Understanding how Novice Indian Faculty Engage in Engineering Education Research

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Abstract

Unlike engineering research, engineering education research (EER) in India has lacked popularity and acceptance. However, EER is gaining recognition globally, and specifically in India, faculty members housed in traditional engineering programs are starting to engage in EER. This study sought to understand how faculty members in India with a formal engineering background engage in the process of learning to and conducting EER. This qualitative research study involved four research participants from two different universities in India. Four interviews were conducted and analyzed to address the following research question, How do faculty members housed in traditional engineering programs build, interpret, apply and communicate new knowledge in engaging in engineering education research in India?, four interviews (~ 60 minutes each). The Boyer's Model of Scholarship was used as a theoretical framework to guide this research study.

The themes that emerged from this study were: motivations to pursue EER; processes followed in EER; professional development required for transition; factors influencing the conduction of EER; challenges in conducting EER; and suggestions for novice engineering education researchers. Faculty members were more oriented towards quantitative research, which could result from similarities between quantitative approaches and traditional engineering research. Additionally, despite their reliance on quantitative methods, faculty lacked prior training and/or experience designing survey instruments as well as validity and reliability tests. It was also found that a lack of understanding of the field influenced faculty members' resistance to engaging in EER. This work initiates identification of process intervention points that, if addressed, could serve to enhance the transition to engaging in EER for Indian faculty, and potentially other novice faculty, in general.

Introduction

Unlike engineering research, EER in India is not popular and is not accepted by many. Most Indian faculty members participate in EER related activities because they are asked to do so. EER is attracting the top officials (principals, deans, vice-chancellors, management officials) and hence few universities are now focusing on EER in India. These top officials see value in EER, however there is a need to convince faculty members in engineering institutions about its importance and build a strong community of engineering education researchers in India.

Javeed's (the first author) association with engineering research communities in India and engagement in the private body Indo-Universal Collaboration for Engineering Education (IUCEE) [1] has exposed him to the current state of engineering education in India. Also, this association has made him anecdotally aware that very few faculty members seem genuinely interested in EER and the ones who are interested are unsure of how to proceed. There could be many reasons for this issue, such as lack of awareness of EER, inability to see value in EER, lack of formal training opportunities on EER, focus on core technical research, unavailability of an expert in EER for

guidance, being uninformed about the need of EER, being unclear about the process to be followed in EER [2].

There are a limited number of doctoral programs focusing on EER in India. Also, there is a dearth of experts in EER with the relevant or associated degree. Hence, faculty members must heavily rely on the literature for most of the difficulties they would encounter in EER. Most universities rely on global experts in engineering education mostly from United States because of their rich background in the field and expertise. A few Indian universities have EER faculty from US universities on their board as academic members for guidance and support; however, their scope is mostly limited to recommendations in the curriculum and overall planning with minor focus on research activities. The accessibility of these experts for all the faculty members is limited. To overcome these issues, IUCEE was established with a vision to improve the quality and global relevance of engineering education in India [1].

Research performance is a significant factor that is commonly used in comparing universities. The concept of research performance is defined in two parts: one is research (all faculty are expected to engage in research) and the other is performance (which is evaluated based on the quality of the published work) The different parameters considered under research component are research skills and techniques, research funding, research management, communication, networking and teamwork. There are different parameters used to measure research performance and the most important ones are number of articles published in journals, impact factor of the journals, research funding and grants, number of citations, and number of books published [3]. The factors that affect research productivity are characteristics of the researchers, competencies in research, and support from the institution [4]. Faculty research output is dependent upon different parameters such as gender, race/ethnicity and marital/parental status [5]. Collaboration and working in teams are also shown to be a positive influencer for research productivity. The type of institution (private or public) also influences the research performance of the faculty [6].

In a study conducted in Hong Kong, factors that influenced research performance were found to be demographics, workload, research style and institutional characteristics [7]. This study measured research performance across individuals and academic disciplines from different institutions. The findings from this article conveyed that research productivity varies and depends on the four factors mentioned above. It was also found that there exist differences in research productivity across disciplines and institutions with respect to the four parameters. This was a quantitative study that relied heavily on self-reported data by faculty members from different disciplines and institutions. Hence, in this paper, we conducted a qualitative study that will deepen our understanding of the experiences of faculty members as they are pressured by their institutions to increase research performance.

Most of the research available on this topic essentially discusses how to measure the research productivity or the research performance of faculty in the core technical research area. The process of engagement of faculty members in research and specifically EER is glaringly missing. Hence an effort would be made in this study to address this gap by understanding the process that novice engineering education researchers follow.

The purpose of this qualitative study was to understand the process followed by the faculty members in engineering programs in engaging themselves in EER in India. This study also aimed at identifying promising practices to successfully transition Indian faculty into EER to guide the novice engineering education researchers in India. The proposed research question in this study is: How do faculty members housed in traditional engineering programs build, interpret, and apply new knowledge while engaging in EER in India?

