the contextual factors, faculty shared similarities and differences. Both UAEU and UNL faculty were similar for the following contextual factors across all answer options (i.e., never true, sometimes true, and true nearly all of the time): department's priority on research, department's reward system, availability of required resources, and time constraints due to research commitments. These findings may point to similarities between UAEU and UNL in these contexts. However, larger differences (i.e., about 25% or more) between factors faculty identify as influencing their teaching practices most of the time are as follows:

1. required textbooks or a syllabus planned by others (57% of UAEU faculty versus 12% of UNL faculty),
2. time constraints due to teaching load (54% of UAEU faculty versus 31% of UNL faculty),
3. student ability levels (94% of UAEU faculty versus 58% of UNL faculty),
4. teaching evaluations based on students' ratings (31% of UAEU faculty versus 8% of UNL faculty), and
5. number of students in a class (57% of UNL faculty versus 29% of UAEU faculty).

The surveyed faculty responses regarding contextual factors that influence their teaching practices also make sense in light of faculty demographics. Namely, more UAEU faculty agreed that time constraints due to administrative/service commitments and teaching load, student ability levels, and teaching evaluations based on students' ratings influence their teaching practice choices nearly all of the time. Not only is UAEU faculty's teaching load high compared to that of surveyed UNL faculty, but given the authors' understanding of both UAEU and UNL teaching contexts, UAEU faculty tend to have more administrative/service responsibilities as compared to that of UNL faculty.

Moreover, student ability levels in the UAEU context are understandably a potentially high influence on faculty teaching practices given the UAE's historic tendencies toward passive, teacher-centered learning that (on a relative basis) lacks focus on critical thinking, analyzing, and problem solving [37–41]. As such, when UAE undergraduate students are asked to perform such tasks, they may find it difficult and unusual, causing their ability levels to be a factor that UAEU faculty need to consider more often when selecting their teaching practices. Teaching evaluations based on students' ratings also place considerable influence on UAEU faculty teaching practices, as student teaching evaluations are given much weight in determining faculty employment continuation (considering that there is no tenure track for non-Emirati faculty members at UAEU) and promotion.

When considering surveyed UAEU faculty EBIP awareness and adoption in light of reported contextual findings, Lund and Stain's work appears to ring true: faculty who experience contextual influences that are supportive of EBIPs are more likely to have higher EBIP awareness and adoption levels [9]. Specifically, UAEU faculty's lower EBIP awareness and adoption levels (when compared to UNL) make sense in light of the contextual influences that can be seen as not supporting EBIPs (e.g., high teaching load, more administrative/service responsibilities, etc.).

4.2. Research Question 5: Combined UAEU and UNL Faculty Results

A summary of the findings of combined UAEU and UNL STEM faculty responses are highlighted below. First, faculty EBIP awareness, adoption, and ease-of-implementation perception findings are discussed in light of both faculty demographics and contextual factors identified as influencing faculty teaching practices. Next, faculty EBIP awareness versus faculty EBIP adoption, as well as faculty EBIP adoption versus faculty perceived ease-of-implementation of EBIPs are discussed. Lastly, relationships between faculty affirmation/disaffirmation of specific contextual factors' influence on their teaching practices versus reported faculty adoption of the selected EBIPs are discussed.

4.2.1. Combined Faculty EBIP Awareness and Adoption

Several significant findings arose when UAEU and UNL faculty responses were combined and analyzed as a whole. First, surveyed faculty profess high awareness of the selected teaching practices (85.6%), with nearly 70% stating that they are easy to implement; however, only 36% are frequently adopting them.

Next, patterns arose when considering faculty demographics and their influence on faculty EBIP awareness and adoption in that both were significantly influenced by:

1. percentage of time spent on teaching,
2. teaching experience,
3. typical class time spent lecturing, and
4. the number of teaching workshops/programs/courses attended.

In terms of percentage of time spent on teaching, the more time faculty spend on teaching, the higher their EBIP awareness and adoption levels. Similarly, in terms of teaching experience, more teaching experience in the university/college setting positively impacted faculty EBIP awareness and adoption levels. The positive impact that more teaching (i.e., more time spent on teaching and more years of teaching experience) has on EBIP awareness and adoption makes sense given the potential for not only more EBIP and teaching workshop/program/course exposure, but also increased faculty interest in more effective teaching practices. In terms of typical class time spent lecturing, results demonstrated that the more time faculty spend lecturing, the lower their EBIP awareness and adoption levels. This is logical in that if faculty are not aware of EBIPs, they will not implement them and spend more time utilizing non-EBIP teaching practices (e.g., lecturing).

