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Design and Development of Survey Instrument to Measure Engineering Doctoral Students' Perceptions of Their Teaching Preparedness

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Abstract

Doctoral students who choose an academic career path will essentially be required to teach courses. However, literature says most doctoral students have more research experience than teaching experience. Additionally, the teaching experience they have is through their graduate teaching assistantships, which may or may not have associated training on how to teach. Teaching can be difficult if you are not fully aware of the different aspects associated with it. This research project aims at understanding engineering doctoral students' perceptions on their readiness to teach courses once they begin their academic careers. To understand engineering doctoral students' perceptions on their preparedness to teach courses, a survey instrument was designed and deployed.

The survey instrument included three parts: Likert scale questions, free response questions, and demographic information. The Likert scale questions evaluate the participants' confidence/preparedness in areas of teaching such as the teaching and learning process (9 items); course design and delivery (8 items); creating a dynamic classroom (9 items); harnessing the power of technology (6 items); collaborative learning (6 items); and effective assessment (8 items). To collect the content and face validity evidence, the survey was sent to three content experts with expertise in survey design and three potential participants – engineering doctoral students from three different institutions. This study was approved by the Institutional Review Board and the survey instrument was administered in fall 2023. The survey was distributed to approximately 3500 engineering doctoral students from 20 different R1 universities, and 285 responses were included in the analysis post data cleaning and data pre-processing. Exploratory factor analysis (EFA) was conducted to validate the factor structure. EFA revealed six factors, five factors were same as hypothesized (the teaching and learning process, course design and delivery, creating a dynamic classroom, collaborative learning, and effective assessment) and one new factor (ethical practices). The factor loadings for the final factors ranged from 0.42 to 0.99, and the internal consistency reliability (Cronbach's α) for the six factors ranged from 0.77 to 0.86, indicating high reliability.

Keywords: academic career, engineering doctoral students, teaching preparedness

Introduction

Doctoral students who choose an academic career path will essentially be required to teach courses. However, literature says most doctoral students have more research experience than teaching experience. Additionally, the teaching experience they have is through their graduate teaching assistantships, which may or may not have associated training on how to teach. Teaching can be difficult if you are not fully aware of the different dimensions associated with it. Engineering doctoral students who look to enter academia after graduation are incentivized to take a research-first career, though they likely would also be in instructional positions. However, some doctoral students go out of their way to gain experience as course instructors. In a survey of engineering doctoral students, a subset of the respondents reported being uninterested in working in the professoriate, and among that group, a small portion of them were uninterested due to their perceived lack of ability to teach. This research project aims at understanding engineering doctoral students' perceptions on their readiness to teach courses once they begin their academic careers.

There is no singular shared opinion of the purpose of a doctoral degree in America. The resulting career sectors of an engineering PhD can include industry, government, and academia, where each field has different demands and necessities from a graduate. Currently, a significant portion of engineering PhD recipients have academic or post-doctoral commitments, with 42.7% of recipients having these commitments in 2022 [1]. Academic responsibilities can be quite varied; often featuring research, teaching, and institutional service requirements. Despite the diverse responsibilities, there is usually a focused emphasis on research, especially for early career academics. This can lead to instructors feeling that the time they spend on teaching interferes with the time they could spend on research [2].

Regarding engineering instruction, there is always room for improvement. Proposals for improving engineering education vary from improving teaching training to overhauling the culture of academia [3]. While the view of improving engineering education through the use and evolution of instructional materials has been widely researched and practiced, something that has often been overlooked is how teaching preparation can begin before one becomes a member of faculty. There are options for PhD students to begin instruction through resources such as teaching assistantships or workshops. Some students opt to participate in these while others do not. In addition, some PhD students have extensive prior teaching experiences while others have none.

While a career in academia typically requires research, teaching, and service, most doctoral degrees in the United States are conferred at research intensive universities, where research accomplishments are prioritized over instructional training for future faculty members [4]. However, as some engineering PhD students wish to pursue a more teaching-focused career at a primarily undergraduate institution, these future faculty members eventually find they did not feel adequately prepared for their career [5].

