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Conducting Quantitative Research Study: A Step-by-Step Process

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Abstract: In the recent past, engineering education research (EER) is gaining increasing acceptance and recognition globally. Specifically, EER is growing in India over the last decade. As EER is nascent in India, there is a need to understand the different research methods in EER such that appropriate methods are chosen while conducting EER-related activities. EER involves three methods: quantitative, qualitative, and mixed research methods. The purpose of this paper is to document in detail all the steps followed by specific examples in quantitative research methods when conducting EER. Quantitative research is a systematic investigation of a research topic under consideration by collecting quantifiable data and performing mathematical and statistical manipulations on the collected data to produce findings that add to the existing body of literature. In quantitative research studies, data is collected by sending out online polls, questionnaires, surveys, etc. Quantitative research methods are used to fundamentally quantify different aspects in research-related activities such as attitudes, beliefs, behaviours, opinions, etc. of the samples under study to provide meaningful conclusions with noteworthy implications. The different steps used in a quantitative research study typically include (1) focusing on your interests and finalizing the research topic, (2) framing research questions to be investigated, (3) conducting a thorough literature review, (4) choosing/creating an appropriate framework to guide the study (5) designing the research, (6) selecting the research site and research participants, (7) collecting data by sending out surveys, (8) analysing the collected data, (9) documenting important findings, and (10) publishing results. Quantitative research offers various advantages including reaching a higher sample size, quick data collection, the generalizability of the findings, etc. This paper will be of help to novice engineering education researchers as they can use this paper as a process document to guide themselves when conducting quantitative research projects.

Keywords: engineering education research, novice researchers, quantitative research, statistical analysis, survey design

1. Introduction

Engineering education research (EER) is nascent in India, and engineering education researchers in India need guidance and support in successfully conducting EER. For example, in the study [1] it is described in detail how Indian faculty members engage themselves in conducting EER, also the study reported that these faculty members lack awareness of the overall process of EER, and they do not follow all

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the required steps in conducting EER. In another study [2], the self-efficacy of Indian faculty members in conducting EER was reported to be relatively less in comparison with the faculty members in the United States as EER is well established in the USA.

In a preliminary study conducted to investigate the overall quality of the recently published research papers in the Journal of Engineering Education Transformations (JEET), it was found that most of the published papers do not follow all the required steps in the research process. The papers were reviewed following the framework of scholarly teaching and scholarship of teaching [3]. The following were some of the observations/findings: a gap in the literature not identified, literature not cited, research questions missing, absence of theoretical framework, lack of appropriate data collection and survey instruments, the analysis only in the form of student feedback and test/exam scores, etc. These papers essentially are related to curriculum development and teaching and learning. There is a need to shift this focus of research to more rigorous research such that engineering education researchers in India will start exploring and contributing to the direction of rigorous research in EER.

EER is "the field of inquiry that creates knowledge which aims to define, inform, and improve the education of engineers" [4]. Engineering education as a discipline offers five major areas of research [4-5]:

- engineering epistemologies – research related to engineering knowledge and thinking within social contexts now and in future
- engineering learning mechanisms – research related to engineering learners' developing competencies and knowledge in the context
- engineering learning systems – research related to instructional culture, institutional infrastructure, and epistemology of engineering educators
- engineering diversity and inclusiveness – research related to how diverse human talents contribute solutions to the social and global challenges and relevance of our profession
- engineering assessment – research related to the development of, assessment methods, instruments, and metrics to inform engineering education practice and learning

Engineering research and EER are different and most of the researchers who conduct EER are formally trained to conduct engineering research and not EER [6]. Hence, this paper will serve as a basic guide to researchers interested in successfully conducting EER. This paper does not aim to provide training material to novice researchers instead it makes them aware of the different steps involved in conducting EER and where to look for the required information. EER involves three methods: quantitative, qualitative, and mixed research methods. As EER is nascent in India, there is a need to understand the different research methods in EER by novice engineering education researchers such that appropriate methods are chosen while conducting EER-related activities.