Finally, participation in 4 or more teaching workshops/programs/courses positively impacted faculty EBIP awareness and adoption, which not only points to the importance of teaching workshops, but also to the need for multiple experiences of the same. Research on the positive impact that teaching workshops have on STEM faculty teaching practices are numerous and support this study's findings [10,18,36,71]. Interestingly, significant relationships between faculty participation in four or more teaching workshops and both faculty awareness and adoption of the following specific EBIPs emerged as well: Clickers/Personal Response System, Minute Papers, Peer Instruction, Think-Pair-Share, and Just-in-Time Teaching. Given these findings, institutions may focus on exposing faculty to EBIPs and ensuring their clear understanding of the same through participation in teaching workshops/programs/courses, as this can play a key role in increasing faculty EBIP awareness and adoption levels, as well as their ease-of-implementation perceptions. Moreover, when EBIP awareness and adoption levels are increased, class time spent lecturing decreases.

4.2.2. Combined Faculty EBIP Ease-of-Implementation Perceptions

Faculty ease-of-implementation perceptions of the selected EBIPs were influenced by teaching experience and the number of courses taught. In terms of teaching experience, faculty with less teaching experience (i.e., less than six years) find the selected EBIPs not easy to implement, while those with more (i.e., 11+ years) find them easier to implement. This makes sense in that increased faculty teaching experience creates an increased likelihood of exposure to teaching research and workshops, which may discuss EBIPs, as well as more time to understand EBIPs and implement them.

In terms of the number of courses taught, the more classes faculty teach per academic year (i.e., those who teach more than six), the lower their EBIP perceived ease-of-implementation levels. While more teaching experience translates into easier perceived EBIP implementation levels, as well as higher EBIP awareness and adoption levels, teaching too many courses per academic year negatively affects how easy faculty find it to implement EBIPs. This again aligns with previous findings regarding insufficient time as being a barrier to faculty implementation of EBIPs [10] and makes sense in that too high of a teaching load likely translates into less time to focus on understanding and implementing EBIPs, likely affecting how easy it feels for faculty to use them. As such, institutions would be wise to focus on teaching but to also keep in mind a reasonable teaching load given all faculty demands. This calls for institutions and their departments to assess their priorities on teaching and research, as well as use of faculty time (e.g., course load, administrative or service commitments, etc.).

4.2.3. EBIP Awareness Versus Adoption, EBIP Adoption versus Ease-of-Implementation Perceptions

When comparing faculty EBIP awareness versus faculty EBIP adoption, as well as faculty EBIP adoption versus faculty perceived ease-of-implementation of EBIPs, significant relationships were found. Faculty who are unaware of EBIPs never adopt them, whereas those who are aware do. Furthermore, faculty who find EBIPs easy to implement frequently adopt them, whereas those who find them difficult do not adopt them. These findings stress the importance of faculty exposure to and clear understanding of EBIPs. Again, consistent participation in EBIP workshops/programs/courses is a very practical way for institutions to support their faculty in EBIP awareness and in finding EBIPs easy to implement, which both positively impact their EBIP adoption.

4.2.4. Contextual Factors

Next, the authors assessed relationships between faculty affirmation/disaffirmation of specific contextual factors' influence on their teaching practices versus reported faculty adoption of the selected EBIPs. Several significant relationships were found. Namely, more frequent adopters of the selected EBIPs identify these factors as always influencing their teaching practices:

1. the level of flexibility they are given by their department in choosing the way they teach a course ($p = 0.003$),
2. the textbook/s that they choose ($p = 0.000$),
3. the number of students in a class ($p = 0.006$), and
4. the physical space of the classroom ($p = 0.003$).

Finally, more infrequent adopters of the selected EBIPs identify these factors as never influencing their teaching practices: (1) their department's priority on teaching ($p = 0.064$) and (2) their knowledge of appropriate instructional methods ($p = 0.001$).

In terms of the results for factors that always influence faculty who frequently adopt EBIPs, the following can be noted. The first and second factors, which involve faculty members' freedom in choosing how they teach a course, may cause faculty to perceive it easier to implement EBIPs into their courses, thus resulting in the significant relationships. The third and fourth factors—the number of students in a class and the physical space of the classroom—also may cause faculty to perceive it easier or harder to implement EBIPs. This makes sense in that faculty may think they need more space for students to participate in peer/group work (e.g., Collaborative Learning) or fewer students if they are going to implement an EBIP like Just-in-Time Teaching where they must check student answers before class (more students in a class likely makes this more challenging).