Further investigation on the self-efficacy regarding instruction for engineering PhD students is needed. Specifically, there is a need to better understand which areas of instruction self-efficacy are related to each other and which areas engineering PhD students lack confidence. This paper aims to support these efforts through developing a survey instrument to measure student confidence levels and attitudes related to several different factors of instruction. The survey instrument was utilized as part of a larger project undertaken to determine how different external factors may influence engineering PhD students' self-perceptions on their abilities to teach as well as exploring the expectations, concerns, and experiences regarding a career in academia and pedagogical preparation of engineering PhD students who are considering careers as academics.

Areas of Teaching

There are a variety of ways for students to learn, from reading and listening to creating their own study tools and applying their knowledge to other methods merging these and/or including other ways to learn, and for a given student to learn best depends partially on how compatible the student's preferred study methods interact with the instructor's teaching methods [6-7].

Also, how a course is designed and delivered may impact how a student can learn. A flipped class is a type of blended online-offline course which involves teaching students through requiring students to view some type of material, such as a video or an excerpt from a book, before a lecture to encourage active participation for the students in lectures [8]. Designing a flipped class requires considerations which may not be necessary for traditional, in-person classes, such as the types of pre-lecture study content, and can lead to a greater amount of time spent on a class for both the students and the instructor outside of the classroom as a result of reallocating the time spent familiarizing students towards a topic inside of class to outside of class [9].

To effectively evaluate how well a student is progressing, there needs to be some type of assessment. One of the most common methods of assessment for engineering courses is the final examination (exam), which can simply evaluate a large amount of students' proficiencies in practicing knowledge gained from the course [10]. However, exams are not always the most effective method of evaluating a student's proficiency as these examinations are affected by external factors, such as examination stress, where students' ability to succeed is hindered by their worries over the exam itself [11]. As a result, alternative assessment methods such as the more open-ended course project allow students to apply their knowledge over a longer period and encourage students to collaborate.

While diagnosing tools for the results of programs such as Preparing Future Faculty exist, these tools are typically focused on how these programs prepared the students generally for faculty life [12]. Other survey instruments place a focus on the self-efficacy of new faculty members rather than current PhD students who are preparing for a career in academia [13]. Additionally, examining the data through exploratory factor analysis allows grouping teaching into related modules. Prior studies have focused on areas such as STEM PhD students' perceptions of their skills in relation to their career plans and self-perceptions of graduate students' teaching skills in regard to determining the efficacy of a teaching workshop, but prior studies have not investigated the general self-perceptions of engineering PhD students regarding teaching [14-15].

This study is a part of a bigger project focused on understanding engineering doctoral students' perceptions of their preparedness to teach. In this study, the focus is only on the design and development of the survey instrument and validated the survey instrument by exploratory factor analysis. In a parallel study of this project, we aim to further investigate the findings from this study by examining engineering doctoral students' perceptions on their preparedness to teach vary based on their demographic characteristics, prior teaching experiences and trainings, etc. [16]. In another study, we analyze engineering doctoral students' expectations, reflections, and concerns regarding their future in academia [17].

Theoretical Framework

The survey instrument developed is grounded in the self-efficacy and self-perception theory. The self-efficacy theory provides a framework to act as a predictor of how individuals may perform in the future based on their confidence in their ability in a certain task or domain [18]. According to Bandura [19], [20], a person's self-efficacy can be influenced by key experiences, such as mastery experiences, vicarious experiences, social persuasion, and physiological states. Self-perception theory states that individuals interpret their attitudes towards a behavior through the behavior itself and the context it occurs in [18].

In relation to teaching, self-efficacy implies that the confidence one feels towards teaching is related to their future performance as well as being related to their prior experiences [18]. For example, a PhD student who was formerly a course instructor would likely have a greater self-efficacy regarding teaching than a PhD student who focuses on research primarily. As a result, if they were put in charge of being a teaching a course, (barring significant pre-existing attitudes towards teaching) the self-perception theory suggests that the former instructor would likely interpret their attitude towards teaching the new course more positively as they are more familiar with the situation and do not necessarily need to deal with the stress of needing to learn how to lead a course effectively.