In this paper, the focus is only on the quantitative research methods in engineering education research. Quantitative research is a systematic investigation of a research topic under consideration by collecting quantifiable data and performing mathematical and statistical manipulations on the collected data to produce findings that add to the existing body of literature. Most engineering research studies focus on measuring certain outcomes by varying a set of parameters or variables. Quantitative research methods are a good fit for studies involving a hypothesis or theory which supports the variables, the purpose statement, and research questions. Data collection essentially depends on the hypothesis under test and the framing of the research questions. The sample types of data collected, or the approaches used to collect data in a quantitative study among others include developing a new survey instrument, using an existing survey instrument, test/exam scores, and grades [7].

One of the main purposes of quantitative research studies is to project the findings to a larger population which could be generalized to draw inferences. The findings are generalizable as the data is collected by administering the survey to a large subset of the sample representing the population. Quantitative research methods help in identifying relationships and trends in data. They are also useful for quantifying outcomes, attitudes, behaviours, beliefs, etc. The results from quantitative studies are generally interpreted in detail such that the findings obtained for the sample will be of help to replicating the study within a larger population. Statistical analysis is performed on the collected data to derive conclusions from the study [7].

A huge number of topics have been investigated in engineering education using quantitative research methods. For example, a survey instrument was developed to measure the engineering education research self-efficacy of Indian and U.S. faculty members, and U.S. graduate students [2]. In this study, the authors used a quantitative research method, collected data by administering the developed survey, and performed a statistical test (Kruskal-Wallis analyses) to derive conclusions from the study. In another study [8], a survey instrument was developed to measure the computer programming self-efficacy of electrical and electronics undergraduate engineering students. A quantitative research method was used in this study and the collected data was analysed using the regression analysis. For more articles, the readers are directed to different outlets such as the Journal of engineering education (JEE), European journal of engineering education (EJEE), IEEE Transactions on education, International journal of engineering education (IJEE), Australasian journal of engineering education (AJEE), Advances in engineering education (AEE), etc. These and other journals' websites in the EER space can be found online [9].

2. Quantitative Research Methods

Quantitative research methods can be distinguished into four distinctive methods [10] and these methods are described below.

Survey Research – this is one of the most fundamental approaches used in quantitative research studies. There are various types of tools used to ask questions to the respondents through surveys such as online surveys, online polls, paper-based surveys, etc. Conducting survey research will permit researchers to ask the required set of questions to respondents through surveys and collect and analyse data in the form of numerical results. The target audience in this type of research can be a specific group or multiple groups depending on the scope and requirement of the research. Randomly selecting the respondents from the sample is a prerequisite in survey research. Hence, reaching out to many respondents through random selection will ensure greater accuracy of the results. There are two types of surveys: cross-sectional surveys and longitudinal surveys. Cross-sectional surveys are conducted when a researcher aims at collecting data from the sample at a certain point in time. However, longitudinal surveys are conducted across different time points which will help capture the changes over time in the responses related to thought-process, behaviour, learning, etc. The time points can be different days, months, years, etc. Examples of survey research include self-efficacy of engineering faculty teaching online, engineering students' confidence in computer programming skills at freshmen, sophomore, junior and senior levels, etc.

Correlation Research – this type of research is used when there is a need to compare two variables or entities. One of the purposes of using correlation research is to understand the relationship between two entities and the impact of one on the other entity. A certain value to the relationship between two entities is given using this method and one of the requirements of this type of research is that a minimum of entities is needed. Examples include the relationship between learning habits and students' learning, the relationship between gender and self-efficacy in learning, etc.

Causal-comparative Research – this type of research method is used to explore the cause-effect relationship between two or more entities/variables. One variable is called the dependent variable and the other variable is called the independent variable. The impact of the independent variable on the dependent variable is evaluated. This type of research is not specifically limited to studies with two variables but can be used in studies that include two or more groups. The relationship between the two variables or groups is not a matter of concern when using this type of research method. Examples include the impact of different pedagogies on students learning, the effect of learning styles on course enrolments, etc.