In terms of the results for factors that never influence faculty who do not frequently adopt EBIPs, the following can be noted. It logically follows that faculty who do not frequently adopt EBIPs are not influenced by their department's priority on teaching. The influence that departments can have on faculty teaching practices has been shown in other studies—the lack of it can be a barrier to faculty adoption of EBIPs, and the focus on it a support [9,10,36]. Lastly, knowledge of appropriate instructional methods shows up as a factor that never influences faculty who do not frequently adopt EBIPs. Given that these faculty are likely unaware of other instructional methods, it makes sense that they do not identify their knowledge of appropriate instructional methods as a factor that influences their teaching practices and are in turn not frequently utilizing EBIPs.

4.3. Summary of Findings and Implications

4.3.1. UAEU Versus UNL Faculty

Findings demonstrate that surveyed UAEU STEM faculty compared to UNL STEM faculty on the whole are: (1) less aware of the selected EBIPs, (2) similar in terms of their overall EBIP usage but less frequent adopters considering their weekly usage, and (3) similar in their EBIP ease-of-implementation perceptions. Both surveyed UAEU and UNL faculty still most frequently utilize the first three traditional, non-EBIP teaching practices on a weekly basis and half of all surveyed faculty still spend 61–100% of their class time lecturing. Both UAEU and UNL surveyed faculty teaching workshop participation can be seen as low with nearly half having only attended up to three. Differences in contextual factors identified by UAEU faculty as influencing their teaching practices align with UAEU faculty demographics (e.g., high course loads).

UAEU may use these results to gauge its progress on STEM faculty EBIP practices, and more specifically, when considering these results in light of UAE's Vision 2030 and National Strategy for Higher Education 2030 goals [49], noting that while UAEU STEM faculty are nearing levels that are comparable to STEM faculty from a consistently ranked, top tier research university and lead teaching institution in the USA (UNL), there is room for improvement (e.g., increase EBIP awareness and adoption, increase teaching workshop participation, decrease time spent lecturing). As such, areas of improvement for UAEU STEM faculty, as well as their departments, may then include attention to faculty participation in teaching workshops that focus on EBIPs in STEM, as well as an evaluation of factors that may encourage and discourage faculty to more frequently utilize EBIPs. For UAEU, these factors may include a stronger priority on teaching while reassessing high faculty teaching load coupled with high faculty research output.

UNL may utilize this study's findings toward its ongoing assessment of its STEM faculty practices, noting that while STEM faculty are aware of and utilizing many EBIPs on a frequent basis, there are still potential improvements to be made (e.g., increase EBIP awareness and adoption, increase teaching workshop participation, decrease class time spent lecturing). As such, areas of improvement may include a focus on teaching workshop participation that deal with EBIPs in STEM, as well as an evaluation of factors that may encourage and discourage faculty to more frequently utilize EBIPs. Such factors may include a stronger priority on teaching coupled with a focus on ways to integrate EBIPs into varying class sizes, as more than half of UNL faculty identified the number of students in a class as influencing their teaching practices most of the time.

4.3.2. Combined Faculty

Findings from combined UAEU and UNL STEM faculty responses demonstrate that while faculty profess high awareness and ease-of-EBIP-implementation perceptions, this is not reflected in their adoption patterns, as most are either infrequently or never adopting them. Faculty EBIP awareness and adoption levels were positively influenced by more time spent on teaching, more teaching experience, and more teaching workshop participation faculty have (specifically four teaching workshops or more). The more teaching experience faculty have, the easier they perceive EBIPs are to implement, while the higher the teaching load (i.e., more than six) faculty have, the harder they perceive the same. Contextual factors identified as always influencing the teaching practices of faculty who frequently adopt EBIPs point to potential factors for universities to consider in their efforts to increase faculty EBIP adoption.

Based on these findings, institutions would be wise to evaluate their priority on teaching, especially at the departmental level, along with faculty use of time (e.g., course load, administrative/service commitments, etc.) and potential incentives for faculty implementation of EBIPs and teaching workshop participation (e.g., implementation of EBIPs being factored into faculty annual merit decisions and mandatory new faculty teaching training). These are further discussed in the Recommendations section of this paper. Lastly, the findings of this study contribute to existing literature that points to the importance of supports [9] and teaching workshops [10,18,36,71] to EBIP adoption, and the negative impact that lack of training and insufficient time have on faculty teaching practices [32].