6 constructs were identified as areas in which self-efficacy and self-perception could apply in being an instructor: the teaching-learning process, course design and delivery, creating a dynamic classroom, harnessing the power of technology, collaborative learning, and effective assessment.

Methods

1. Development of the Survey Instrument

The survey instrument was developed during the summer of 2023 by a small group made up of a faculty member and an undergraduate. The instrument is built using six scales (Table 1), where the scales align with the constructs outlined in the theoretical framework and are intended to capture the projected experiences of doctoral students in the U.S. The instrument included a total of 46 items across the six scales. On a 5-point Likert-type scale, the participants were asked to rate their perceptions on their teaching preparedness. The Likert scale was anchored with different levels (5) strongly agree (4) agree (3) neither agree nor disagree (2) disagree (1) strongly disagree. A separate demographics section asking questions about the participants' background characteristics was also included.

The scales drew inspiration from a survey instrument utilized to examine the learning experiences of International Engineering Educator Certification Program participants' learning experiences in India [21]. While the scales are shared, the contents of each scale have been altered to more effectively fit the participant pool which is engineering doctoral students. These changes range from adjustments to diction (such as replacing mentions of specific educationalists with descriptions of their theories) to replacing entire questions.

The *Teaching-Learning Process* scale measures students' perceptions of interactions with students and the processes regarding teaching. These items capture the participants perceptions of their understanding of what an engineering instructor does, the roles and importance of keeping students engaged and motivated, effective teaching philosophy, and the importance of inclusion regarding student diversity. This scale included nine items.

Course Design & Delivery scale measured participants' perceptions of their ability to incorporate effective teaching practices, writing student learning outcomes, course design and implementation.

This scale also included aspects like designing and implementing blended classes, catering for students with diverse needs, etc. Eight items were a part of this scale.

Table 1. Overview of Scales within the Instrument

Scale (# of items)	Definition	Example Items
The Teaching-Learning Process (9)	Students' perceptions regarding teaching and interacting with students	- I can identify the needs of my students - I understand the importance of keeping my students engaged
Course Design and Delivery (8)	Students' perceptions on writing courses, planning course outcomes, and adjusting course designs.	- I can write desired student learning outcomes for my course - I can design courses that provide effective student learning experiences
Creating a Dynamic Classroom (9)	Students' perceptions regarding promotion of active learning, promotion of peer-peer and peer-instructor interactions and supporting student needs.	- I can plan my office hour effectively - I can identify students in class who would benefit from additional academic support
Harnessing the Power of Technology (6)	Students' perceptions regarding the use of online tools for class organization and assisting with teaching	- I can create short video messages/lectures - I can effectively use virtual labs in lectures
Collaborative Learning (6)	Students' perceptions regarding the reasons for and methods of creating a collaborative environment	- I understand the advantages of including collaborative activities in class - I understand in what situations implementing a group activity is more effective than implementing an individual activity
Effective Assessment (8)	Students' perceptions regarding writing rubrics and dealing with unethical behaviors in class.	- I can design open book assignments - I can deal with plagiarism practices during assessments

Creating a Dynamic Classroom scale included nine items. This scale was designed to measure participants' perception of their competency in implementing active learning and promoting student engagement and interactions. This scale also measures participants' perceptions of their ability to adjust a course for students who would benefit most from additional support.

Harnessing the Power of Technology scale comprises a total of six items. The items in this scale centered around participants' perception of their ability to utilize online resources in axillary to their class organization and lectures. Specifically, the items focused on creating video messages/lectures, delivering online lectures, use of virtual labs, etc.

Collaborative Learning is intended to measure participants' perception of their understanding of collaboration between students in the classroom and how to manage that collaboration as an instructor. This scale included six items and the items in this scale focused on planning and implementing collaborative activities in class, designing instruments to measure individual and team performance in collaborative activities, etc.

Effective Assessment scale measures participants' perceptions of their ability to design exams and assignments, as well as grading them and managing unethical behavior regarding grades. Eight items were included in this scale. The items focused on designing different exams including question papers, open-book exams, and open-book assignments, designing rubrics for assignments and projects, etc.