Experimental Research – this type of research deals with the conduction of experiments to either prove or disprove a hypothesis/statement. In this research method, it is aimed at understanding whether a statement is valid or invalid. This research method is often used in social sciences. Examples include the evaluation of the hypotheses: modern teaching techniques/methods are more effective than traditional teaching methods, providing hands-on learning experiences will have students higher-order thinking skills.

3. Quantitative Research Characteristics

In this section, the different characteristics of quantitative research are presented.

•Structured tools: Quantitative data is collected using

structured techniques such as surveys, polls, and questionnaires. The use of such structural approaches aids in the collection of detailed and actionable information from survey respondents.

•Sample size: Quantitative research is carried out on a representative sample size of the target market. To strengthen the study purpose, appropriate sampling strategies must be employed while generating the sample.

•Close-ended questions: Closed-ended questions are developed following the study's goal. These questions are frequently used in quantitative research since they aid in the collection of quantitative data.

•Prior studies: Before gathering input from respondents, many elements relevant to the study issue are investigated.

•Quantitative data: Tables, charts, graphs, and other non-numerical forms are commonly used to portray quantitative data. This makes it simple to comprehend the information gathered as well as to demonstrate the market research's authenticity.

•Generalization of results: The findings of this study approach can be used on the entire population to adopt relevant improvement measures.

4. Steps in Conducting Quantitative Research

In this section, the steps involved in conducting quantitative research as described in Fig 1 are explained in detail. All the steps discussed are important and should be followed when conducting a quantitative research study. Examples are provided at specific steps thereby giving more clarity to help novice researchers in this space.

I. Focus on your interests and finalize the research topic

The first and the main step in conducting any type of research in any field is choosing an area of interest. A research project is a serious commitment that an individual or a group takes up, in which you invest a lot of your time, energy, and efforts, hence you must spend an ample amount of time in identifying and selecting an area of research that best interests you. You may start with a broad research idea in mind and

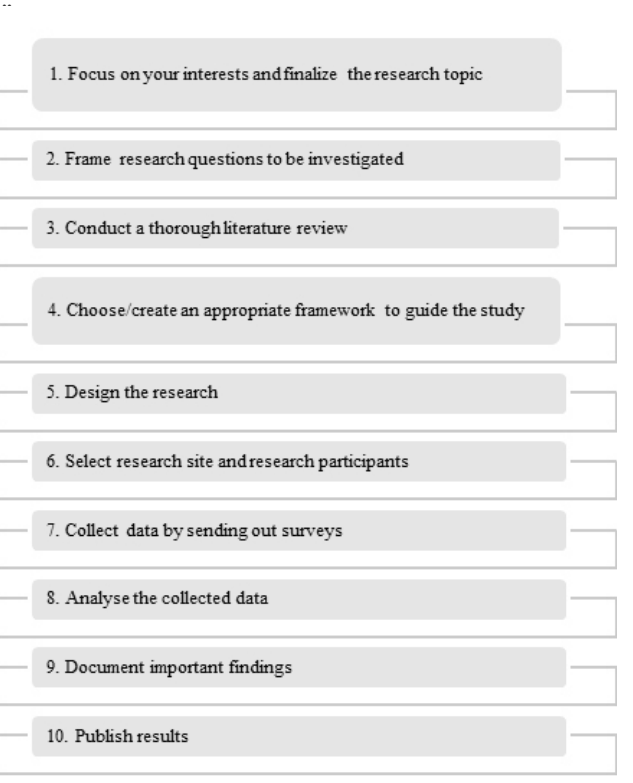

Fig 1 : Steps in the quantitative research process

eventually narrow the scope of research that you plan to conduct. Narrowing the scope of the research area will lead to finalizing the research topic that you eventually would like to study.