Research Design

Theoretical Framework

The Boyer's Model of Scholarship [8] was used as a theoretical framework to guide this research study as a structural model aligning with modes of scholarship with faculty members' engagement in EER. Boyer defines four types of scholarships; discovery, integration, application and teaching. The purpose of each of these scholarships and the associated measures of performance are shown below in Table 2 (this is directly taken from [8-9]). Referring to Table 1, it would be interesting to use the parameters from 'measures of performance' column as a measure to know what is the aim of the research that the faculty members are involved in. Knowing these measures, would be helpful in determining which type of scholarship is being associated with the research process.

Table 1. Boyer's model of scholarship [8-9]

Type of Scholarship	Purpose	Measures of Performance
Discovery	Build new knowledge through traditional research	- Publishing in peer-reviewed forums - Producing and/or performing creative work within established field - Creating infrastructure for future studies
Integration	Interpret the use of knowledge across disciplines	- Preparing a comprehensive literature review - Writing a textbook for use in multiple disciplines - Collaborating with colleagues to design and deliver a course
Application	Aid society and professions in addressing problems	- Serving industry or government as an external consultant - Assuming leadership roles in professional organizations - Advising student leaders, thereby fostering their professional growth
Teaching	Study teaching models and practices to achieve optimal learning	- Advancing learning theory through classroom research - Developing and testing instructional materials - Mentoring graduate students - Designing and implementing a program level assessment system

Site and Participant Selection

This study involved research participants from two universities in India where EER is given equal importance as engineering research. The participants who agreed to be a part of this study were formally recruited into the study and provided consent over email. This study was approved by the Institutional Review Board.

Javeed, the first author, recruited participants at these two universities by sending them an email describing the study and inviting them to participate if interested. Purposeful sampling was used to achieve maximum variability across their engagement in EER, their teaching experience, and their gender [10]. The participant demographics with pseudonyms are shown in Table 2.

Table 2. Demographic information of the participants

Category	P1	P2	P3	P4
Gender	Female	Female	Male	Female
Pseudonym	Iqra	Aisha	Emaaz	Seemen
Qualification Level	Pursuing PhD (Engineering)	Pursuing PhD (Engg. Education)	PhD	PhD
Teaching Experience (in years)	18	09	28	24
Industry Experience (in years)	01	02	00	06
Number of journal papers published related to EER	05	03	05	06
Number of conference papers published related to EER	20	04	22	04
Number of years of engagement in EER activities	4	3	6	10

Note. P1=Participant 1, P2=Participant 2, P3=Participant 3, and P4=Participant 4

Data Collection, Coding and Data Reduction

Four interviews (~ 60 minutes each) were conducted in English and transcribed to answer the research question 'How do faculty members housed in traditional engineering programs build, interpret, apply and communicate new knowledge in engaging in engineering education research in India?.' Narrative interviews were employed to prompt participants to elaborate on their novice experience as engineering education researchers [11]. Then, in a conversational phase, semi-structured questions were administered as a way of ensuring the desired information was addressed.

The interviews were conducted via Zoom and all the transcripts were read in detail to ensure that no information goes missing. The data collected was essentially focused on how faculty members engage in the process they follow in conducting EER. The data also provided additional information in terms of different factors that influence the process of these faculty members engaging in EER. The first author coded the interview responses and the details associated with the coding process are described further.

Brief information about the coding cycles and coding methods used in this study are presented in Table 3 and details are discussed subsequently. In the first cycle coding, open coding methods were used for the first iteration and then for the second iteration in vivo coding was used as it drew from participants own words for codes. Open coding involves labeling and defining codes, categories, and concepts based on the data [12]. During the first iteration of the first cycle coding, the data was manually coded, and splitter coding was followed, 126 codes were generated which directly and indirectly relate to the research questions of this study [13]. Examples of the open coding that was used are 'in-house training,' 'frameworks help guide the research,' and 'moving to active learning practices.' In vivo coding was selected as the research questions of this study specifically deal with the participants stories and experiences and it is helpful to use the participants own language to retain the voices of the participants [13]. Revisiting the codes generated during the first iteration of first cycle coding, some of the codes were renamed or rephrased, redundant codes were removed, a few codes were merged. After this activity the total number of codes were reduced to 30 parent codes and each code associated with few child codes. A few examples from the new and revised codes are 'exposure to tools and techniques,' 'mentoring in EER' and 'developing skills through peer collaboration.'

Table 3. Coding cycles and methods used in this study

#	Coding cycle	Coding methods
1	First cycle coding	
	- First iteration	Open coding
	- Second iteration	In vivo coding (only)
2	After first cycle coding	Code mapping technique
3	Second cycle coding	Pattern coding

Detailed analytic memos were written for the four interview transcripts using the codes generated from first cycle coding to document and reflect on the code choices, and to know more about the emergent categories and subcategories in the data. In transition from the first cycle coding to the second cycle, only in vivo coding was used to recode and reanalyze the data as this coding process relies heavily on the participants own language for codes [13]. The emergent categories and subcategories from the analytic memos were used in the after-cycle coding method to categorize the data.