2. Evidence of Content Validity and Face Validity

The evidence of content validity for the instrument was collected by the review from of the items from three faculty members external to the research team with extensive expertise in survey instrument design. Additionally, the evidence of face validity for the instrument was collected by distributing the survey instrument items to three potential participants and requesting feedback regarding clarity and phrasing of the items. From these sources, adjustments were made to increase the specificity of questions and rephrasing certain questions to minimize redundancy.

3. Exploratory Factor Analysis

Procedure

The exploratory factor analysis (EFA) was conducted to determine the factor structure of the survey instrument [23-24]. The data for EFA was collected during the fall 2023 semester over three weeks from 20 different R1 research universities in the United States. Two reminders were sent to improve the response rate, one during the second week and the other during the third week. The participants were reached through the department program chairs and directly via email (if their email address was listed on their university website). The questions in the survey were randomized using the feature in Qualtrics to avoid bias in the participants' responses. Through a lucky draw, ten participants were provided an incentive of $25 Amazon gift card for their participation in this study.

Analytical Approach

Before performing the factor analysis, the kurtosis and skew of each of the 46 items were looked at to confirm the assumption of univariate normality [22]. The Kaiser-Meyer-Olkin (KMO test) and Bartlett's test of sphericity were conducted to examine the suitability of the survey instrument. Scores above 0.8 of the KMO test results suggest that a factor structure is possible, and by extension a factor analysis is possible, as the test measures shared variance among items. Bartlett's test of sphericity is conducted to examine the possibility of factor analysis by measuring the item correlation matrix, a significant test result of $p<0.05$ indicates the data is factorable. Principal axis factoring (PAF), which allows and accounts for the possibility of measurement error when conducting self-report research, was used to extract the factors [23]. Because the promax with Kaiser normalization rotation method accommodates correlation between factors, which was suspected to be likely in this analysis, it was used with standard kappa (kappa=4).

After ensuring the factorability of the data, the Kaiser's criterion method, parallel analysis and the scree plot were used to determine the number of factors [23]. Items that had factor loadings less than 0.4 (<0.4) or cross loading with more than 0.3 (>0.3) on at least two factors were removed [23]. With the finalized factor structure of the survey instrument, the internal consistency reliability of each scale was evaluated using Cronbach's alpha (α), the α greater than 0.6 (α>0.6) is good and (α>0.8) is preferred [23]. The entire EFA was conducted using the SPSS statistical software package.

Results

Participants

A total of 352 participants responded to the survey, of which 285 participants provided full responses and those responses were retained for the EFA. For the 285 responses, there was no missing data on the 46 items of the survey instrument. The participants' demographic information is presented in Table 2. The final sample was 60 percent male. The participants self-identified as White (44.6 percent), Asian (41.8 percent), Hispanic or Latinx (9.5 percent), Black or African American (7.7 percent), or American Indian or Alaska native (1.1 percent). On average the participants were 2.67 years into their doctoral degree, and on average the participants had 2.06 semesters of teaching experience as a teaching assistant (TA). 40 percent of the participants expressed interest in academia as their career path, industry (34.4 percent), government (7.4 percent), and undecided (17.8). The respondents were from 15 different engineering majors.

Table 2. Demographic Information of Participants

Category	*n*	%
Total	285	100
Gender Identity		
Male	171	60.0
Female	90	31.6
Others	24	8.40
Race/Ethnicity		
White	121	44.6
Asian	119	41.8
Black or African American	22	7.70
Hispanic or LatinX	27	9.50
American Indian or Alaska Native	3	1.10
Native Hawaiian or Other Pacific Islander	1	0.40
Career Path		
Academia	114	40.0
Industry	98	34.4
Government	21	7.40
Undecided	51	17.8
Both industry and academia	1	0.40
Academic Department		
Electrical & Computer Engineering	41	14.4
Engineering Education	37	12.9
Mechanical Engineering	35	12.3
Computer Science	30	10.5

Chemical Engineering	29	10.2
Civil Engineering	21	7.37
Environmental Engineering	19	6.67
Industrial & Systems Engineering	18	6.32
Aerospace Engineering	11	3.86
Materials Science	11	3.86
Biological Engineering	8	2.81
Biomedical Engineering	8	2.81
Agriculture Engineering	5	1.75
Architectural Engineering	4	1.40
Aeronautical Engineering	2	0.70