II. Frame research questions to be investigated

Research questions are an important part and a first active step in any research study as research questions influence and dictate the overall study starting from literature review, methodology, data collection, and analysis. Hence, framing appropriate research questions early in a research study is extremely important and useful. With the finalized research topic at hand, it is the right time to frame the research questions. The research questions can be tweaked and improvised based on the information obtained through the literature review phase which is the next step. A few examples of research questions from quantitative research studies are 'What are the factors that influence the programming self-efficacy of electrical and electronics engineering students in India?' [8], 'Does working in teams formed with mixed learning styles enhance students' learning?' [11], and 'What are the factors that best predict the

engineering education research self-efficacy of faculty members in India and USA?' [2].

III. Conduct a thorough literature review

After having decided upon the research topic and formulating the draft research question(s) to which you would like to find answers, it is then a good time to start exploring the literature to understand more about your area of research and what other researchers have contributed to this direction. The literature review is an important part of a research study as it helps the readers (and researchers) get a concise overview of the topic of research, demonstrate that the researcher (you) has a sound knowledge of the topic under study, and justify your contributions to the existing body of literature. A thorough review of the literature will help you identify the gap which you could potentially plan to address as a part of your study and that becomes the focus of your research. Novice researchers are recommended to spend adequate time on the literature review phase as this is one of the most critical steps in a research project to set an appropriate context for the study and to situate your work in the broader context of the existing literature.

The literature review is a survey of scholarly published work on the topic of research. In brief, it is a five-step process: searching the required and relevant materials, evaluating the searched sources, identifying important key takeaways, findings, and gaps, preparing an outline or a structure, and composing the literature review [12]. An important thing to be careful about when conducting a literature review is to make sure that you are not just summarizing the articles instead you are analysing, synthesizing, and critically evaluating the information from the sources to provide a clear picture of the topic under study.

In addition to the benefits discussed above, the literature review is also helpful in stating hypotheses that are well-grounded in literature and choosing an appropriate framework for the study. Hypotheses are statements used to define the expected relationships between dependent and independent variables. The hypotheses will essentially help the researcher get more clarity on what is to be expected from the results of this study. A few examples of the hypotheses from previously published quantitative research work include "higher will be the programming self-efficacy as we move upward in the levels of class standing from freshmen to senior-level students", "male students will report a higher programming self-efficacy than females", and "higher the prior experience in programming, higher will be the programming self-efficacy" [8]. Details on choosing a framework are described below.

IV. Choose/create an appropriate framework to guide the study

As blueprints are important when constructing a house, frameworks are important when conducting research studies [13]. Frameworks provide a typical structure or boundary which lets researchers stay confined and not deviate from the study. As per one of my colleagues, a research study without a framework is like a blind person walking without a stick. Hence, novices in this space are recommended to find appropriate frameworks that will help them guide their study. Frameworks help researchers determine how to perceive data, make sense of it, and interpret it. Also, including an explanation of the framework in the research articles helps reviewers and readers understand the researcher's perspective and the overall context of the study. For example, in the study designed to measure engineering education research self-efficacy, the self-efficacy theory was used as the framework [2].

The approach that can be used to either choose or create a framework that you can use in your study is described here. Begin with identifying key terms and concepts from the research questions. The key terms and concepts will help you find related information about concepts and theories used in similar studies. If the literature review is thoroughly conducted previously (as described in step 3 above) and it provides information required for justifying the use of an appropriate framework, then you may not want to review the literature further. Otherwise, you will have to go back to literature again but now the focus will be on finding information related to frameworks. Next, use this information to evaluate the concepts and theories and explain how different concepts and theories connect. By this, you are critically evaluating and comparing the approaches used by other researchers in similar studies. Finally, it is a good practice to explain why a certain concept or theory works well with your research and explaining how it particularly fits in your work is an important aspect to include. Also, when choosing a framework, explaining how you would like to use those concepts or ideas in your research project is required.

V. Design the research

Using the research questions to be investigated, a thorough literature review, and a framework to guide the research study, the next step is to plan and design the research study. In this phase, you are required to finalize the methods that you will use to find answers to the research questions under consideration. In this paper, the discussions will be limited to quantitative methods and survey instrument design. The first step in this phase typically is to brainstorm and identify what data will help answer the research questions. Let us move forward with the assumption that we would like to design a quantitative study using a survey research methodology.