In after first cycle coding, the code mapping technique was used and the details of the same are shown in Table 4. Code mapping is a technique that helps in assembling and organizing the codes generated from the first cycle coding process [13]. Following this technique, the first step was the 'List of codes' and few like codes were merged to form a single code. The total number of codes were reduced to 26 parent codes with child codes associated with parent codes. An example of merging the like codes, 'scan through the data,' 'data cleaning,' and 'data manipulation' were merged and defined as 'data-processing.' The next step in code mapping technique was 'Initial categorization of codes' and in this study the initial 26 parent codes (and the associated child codes) were categorized into ten categories with the related codes for each category. The ten categories emerged by merely comparing and sorting the codes. The ten categories were 'General Research Process,' 'Literature Review, 'Research Questions,' 'Qualitative Research,' 'Quantitative Research,' 'Required Skills,' 'Training Requirement,' 'Factors Influencing EER,' 'Challenges in EER' and 'Suggestions for novice EERers.' One example for the initial categories; 'Research Questions' with related codes 'help dig deeper in literature,' 'decide methodology,' 'research framework,' and 'help connect results to the study.' Another example of an initial category; 'Training Requirement' with related codes 'how to conduct EER,' 'human subjects research,' 'identification of areas of research,' 'good quality research,' 'frameworks,' 'data collection,' and 'data analysis.'

Further brainstorming on these categories and linking these categories to the research questions of the study, six major categories were developed. This was the next step in the code mapping technique, the ten initial categories were recategorized into six major categories, Category 1: Research Process, with associated subcategories General Research Process, Literature Review and Research Questions, Category 2: Research Methods with associated subcategories Quantitative Research and Qualitative Research, Category 3: Requirement: Qualities and Trainings with associated subcategories Required skills and Training requirement, Category 4: Factors influencing EER with no subcategories, Category 5: Challenges in EER with no subcategories and Category 6: Suggestions for novice EERers with no subcategories. These six major categories directly link to the research questions in terms of the how research participants' build, interpret, apply and communicate knowledge required to engage in conducting EER. These six categories were influenced by the participants' experiences in the past, and the associated stories and

aspirations. Analytic memos were written for these categories to document and reflect on these categories in detail.

Table 4. Details about the code mapping technique used in after first cycle coding

Step	Name	Details	Examples
1	List of codes	26 parent codes with few child codes	Data-processing, Publishing research, Professional development
2	Initial categorization	10 categories	General Research Process, Literature Review, Research Questions, Qualitative Research, Quantitative Research, Required Skills, Training Requirement, Factors Influencing EER, Challenges in EER, Suggestions for novice EERers
3	Re-categorizing initial categories	6 categories	Research Process General Research Process Literature Review and Research Questions Research Methods Quantitative Research Qualitative Research Requirement: Qualities and Trainings Required skills Training requirement Factors influencing EER Challenges in EER Suggestions for novice EERers

The second cycle coding analysis starts with an aim of not just transforming the data but surpassing the data to find additional insights. Pattern coding helps in finding the relationship between different categories and subcategories from the data [13]. To start with, the passages that are similarly coded are collected and the codes associated with these passages are assessed for the commonality and a pattern code is assigned. The six themes defined are Theme 1: Motivations to pursue EER, Theme 2: Experiences in building comfort with EER process, Theme 3: Professional development required for transition, Theme 4: Factors influencing the conduction of EER, Theme 5: Challenges in conducting EER and Theme 6: Suggestions for novice engineering education researchers.

Validity

Having worked in India, the first author was concerned about being biased about the Indian faculty not following the appropriate process in EER. From his interaction with Indian faculty members at conferences focused on EER, he found that they are not conversant with the best practices in EER and the work they present at these conferences falls in the category of scholarship of teaching and learning. This experience could strongly bias his conclusions [14]. The second threat that he

saw in this study was that, the three participants (out of four) that qualified for the interview as per the selection criteria were the ones whom he has known for quite some time. He believes that his association with these participants in the past has led him build a perception on each of these three participants and was afraid that this perception can bring some bias in his analysis to a certain extent [14]. To deal with these threats, the authors collected 'rich data' [15], through intensive interviews which reveals the big picture with enough variation.

Findings

The six themes that emerged from the interview data are described in detail in this section.

A. Theme 1: Motivations to pursue EER

From the interview data it was confirmed that EER was a new and upcoming field in India. As EER is different in comparison with engineering research in several aspects, it is interesting to know what motivates the participants to pursue EER, what steps are involved in initiating EER related activities and what approaches in EER were followed by the Indian faculty members. However, the overall process for both EER and engineering research was perceived as being the same. The motivation of the faculty members to conduct EER revolved around helping students learn better. Below a faculty member shared her experience and what motivated her to conduct EER:

"In order to deliver any content in a better way, the research is one of the experiences which makes us clear about the concepts and the process" [Iqra]. Iqra was motivated to conduct research to help her become a stronger teacher. Other motivation to conduct EER was the lack of evidence of best practices specifically contextualized to Indian universities. For example, Aisha explained,

> …… but the one that is very significant to me is that informing practice, because all of us work on a hunch that this education intervention may work, or this classroom activity may add value to students' learning, but we don't have evidence based on practices in the context of my institute [Aisha].

'What are the factors that possibly affect my students' learning?' is a question that every faculty thinks about. This was the other reason that attracted the faculty members towards EER, an example;

> A broad question asked, what could be the technical and non-technical and related aspects affecting teaching process and learning process. Teaching by the teachers, and learning by the students could be affecting the learning which is taking place in the class. Essentially that broad question drove me towards engineering education research [Seemen].