Exploratory Factor Analysis

According to Seltman [22], an acceptable limit was reached when the absolute values of skewness and kurtosis for all the 46 items in the survey instrument were less than 3.0 (see Table 3). Some of the aspects that engineering doctoral students were confident about their readiness to teach based on the average response ratings (greater than 4.0 out of 5.0) are I understand my responsibilities as an engineering educator (mean=4.13), I can reflect on my experiences as an instructor (mean=4.22), I understand my role in keeping my students motivated (mean=4.24), I understand my role in keeping my students engaged (mean=4.16), I understand the importance of keeping my students motivated about the field of engineering (mean=4.35), I understand the importance of keeping my students engaged in class (mean=4.36), I understand the importance of inclusion in context of student diversity in the classroom (mean=4.22), I can adjust my instructional design based on my reflections on my own teaching (mean=4.11), I can plan my office hour effectively (mean=4.04), and I understand the advantages of including collaborative activities in class (mean=4.19).

Bartlett's test for sphericity confirmed that the items were appropriate for factor analysis ($p<0.001$). If factor analysis was to be performed, the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) (KMO=0.95) approved the extraction of factors for accounting meaningful variance [23]. Kaiser's criterion, scree plot, and parallel analysis revealed seven, six, and six factors, respectively, that could be inferred from the data. Six factors were selected as they match with the hypothesized set of factors. As the factor correlations were highly correlated (>0.33), promax rotation was used [23].

Table 3. Descriptive Statistics of Survey Items

#	Measure	Mean	*SD*	Skew	Kurtosis
	The Teaching Learning Process	4.14	0.81		
1	I understand my responsibilities as an engineering educator	4.13	0.86	-1.14	1.51
2	I can reflect on my experiences as an instructor	4.22	0.80	-1.04	1.34
3	I can identify the needs of my students	3.80	0.85	-0.77	0.96
4	I understand my role in keeping my students motivated	4.24	0.76	-1.43	2.79
5	I understand my role in keeping my students engaged	4.16	0.75	-1.04	2.13
6	I understand the importance of keeping my students motivated about the field of engineering	4.35	0.71	-1.40	2.89
7	I understand the importance of keeping my students engaged in class	4.36	0.70	-1.33	2.45
8	I understand effective teaching philosophy	3.74	1.02	-0.88	0.46

9	I understand the importance of inclusion in context of student diversity in the classroom	4.22	0.82	-1.18	1.88
	Course Design & Delivery	3.79	0.95		
10	I can incorporate effective teaching practices into my lectures	3.87	0.95	-1.03	1.17
11	I can write desired student learning outcomes for my course	3.96	0.90	-0.96	1.06
12	I can design courses that provide effective student learning experiences	3.81	0.96	-0.80	0.45
13	I can design a blended (hybrid) class	3.56	1.06	-0.45	-0.42
14	I can implement a blended (hybrid) class	3.62	1.01	-0.69	0.09
15	I can design an effective lecture to encourage active learning	3.87	0.95	-0.86	0.66
16	I can design courses that cater to students with diverse needs	3.52	0.96	-0.45	-0.01
17	I can adjust my instructional design based on my reflections on my own teaching	4.11	0.80	-0.86	1.07
	Creating a Dynamic Classroom	3.82	0.92		
18	I can implement active-learning activities in class	3.88	0.95	-0.82	0.42
19	I can design activities for generating intellectual excitement	3.87	0.91	-0.91	0.90
20	I can promote student engagement with me as the instructor	3.95	0.85	-0.77	0.76
21	I can promote student engagement via peer interactions	3.83	0.94	-0.70	0.26
22	I can plan my office hour effectively	4.04	0.90	-0.85	0.48
23	I can identify students with disruptive behavior	3.86	0.90	-0.84	0.60
24	I can manage students with disruptive behavior	3.31	1.03	-0.07	-0.60
25	I can identify students in class who would benefit from additional academic support	3.88	0.88	-0.90	1.06
26	I can adjust a course for students in class who would benefit from additional academic support	3.72	0.94	-0.54	-0.12
	Harnessing the Power of Technology	3.56	1.04		
27	I can create short video messages/lectures	3.88	0.97	-0.76	0.18
28	I can deliver online classes effectively	3.56	1.02	-0.60	0.05
29	I can create a course website using free resources like Canvas, Google Classroom, Edmodo, etc.	3.86	1.07	-0.82	0.08
30	I can effectively use virtual labs in lectures	3.15	1.07	-0.09	-0.71
31	I can effectively use virtual labs in laboratory courses	3.19	1.08	-0.17	-0.68
32	I can implement interactive digital resources in my lectures to promote learning	3.75	1.03	-0.68	-0.17
	Collaborative Learning	3.82	0.95		
33	I understand the advantages of including collaborative activities in class	4.19	0.84	-1.27	2.23
34	I can plan effective collaborative activities for my courses	3.87	0.92	-0.79	0.58
35	I can effectively implement collaborative activities	3.88	0.93	-0.83	0.40
36	I can create instruments for evaluating individual performance in a collaborative activity	3.60	1.02	-0.52	-0.32
37	I can create instruments for evaluating group performance in a collaborative activity	3.70	0.95	-0.49	-0.23
38	I understand in what situations implementing a group activity is more effective than implementing an individual activity	3.71	1.07	-0.66	-0.26
	Effective Assessment	3.81	0.99		
39	I can design question papers for tests/exams	3.90	1.04	-0.96	0.56
40	I can design open-book assignments	3.92	1.04	-0.97	0.53
41	I can design open-book exams	3.73	1.09	-0.54	-0.52
42	I can design effective rubrics for class assignments	3.91	0.93	-0.75	0.33