4.4. Limitations

First, in terms of UAE university faculty teaching practices, this study was conducted at one university in the UAE and is thus limited in its scope. Similarly, only one university in the USA was selected. Second, limited participation was achieved (overall response rate of 15%). Third, reliability of the survey instrument was not measured. Fourth, no statistical test was used to measure the validity of the survey instrument, although a few measures were taken in order for the instrument to collect the data it was intended to collect, such as: (1) utilizing three previously conducted surveys as a basis upon which to build the current survey, one of which [62] obtained face and content validity via a panel of four experts, (2) modifying previously conducted surveys' EBIP descriptions for utmost clarity and succinctness as needed, and (3) utilizing five-point Likert scales for all survey questions in order to maximize variance in responses (except for one four-point Likert scale). While these measures were taken, it is possible that faculty misinterpreted EBIPs (whether this is true or to which extent is unknown) and professed their awareness or adoption of teaching practices in cases where this is not true. Fifth, limitations to self-reported data about faculty instructional practices are widely recognized [72–74] and may thus be a part of this study. Finally, the lack of specificity in the types of teaching workshops/programs/courses that faculty have participated in could potentially cause misleading conclusions to be drawn about the influence these experiences have on faculty responses (e.g., faculty may have participated in various teaching workshops that may not have focused specifically on EBIPs or specific teaching practices). However, respondent data regarding this question is still helpful, as it makes sense that as faculty participate in more teaching workshops/programs/courses, they are more likely to be exposed to various teaching methods compared to those who do not.

Given the limitations listed above, the authors recommend the following for further related research:

1. More surveyed universities: Given the limitations of surveying STEM faculty from only two universities, further studies may be conducted involving more institutions.
2. Larger sample size: Future studies may seek to provide incentives to achieve higher instructor participation in the survey or mandatory instructor participation at the university or department levels.
3. Construct validity and internal consistency tests: Future studies may assess the construct validity (e.g., with factor analysis) and internal consistency (e.g., with Cronbach's Alpha) of this study's survey instrument.
4. Faculty interviews: Given the potential faculty misinterpretation of described EBIPs, future studies may utilize interviews with surveyed faculty in order to check for faculty understanding.
5. Classroom observations: Given the limitations of self-reported surveys, future studies may carry out classroom observations of surveyed STEM faculty to allow for comparison of faculty survey results to that of actual teaching sessions, likely leading to a more holistic picture of STEM faculty teaching practices.
6. Data on specific faculty teaching workshop/program/course participation: Future studies may obtain more detailed information on the kinds of teaching workshops/programs/courses in which faculty have participated.

5. Recommendations

The authors recommend the following in order to promote the understanding and further implementation of EBIPs:

1. Incentives for faculty prioritization of teaching development: Many universities have centers for teaching and learning that provide workshops, resources, and overall support for its faculty's professional development. The more an institution's faculty take part in these centers and their initiatives, especially teaching workshops, the better. However, it is likely that given the varying demands on faculty time, workshops may go unnoticed or are not prioritized by faculty [71]. As such, the authors recommend more incentives for faculty participation in university centers for teaching and learning. This could involve putting more emphasis on teaching development in promotion criteria, as well as mandating that all faculty participate in a certain number of self-selected teaching workshops per academic year. Moreover, implementation of EBIPs could be factored into faculty annual merit decisions [18].
2. Clear EBIP descriptions and usefulness presented in teaching workshops: Given the important role that EBIPs play in improving STEM education, teaching workshops should ensure that their presentations are clear and easy to understand. They should also present clear reasons (preferably backed by research findings) as to the usefulness of each EBIP as well as of EBIPs in general in order to aid faculty understanding and interest in implementing them. Furthermore, they should include instruction on how to easily implement them in varying contexts that can potentially discourage EBIP usage (e.g., in classes with limited space, classes with a large number of students, and classes with varying student ability levels).
3. New faculty training: It is known that university instructors often must teach themselves to use new teaching practices that they did not experience as students, as graduate and post-doctoral education rarely focuses on teaching [75]. Thus, the authors recommend that new faculty be required to take part in training related to teaching that focuses primarily on incorporating active learning strategies in all courses. The training should occur before they begin teaching at an institution.

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