Another reason that motivated the faculty members to conduct EER was because they were expected to conduct research and because they intrinsically enjoyed doing research. For example, Emaaz explains these intrinsic and extrinsic motivations to conduct EER:

> To me, one is it is a professional requirement. Second is, I enjoy it, especially engineering education research. It is so relevant to what I'm practicing. So I'm really happy and I'm enjoying doing it. So these two are the motivations for me to do this…Actually whatever research we do and the learnings from the research, we bring it into practice and the practice

> shows visible results, impact and you'll observe it. And you are able to measure the success and you obviously feel happy. One of the example that I can take is moving to active learning practices [Emaaz].

B. Theme 2: Experiences in building comfort with EER process

With the reasons mentioned in the previous theme as motivations of faculty to conduct EER, the next important part was to know the process these faculty members follow in conducting EER. The process followed by four faculty members was similar, below are examples from two different faculty members:

> A typical research lifecycle starting from the problem, doing literature review and then coming out with specific research questions, going into those qualitative and quantitative ... designing the research methodology, implementing it, and then collecting the data, doing the measurement, doing the analysis and publishing it [Emaaz].

> So, eventually, after that, most of the articles began with formulating the research question, and then collecting data. The research question identify your appropriate research framework, and then implement the research, and then go ahead the analysis of results, and then the usual process of research we followed, all the six steps [Aisha].

From the interview data it was found that there was no set process for a research study to get approval from the institution. The participants explained that anyone interested in conducting an EER related activity could just start by themselves without any prior approval. However, once the faculty decided to start an EER project, they followed steps that are typically taken in conducting research. The first step in conducting EER was problem identification followed by formulating research questions. The faculty said that research questions helped them dig in deeper and took them in the right direction in the literature. They decided on the methodology and framework using the research questions. They also used the research questions to help them connect the results back to the study. One of the faculty members explained that research questions are the heart of an EER related study,

> A study without research questions will be like a blind man walking without a stick, and mostly you would fumble… When I was in my first year of my coursework on PhD, I realized that all subsequent phases of research are dependent on your research question because once you have a research question, you know what to find. You know the keywords in your research question, you can find appropriate articles related to your study, literature reviews [Aisha].

Considering the scope of the research questions, the details from the existing body of knowledge were accordingly referred. The faculty members believed that literature review helped them in following ways: created awareness of the area of research to the researcher, established relevance of the research work by identifying the gap in literature, built vocabulary and knowledge in the domain of research, and understood how others approached the problem. The faculty are of the opinion that the literature review was helpful in all the phases of research and was a continuous process. Below are a few quotes from participants where they explain their perspective of the literature review:

> There are three things that I expect [from lit. review]. One is the awareness that it brings to the area and then that is my first one. Secondly, identification of gaps. Lastly, what happens is when I'm writing a research article, I need to be writing it or rather than discussing it in the vocabulary of that domain. So, without reading at least 15 to 20 articles in that area, I will be unable to articulate my thoughts using the vocabulary that is appropriate in that area [Aisha].

> There could be somebody elsewhere faced this problem. And then what do they say? Isn't it better to know what others have said? Those who have encountered same problem or similar problems. How have they attempted to find solution to these problems? That helps me when I do literature review [Emaaz].

There was also a focus on theoretical frameworks that emerged in the analysis. One faculty said that identification of appropriate framework was essential as it guides the entire research study. She further added that frameworks help the researchers by fixing a path and a boundary keeping the focus of research intact and the framework was essential to get into the right directions of addressing the research questions. An example:

> Framework essentially gives overarching guidelines for whatever you want to do. Validation at the very beginning, I think, is extremely important because it goes as the same story, “if you want to cut a tree and if you have 10 minutes, nine minutes or up to eight minutes you should sharp the knife, and then two minutes you should just need to cut the tree”. So, this is what is ... I think it's equally valid in research also, that you have to, must have a robust framework of your research [Seemen].

The process that faculty engaged in was different when they discussed quantitative and qualitative research. The four research participants in this study identified themselves as mixed methods engineering education researchers however, they have more work published related to quantitative methods than qualitative methods.

When faculty engaged in quantitative research, they selected participants from their respective classes. The faculty did not have strategies to select samples from a large population. For example, Seemen explained,

> I don't have the liberty to select them, because of granularity of students in this division, which has 60 to 70 students. Collecting them randomly on different ... Again, some criteria, I would not be able to do it because since I couldn't administer intervention to an entire division, which comes to me, I cannot randomly select my students. I'm unable to in my context so far [Seemen]

The faculty members did not have experience in designing surveys, thus they used existing surveys available in the literature and assumed that using these existing surveys did not require validity and reliability tests. They also did not have experience in establishing face and content validity of items in survey instruments. For example, Aisha and Seemen explained,

> I don't have any prior experience in survey design. No, I haven't. I do consult ... There was this article I wrote startup internship experience. Thankfully what I generally do is just to avoid the questions of validity and reliability of a survey instrument. I can really end up

> using survey instruments which have already been published in research in previous article [Aisha].
>
> But usually I look at the literature to find any similar kind of instruments already available. And if there is enough evidence of them being already validated, then I would like to do that [Seemen]

Pilot tests on the survey instruments were rarely conducted and the consent from the participants was received orally or, in some cases, was written. This may be due to many Indian universities not having Institutional Review Boards, which are required in many countries. For example, Emaaz explained,

> We do design a survey, we refer to literature and then based on our experience with design a survey. But I must tell you that we don't have a formal commitment being taken about the ethical conduct of this that which are normally there in western systems. Such a thing is not strictly followed. We tell them orally about the participation [Emaaz].