43	I can design effective rubrics for class projects	3.84	0.97	-0.87	0.60
44	I can deal with plagiarism practices during assessments	3.75	0.91	-0.63	0.17
45	I can deal with individual fraudulent actions during assessments	3.76	0.94	-0.79	0.51
46	I can deal with unethical collaboration during assessments	3.68	0.96	-0.57	-0.02

Note. *N*=285, all items were rated on five-point scales

None of the items cross loaded; however, there were several items in total with factor loadings less than 0.4 in the survey instrument and such items which were removed [25]. Some of the items that were exclude are 'I understand my responsibilities as an engineering educator', 'I can identify the needs of my students', 'I can write desired student learning outcomes for my course', 'I can design a blended (hybrid) class', 'I can plan my office hour effectively', 'I can create instruments for evaluating group performance in a collaborative activity', 'I understand in what situations implementing a group activity is more effective than implementing an individual activity', etc. A total of six factors emerged from the EFA, however, the scale 'Harnessing the Power of Technology' did not make it to final factors and a new factor was suggested 'Ethical Practices'. The factor loadings of the final factor structure are shown in Table 4. The factor loadings for the first factor (F1) ranged from 0.56 to 0.8, second factor (F2) from 0.58 to 0.77, third factor (F3) from 0.54 to 0.84, fourth factor (F4) from 0.54 to 0.78, fifth factor (F5) from 0.42 to 0.81, and sixth factor (F6) from 0.71 to 0.99. The internal consistency reliability (Cronbach's α) for the six factors ranged from 0.77 to 0.86, indicating high reliability.

Table 4. Factor loadings of the survey item structure

#	**Items**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
The Teaching Learning Process (Cronbach's α = 0.83)							
4	I understand my role in keeping my students motivated	0.80					
5	I understand my role in keeping my students engaged	0.78					
6	I understand the importance of keeping my students motivated about the field of engineering	0.67					
7	I understand the importance of keeping my students engaged in class	0.78					
9	I understand the importance of inclusion in context of student diversity in the classroom	0.56					
Course Design and Delivery (Cronbach's α = 0.85)							
10	I can incorporate effective teaching practices into my lectures		0.76				
12	I can design courses that provide effective student learning experiences		0.58				
15	I can design an effective lecture to encourage active learning		0.77				
16	I can design courses that cater to students with diverse needs		0.65				
Creating a Dynamic Classroom (Cronbach's α = 0.79)							
18	I can implement active-learning activities in class			0.82			
19	I can design activities for generating intellectual excitement			0.56			
20	I can promote student engagement with me as the instructor			0.54			