After collecting the data from the survey, the first step the faculty followed was to scan through the data, perform data cleaning and manipulation operations. Then, once the data was ready the statistical analysis was done, the outputs of the tests were analyzed, and findings were documented. The faculty also said that statistical tests were decided on during early stages of research prior to data being collected. For example, Aisha explained,

> The first thing I do is I clean up the data and then find whether I have my required sample size. That's important for me. That's the first thing. After it's done, I kind of look at the first 10% of the responses to see if there's any bias and then I go ahead and I look at my research question. I see what was that I was looking for and based on the research question, I kind of do descriptive statistics and initial process. With comparison, I do a T[t]-test [Aisha].

The process that participants described was different in qualitative research projects. In this study, it was found that the one of faculty members manually transcribed audio recordings, conducted pilot interviews and followed a similar protocol for both interviews and focus groups. Aisha explained,

> I do a pilot for qualitative. I still do it for two or three participants in a qualitative to check which direction I'm going because the questions could be ... What do you call it? Could be a structured or unstructured interview. If the structured is I had to administer it to at least one or two students to understand where I'm leading [Aisha].

Out of four participants, only two have conducted interviews for a research study and one faculty explained that framing appropriate interview questions was an extremely crucial task. This participant felt that poor interview questions would result in poor data that may not help answer the research questions. For example, Seemen explained,

> Yes, preparing the questions for qualitative analysis is extremely important. Questions should be unambiguous enough ... they should be asking what they are meant for asking. So, if you want to ask a person where does he want to go, we must not ask only this question, “Where do you want to go?” We must ask a quest[ion] like, "Where do you want [to] go [at]

> 9 AM in this morning with 50% fuel in your car and with your two kids at the back?" [Seemen]

The research participants had limited exposure to types of coding techniques and limited exposure to approaches to analyze the qualitative data in a research study. For example, Aisha explained,

> No. It's all about reading and re-reading the data. As a researcher for qualitative analysis, tells us it's having a couple of ... Sort of our prejudice is if I start looking at data with prejudice is that having already identified set of keywords, you kind of lost half of your participants' inputs. Just to avoid that, I totally disengage myself from what I feel about this. I just go ahead and read and re-read data. That's when the words emerge [Aisha].

One participant believed that the phases of quantitative and qualitative research studies are the same with differences appearing in data collection and analysis. For example, Aisha explained,

> I have some articles which are mixed methods now and principally they are different because the research process is the same. It's the same steps. The phase of research are the same. What deviates there is only the data collection section and the analysis section and discussion section, but the phases of research are the same, they don't change. It doesn't matter what method you're following, but eventually during your analysis phase, it matters [Aisha]

C. Theme 3: Professional development required for transition

Considering the increasing acceptance of EER in India, it's awareness and newness, the faculty members required some sort of professional development so that their transition from conducting engineering research to EER is smooth, meaningful and eventually they become successful engineering education researchers.

As per the research participants of this study, there are different qualities required to be a successful engineering education researcher and they were:

- understanding the problem in EER is the most important quality needed,
- accessing the relevant research papers to conduct a thorough literature review,
- selection of appropriate framework and the research design,
- conducting interviews and focus group discussions to collect rich and meaningful data,
- awareness and ability in using the different tools and techniques needed in research,
- rigorous research experience,
- willingness to self-learn,
- involving oneself in ongoing EER related projects,
- ability to effectively function as an individual and in a team through relevant collaborations with peers.

In explaining the importance of understanding the current literature in the field, Emaaz explained,

> To me what is absolutely essential is the ability to understand that the problems of the field is fast [first] requirement. And the second requirement is a rigorous research experience [Emaaz].

In addition to understanding literature, Aisha explained the importance of understanding theoretical frameworks,

> We need to be aware of the various research papers that are available to us in the science space, first one. That is primarily the distinction between what I was then and what I am now, aware of various research frameworks [Aisha].

In addition to understanding the way of conducting research, Iqra discussed the importance of the researcher being motivated and gaining confidence in themselves as engineering education researchers,

> First, we should have a proper motivation. Unless we have a motivation towards learning, anything else, whatever we have may not help us. First is a motivation. Then, confidence, and a hold on the main knowledge, and a clarity on what presently the processes and the frameworks and the techniques are available [Iqra].