21	I can promote student engagement via peer interactions			0.84			
Collaborative Learning (Cronbach's α = 0.77)							
34	I can plan effective collaborative activities for my courses				0.67		
35	I can effectively implement collaborative activities				0.78		
36	I can create instruments for evaluating individual performance in a collaborative activity				0.54		
Effective Assessment (Cronbach's α = 0.86)							
39	I can design question papers for tests/exams					0.80	
40	I can design open-book assignments					0.59	
41	I can design open-book exams					0.81	
42	I can design effective rubrics for class assignments					0.42	
43	I can design effective rubrics for class projects					0.43	
Ethical Practices (Cronbach's α = 0.83)							
44	I can deal with plagiarism practices during assessments						0.71
45	I can deal with individual fraudulent actions during assessments						0.99
46	I can deal with unethical collaboration during assessments						0.72

Note. F1=The Teaching Learning Process, F2=Course Design and Delivery, F3=Creating a Dynamic Classroom, F4=Collaborative Learning, F5=Effective Assessment, F6=Ethical Practices

Conclusions

In this paper, a survey instrument designed to measure engineering doctoral students' perceptions on their teaching preparedness is presented. The final six factors are the teaching-learning process, course design and delivery, creating a dynamic classroom, collaborative learning, effective assessment, and ethical practices. In the process of survey design and development, the research team followed the required steps including collecting evidence for content and face validity, factor analysis, and internal consistency reliability for all the six factors. The results from EFA supported the five hypothesized factors and a new factor was suggested (ethical practices). The factor loadings for the final factors ranged from 0.42 to 0.99, and the internal consistency reliability (Cronbach's α) for the six factors ranged from 0.77 to 0.86, indicating high reliability.

This study has several implications. Regardless of their field of study, doctorate students can use the survey instrument as a self-assessment tool to determine whether they are prepared to teach courses if they want to pursue a career in academia. Students will gain insight into their areas of strength and need for improvement as a teacher from the survey results. This survey instrument can also be used by programs and institutions to find out how their doctorate students feel about their readiness to teach. The survey's results can help programs and institutions make decisions about how best to prepare students who want to pursue careers in academia.

References

[1] J. F. Kelly Kang, "Research Doctorate recipients with definite postgraduation commitments, by major field of doctorate," NSF, https://ncses.nsf.gov/pubs/nsf24300/data-tables (accessed Feb. 2, 2024).

[2] I. Mena, H. Diefes-Dux, and B. Capobianco, “Doctoral students as course instructors: Three engineering teaching assistants’ socialization experiences,” *2011 ASEE Annual Conference & Exposition Proceedings*, 2011. doi:10.18260/1-2--17790

[3] C. J. Finelli and J. E. Froyd, “Improving Student Learning in Undergraduate Engineering Education by Improving Teaching and Assessment,” *Advances in Engineering Education*, 2019.

[4] R. R. Baiduc, R. A. Linsenmeier, and N. Ruggeri, “Mentored discussions of teaching: An introductory teaching development program for future STEM Faculty,” *Innovative Higher Education*, vol. 41, no. 3, pp. 237–254, Nov. 2015. doi:10.1007/s10755-015-9348-1

[5] N. T. Buswell, “The purpose of a Phd in engineering: Where does teaching fit in?,” *Studies in Engineering Education*, vol. 1, no. 1, p. 83, Jan. 2021. doi:10.21061/see.8

[6] R. M. Felder, “How students learn: Adapting teaching styles to learning styles,” *Proceedings Frontiers in Education Conference*, 1988. doi:10.1109/fie.1988.35029

[7] N. S. Raj and V. G. Renumol, “A systematic literature review on adaptive content recommenders in personalized learning environments from 2015 to 2020,” *Journal of Computers in Education*, vol. 9, no. 1, pp. 113–148, Aug. 2021. doi:10.1007/s40692-021-00199-4

[8] D. B. Hastie, M. Ros, B. Stappenbelt, and S. Kiridena, *Development and Implementation of a Flipped-Classroom Delivery in Engineering Computing and Analysis for First Year Engineering Students.* , 2015.