The participants also believed that novice engineering education researchers need trainings on different aspects to stay focused in EER and to produce good quality work. The different trainings required for novice researchers identified by the research participants included:

- exposure to human subjects' research and specifically how to conduct EER,
- identification of areas of research in EER
- how to produce good quality work in EER,
- trainings on identifying, relevance and using a framework in the research study,
- data collection in quantitative and qualitative studies, and
- data analysis

For example, Emaaz discussed the importance of teaching faculty to be engineering education researchers,

> Definitely yes. In my opinion there is no choice. If one wants to do good quality research in engineering education, I think that training is very much essential because there is a difference between engineering research and engineering education research. We need to understand that. It requires training [Emaaz].

There seemed to be agreement that there was a new skillset that needed to be learned when transitioning from engineering research to EER. For example, Aisha explained some of the differences due to EER involving people.

> Mostly, it is about the areas of EER, because there is a need to know what engineering education research is all about. That's the first thing. I think that's the first part. Eventually, the paradigm shift in our research when it comes to EER, human subjects research, that is the other one. The areas of ... The EER areas and the human subjects research. [Aisha]

D. Theme 4: Factors influencing conducting EER

The participants believed that there are different factors that positively influence conducting EER and they were treating EER as important as engineering research in all possible dimensions, including, for example, peer support, value addition to EER locally and nationally, motivation towards EER, institution culture, teaching and industry experience, qualification of researchers, growing interest in EER, and stakeholder's excitement about EER. For example, Seemen explained that she believes that engineering education research is considered as equivalent to engineering research at her university.

> In our university, yes, engineering education research would be kept in the same bucket, or will be given the same weightage as any other core engineering research [Seemen].

Seemen also described the importance of teaching and industry experience for new or future engineering education researchers. Here she explained that engineers focus on social problems, thus engineers are well-equipped to become engineering education researchers.

> Because definitely experiences helps, whether it is an industry, because we are talking about engineering education, right? And engineering is about solving industry and social problems. So any experience within the industry or teaching experience or working with international community or working with social community, it does help. It does help [Seemen].

The participants also reported several factors that negatively influenced conducting EER. For example, some participants explained peers that considered minor pedagogical innovations without any data collection as EER and thus devalued EER. For example, Iqra explained,

> The design of activities will be excellent to carry out the many things, but they will not go with any collecting of data or anything. That is where the gap exists, I think [Iqra].

Moreover, Aisha used Boyer's model of scholarship to describe the type of scholarship that their peers are engaging in. They explained that scholarship of teaching and learning and scholarly teaching has been ongoing in their university for years and has involved many faculty

> We are 230 I think in the campus, but it is two years old in EER and it's called Engineering Education Research, but scholarship of teaching and learning, we have hundreds of faculty members involved. ….. what I observe is most of our faculty members are in either scholarly teaching or a scholarship of teaching and learning [Aisha].

Some faculty also pointed to a need for faculty to learn research techniques that are specific to EER, which include conducting ethical research, designing educational research studies, and collecting and analyzing data. For example, Iqra explained,

> According to my knowledge, instruments, tools, techniques, we are not clear about in engineering education [Iqra].

E. Theme 5: Challenges in conducting EER

There are different challenges that engineering education researchers face and this section highlights some of the challenges faced by the participants in this study. One of the major challenges identified was that EER is relatively new in India and very few people are actively involved in conducting EER. For example, Iqra explained,

> Rough number, 50 plus faculties are involved. To be frank, few are involved in a proper way. The others are, as I said, without any proper guidance started working on engineering education. But very few have started with the proper way [Iqra].

Iqra further elaborated that the "proper way" refers to … The other hurdles were access to resources such as conference and journal papers was easy, but the access is limited only to a certain conference and journal papers. For example, Iqra explained,

> The materials and resources. As I mentioned, some resources are not there. All the resources, if they're available to us, the right time, which will definitely help us to go further in this [Iqra].

In addition, the faculty members considered the lack of experts in EER and finding local mentors in EER as a challenging task and this eventually slowed down their progress of becoming engineering education researchers.

> We do have an access to these [journal articles], because institution has subscription to most articles or most journals and we also have access to JEE, EJEE is provided through ABC parent university, so we have access to all this, but when it comes to intellectual human capital in EER, it's scarce. ……. the printed intellectual resources, yes it's available, but human intellectual resource, no [Aisha].

Another major challenge was getting funds for EER related projects. Participants explained that EER is a relatively new field and it is difficult to secure funding for these projects. Emaaz elaborated,

> But when it comes to external funding for education research, there are few agencies or opportunities for us to get funding, get connected to the network of engineering education research… such as ... that is a real challenge. This is one thing [Emaaz].

Hiring professors with EER background was a challenge and hence most Indian universities collaborate with international universities in conducting EER however these collaborations are not very fruitful considering the accessibility of the international experts is limited. Emaaz explained this,

> career progression when I refer to in my institution how many people can my institution afford to have in engineering education research? Is a question of ... is a point of concern. How many people can we afford to have as professors with engineering education research as their expertise. That is a challenge [Emaaz].

Building the engineering education researchers community was also a challenge. An indicator of this is that there are very few conferences and journals related to EER in India. Emaaz further elaborated,

> But engineering education research ecosystems are less here in India. So, within an institution having it requires a lot of effort. That's my personal experience and national level also we need such engineering education research ecosystems where people get connected to the happenings, they become part of that community [Emaaz].