[9] M. Lundin, A. Bergviken Rensfeldt, T. Hillman, A. Lantz-Andersson, and L. Peterson, “Higher education dominance and Siloed Knowledge: A systematic review of flipped classroom research,” *International Journal of Educational Technology in Higher Education*, vol. 15, no. 1, May 2018. doi:10.1186/s41239-018-0101-6

[10] I. Gratchev, S. Howell, and S. Stegen, “Academics’ perception of final examinations in engineering education,” *Australasian Journal of Engineering Education*, pp. 1–10, Nov. 2023. doi:10.1080/22054952.2023.2284484

[11] D. Parsons, “Is there an alternative to exams? Examination stress in engineering courses.,” *International Journal of Engineering Education*, vol. 24, no. 6, pp. 1111–1118, 2008.

[12] A. L. Jones, S. N. Davis, and J. Price, “Preparing future faculty: A new approach at North Carolina State University,” *Teaching Sociology*, vol. 32, no. 3, pp. 264–275, Jul. 2004. doi:10.1177/0092055x0403200302

[13] M. R. Connolly, Y.-G. Lee, and J. N. Savoy, “The effects of doctoral teaching development on early-career STEM scholars’ college teaching self-efficacy,” *CBE—Life Sciences Education*, vol. 17, no. 1, Mar. 2018. doi:10.1187/cbe.17-02-0039

[14] H. Horta, “Phd students’ self-perception of skills and career plans while in doctoral programs: Are they associated?,” *Asia Pacific Education Review*, vol. 19, no. 2, pp. 211–228, Apr. 2018. doi:10.1007/s12564-018-9532-y

[15] J. S. Boman, “Graduate Student Teaching Development: evaluating the effectiveness of training in relation to graduate student characteristics,” *Canadian Journal of Higher Education*, vol. 43, no. 1, pp. 100–114, Apr. 2013. doi:10.47678/cjhe.v43i1.2072

[16] Garcia, O. J., & Kittur, J. (2024). Factors Influencing Engineering Doctoral Students' Perceptions on their Readiness to Teach Engineering Courses. In *2024 ASEE Annual Conference & Exposition*.

[17] Garcia, O. J., & Kittur, J. (2024). Engineering Doctoral Students’ Expectations, Reflections, and Concerns Regarding Future in Academia. In *2024 ASEE Annual Conference & Exposition*.

[18] D. Wiles, J. Smart, A. Morrison, L. Bennett, and S. Peters, “Online teaching motivation scale (OTMS): Development and validation of a survey instrument,” *Online Learning*, vol. 27, no. 4, Dec. 2023. doi:10.24059/olj.v27i4.4035

[19] A. Bandura, “Regulation of cognitive processes through perceived self-efficacy.,” *Developmental Psychology*, vol. 25, no. 5, pp. 729–735, 1989. doi:10.1037//0012-1649.25.5.729

[20] A. Bandura, W. H. Freeman, and R. Lightsey, “Self-efficacy: The exercise of Control,” *Journal of Cognitive Psychotherapy*, vol. 13, no. 2, pp. 158–166, Jan. 1999. doi:10.1891/0889-8391.13.2.158

[21] J. Kittur and V. Kumar, “Developing an instrument to measure the International Engineering Educator Certification Program Participants’ Learning Experiences,” *9th Research in Engineering Education Symposium (REES 2021) and 32nd Australasian Association for Engineering Education Conference (REES AAEE 2021)*, 2022. doi:10.52202/066488-0084

[22] H. J. Seltman, *Experimental Design and Analysis*.

[23] D. B. McCoach, R. K. Gable, and J. P. Madura, *Instrument development in the affective domain*, 2013. doi:10.1007/978-1-4614-7135-6

[24] Kittur, J. (2023). Conducting Quantitative Research Study: A Step-by-Step Process. *Journal of Engineering Education Transformations*, *36*(4), 100-112.

[25] M. A. Pett, N. R. Lackey, and J. J. Sullivan, *Making Sense of Factor Analysis: The Use of Factor Analysis for Instrument Development in Health Care Research*. Thousand Oaks: Sage, 2006.