F. Theme 6: Suggestions for novice Engineering Education Researchers

The four research participants proposed some suggestions for the novice Indian engineering education researchers. Below is a bulleted list of their suggestions, with each suggestion followed by a participant quote elaborating on that advice:

- thoroughly understand the field of EER and get connected with it.

"Engineering education researchers should be ... first of all, they should feel need for it. They should not do engineering education research just for the sake of it, first of that. First of all, you should be sure enough that you want to do this. Because unless you are sure enough of why and how and for what purpose you want to do this EER, it doesn't make sense to conduct any of this kind of EER. So there should be valid questions in your mind. There should be reason enough for you to design experiment on EER" [Seemen].

- Identify relevant research problems and appropriate frameworks as these things help get the work reachable to a broader audience. Ensure data collection is consistent across samples and use appropriate tools for data analysis.

"With that, even though our activities are excellent, we are not having relevant data too. That's where the process slides some, choosing a framework to the conducting an activity, and collecting the data, and then performing a statistical analysis using your relevant techniques and tools, it's very relevant" [Iqra].

- Do not work in isolation, find engineering education researchers and collaborate. An example:

"I would say team up with somebody who knows EER. It's much easier than you try to do it all by yourself. Team up with somebody who knows EER, first thing. Get some contacts in social sciences space. Very important" [Aisha].

- Attend as many workshops and conferences related to EER as this helps in creating awareness and exposure to the trending research areas in EER, provides an opportunity for networking and possible collaborations for research. An example:

"Yes, definitely it helps them. It is necessary but it is not sufficient. They have to be part of ... because conferences act as platforms for networking. You get connected to fellow researchers. I do recommend these things" [Emaaz].

Discussion

The purpose of this study was to understand how the faculty members get engaged in process of conducting EER in India. EER is globally gaining an increasing recognition and acceptance, and this is evident by the increasing number of publications every year [16]. Specifically, in India, there is a high volume of research papers submitted by faculty members to journals (particularly the *Journal of Engineering Education Transformations* based in India) (www.journaleet.org). This shows growth in the Indian EER community however some Indian faculty may not understand that EER is different from engineering research and requires different research skillsets [2][17].

The factors that motivated the research participants towards EER were constantly in search of answers to problems that they encounter in classroom, enhancing students' learning, designing pedagogical interventions in classroom and measuring its impact, and professional requirement. This finding is in line with that reported by Borrego [2] that one of the major reasons that faculty members involve themselves in EER is through classroom-based research. Brodie, et. al, [18] in a study aiming at developing the culture of EER found that the motivations to take up EER were belief in, and commitment to good teaching, improved student evaluations, desire to understand

how students learn or why students fail to learn, etc. Referring to the Boyer's model of scholarship, this aligns with the 'Teaching' type of scholarship as faculty members consider the pedagogical interventions, instructional and assessment methods in conducting EER related work.

The approaches in EER are quantitative methods, qualitative methods and mixed methods [19]. The overall process involved in conducting engineering research or EER is similar and involves the following phases: identification of problem, formulating research questions, literature review, framework and methodology selection, implementation, data collection and analysis, and documenting the findings. As the research process of EER and engineering research is similar, most faculty members tend to involve themselves in conducting quantitative EER as there is some sort of similarity and familiarity in terms of statistical tools and analysis [19].

Borrego, et. al, [19] says 'Quantitative methods are a good fit for deductive approaches, in which a theory or hypothesis justifies the variables, the purpose statement, and the direction of the narrowly defined research questions.' In such studies data is collected by administering surveys to a sample of the population and the results obtained from this sample can be generalized to a larger population [19]. Even though faculty members prefer to conduct quantitative studies, in this study it was found that the participants did not feel that they had required expertise in designing survey instruments. In addition, there was there was no process in place through their universities to gain consent from the participants. The research projects in which these participants have been involved has students (approx. 70) in their class as the population for the study. The participants mostly rely on the existing survey instruments in the literature to avoid the face and content validity tests. This implies that faculty involved in conducting EER in India (specifically the research participants) were aware of the important steps in the quantitative research process (mostly through literature review) but they do not have these skills and hence they avoid these steps in the research process. This finding needs attention as the quality of the work produced by these researchers will have evident loopholes as they avoid the important steps in the process. This finding is similar to the finding reported by Brodie et al. [18] that most researchers choose existing survey instruments to avoid the different tests to be conducted on the survey instrument before administering the survey.

Qualitative research studies deal with collecting and analyzing data through interviews, observations, and focus groups. Qualitative research is used to find why something happens in a way or how a certain aspect affects another [19]. The research participants have limited experience in conducting only focus groups and by far they have not had a study that involved interviews or observational data. The participants were not aware of the different coding techniques and ways of analyzing qualitative data.

To be a successful engineering education researcher, researchers must possess different qualities like understanding and appreciating the problems in the field of EER, selecting appropriate framework and research design for a study, rigorous research experience and providing meaningful contributions through collaborations [20]. As EER is different from engineering research, the faculty members housed in traditional engineering programs find it difficult to understand and self-learn the different educational research methods [2]. Hence, there is a need to train novice engineering education researchers on different aspects to conduct EER successfully. The different trainings that should be given to novice engineering education researchers are how to conduct ethical research on human subjects, awareness of different areas of research in EER, need for an

appropriate framework, data collection and analysis, tools available for research and how to use them, and the taxonomy in EER, and similar findings are reported in existing literature [2][18][20][21]. The research participants were building new knowledge required to conduct EER by exploring the literature, attending workshops and conferences and this finding aligns with the 'Discovery' type of scholarship of Boyer's model. These research participants have applied this built knowledge in addressing research problems which needed attention based on their teaching experience. This finding aligns with the 'Application' type of scholarship of Boyer's model.

Different factors that influence conduction of EER are, treating EER in par with engineering research, especially recognition and career progression for faculty members in EER should be considered as for those involved in engineering research [18]. From this study, it was found that faculty members show resistance in being a part of the EER community because of the following reasons: limited understanding/awareness about the overall process and details involved in conducting EER, considering EER to be similar to implementing a small activity (active learning) in class and documenting it, and EER not being recognized by the national body as engineering research. Local and national recognition of EER through policies can help attract more researchers in EER as many faculty members show resistance in involving themselves in EER [16]. The support provided by the institution is the other driving force for researchers to involve themselves in EER [18]. All four participants have worked in industry in the past and currently are working as full-time faculty members in engineering institutions. Out of the four research participants, first and second participant were pursuing a PhD in engineering and engineering education in India, and the third and fourth participant have a PhD in engineering and engineering education. As most engineering education researchers are faculty members teaching at different class standings, having relevant experience and passion in teaching plays a significant role in conducting EER [2]. The research participants say their industry experience and qualification influences their approach in conducting EER. Research through collaborations helps in learning through peers and adds significant value to the research study as each researcher comes with a different perspective [2]. This part of the finding aligns with the 'Integration' type of scholarship from Boyer's model as the participants are using the experiences and skills and integrating them in conducting EER. Availability of mentors with related experience in EER can help speed up the research process [18] however, there was lack of availability of local mentors in EER in Indian institutions and hence they depend on international experts through collaborations.

There were different challenges that these research participants face when conducting EER and they were the following: lack of tools required to conduct statistical analysis and tools to analyze qualitative data, working in isolation as very few faculty members are actively involved in EER as they do not see EER as a career pathway [16][18], lack of funding sources for EER related projects and activities [18], and few conferences and journals focused on EER in India. These challenges need urgent attention of the policy and decision makers in India because if these challenges are not addressed there is a possibility that EER in India will have no future. To begin, cues can be taken from the suggestions given by the research participants of this study as strategies to address these challenges. The research participants have provided suggestions for novice researchers in EER and they are the following: get connected with EER, use appropriate frameworks, use suitable data collection techniques and tools to analyze data, collaborate with other researchers and attend conferences related to EER. Few of the points mentioned above such as suggestions on frameworks, tools, collaboration and data analysis are presented in the literature [2][18][22].

Conclusion and Implications

This study was conducted with the aim of understanding the process followed by faculty members in building, applying, interpreting, and communicating knowledge required in conducting EER. There is a clear distinction in the details in process followed by these four research participants and the distinction is because of the qualifications (degree (or pursuing degree) in engineering and engineering education). Faculty members with relevant experiences in EER (Aisha and Seemen) are conducting research following most of the steps involved in EER however the faculty members with an engineering research background do not explicitly use all the required steps in conducting EER (Iqra and Emaaz). Hence, trainings on how to conduct EER is a need for engineering education researchers in India, so that their work is of good quality and they can make meaningful contributions to the existing body of knowledge. The research done by the participants do not essentially include all the required aspects of both quantitative and qualitative research. Trainings specifically on quantitative methods and qualitative methods in EER are needed to guide the faculty members in the right direction. The research participants have access to most of the literature however they do not have access to software and tools that are helpful in conducting EER. Institutions in India must invest their time and money in arranging these resources and training faculty members to be competent to conduct EER successfully.

Availability of experts and mentors in EER is a major challenge in Indian institutions considering EER is relatively new. To a large extent this slows down the process of research and may also lead to a couple of faculties developing disinterest in EER. Institutions must carve out a means of having experts in EER on campus to help and guide engineering education researchers as they may eventually help build a wider community of researchers as opposed to working in isolation and feeling neglected all time.

EER is now gaining acceptance and researchers are seeing value in it because of the access to online webinars by international experts and interaction with international experts at conferences in India. This exposure has created a buzz and people have started talking about EER however, EER in India has a difficult path to travel on as the current number of active engineering education researchers is very small in India. In order that EER is given serious consideration as engineering research, firstly at institutional level EER must be treated in par with engineering research in all possible ways to attract more researchers in EER. Second, there must be some local and national policies for EER in India as they are available for engineering research so that EER will reach to a broader audience and will eventually help build a robust community of researchers.

In the future, the authors aim to avoid the researchers bias by triangulation with other sources of data such as sample papers published by participants, participants CV. Eventually, we would also like to understand the process followed by the engineering education researchers in the US and hope to propose a model that would be helpful to the novice and future engineering education researchers in India. This model could also be useful to researchers interested in EER located anywhere in the world.

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