The next step is to explore if there already exist survey instruments in the literature review done previously related to the research topic. If the literature provides instruments similar to what is desired in the research study, it is required to further examine the instruments critically to understand if the survey instruments by themselves are sufficient to collect data or if there is a need for some sort of modifications, additions, and/or revisions. Based on the examination, an appropriate next step must be taken. If there exist no instruments to collect the required data for the study under consideration, then this situation provides an opportunity for the researchers to design and develop a new survey instrument that must be well-grounded in the literature.

When designing a new survey instrument, the first step after a thorough literature review is to operationalize the concepts under study. Survey instruments include mainly the demographic questions and a questionnaire related to the study. Based on the research topic, a survey can be designed to measure a set of concepts or themes (popularly called constructs in the context of survey research). A survey can have just one construct with multiple dimensions to it or it can have multiple constructs with a specific number of dimensions. Each dimension has several questions (called items) framed based on the literature. For example, in the study focused on measuring engineering education research self-efficacy (EERSE), EERSE was considered to be the only construct in the study with three dimensions: general research tasks, quantitative research tasks, and qualitative research tasks [2]. In another study [8], computer programming self-efficacy was considered as a construct with four dimensions: basic programming tasks, complex programming tasks, dependence, and self-regulation. Readers are directed to refer to and review papers [2] and [8] for more details on how construct and dimensions are defined in a quantitative research study. Some of the tips to consider when writing items include avoiding terms that can be ambiguous and trying to be precise, writing the items as short as possible, writing items to make sure that the potential participants understand them clearly, and avoiding double barrelling when writing items i.e., avoid words such as and, or, because in an item [14].

The survey instruments are designed using the construct, associated dimensions, and each dimension with several items. Once the survey is designed by the team of researchers of a study, the next step is to validate this survey instrument from a few experts in the field (content validity) and a few potential participants from the population (face validity) [14]. The content experts must be individuals who possess adequate knowledge about the research topic so that their feedback is worth considering. To collect the evidence for content validity, the survey instrument must be shared with the content experts asking them to comment on the survey items based on their relevance, and appropriateness to the research study. The feedback form can also include open-ended questions asking for suggestions such as how a specific item can be better framed or what changes in the items would make the instrument better. The potential participants are the actual participants from the population who would take the final survey when administered. To collect evidence for face validity, the survey instrument is given to the potential participants asking them to comment on the wording and clarity of the items. Based on the feedback received from both content experts and potential participants, the survey instrument must be accordingly updated, and the survey instrument will now be ready to be administered to the participants. There isn't a hard and fast rule for choosing the number of experts and potential participants for collecting the evidence for content and face validity, however, 2 to 6 individuals seem a reasonable choice to get constructive feedback from both the groups. A week is generally given for both the content experts and the potential participants to respond to the request. Based on the timeline and requirements of your study, you may want to have a specific plan that best suits you.

VI. Select the research site and research participants

Depending on the requirement and type of the research project, the research site and research participants vary. For example, if the context of a study is focused on a laboratory setup, then the laboratory becomes the research site and the participants using that specific laboratory become the research participants. For field experiments, the choice of the research site can be a maker's space or a school, and participants involved in the field experiments will serve as research participants. For survey research based on the topic of research, the research site can be more varied (engineering institutions in a particular state or country) and participants from those sites will be considered as the research participants for that study.

It is important to collect the contact information (email and/or phone numbers) of the research participants through an initial demographic survey or by making use of your contacts/network if you like to directly reach out to the participants. If you would like to reach out to a single point of contact (SPOC) who will help you administer your survey, then identifying SPOC and collecting their contact information is a requirement to proceed further in collecting the data. Creating a database of participants' information is a good practice before administering the survey as it comes in handy when required. To determine the minimum number of participants required to conduct a specific statistical test, a tool called G*Power could be used which is freely available [15]. This is called a priori power analysis.

In the study [2] focused on measuring engineering education self-efficacy, the research site was engineering institutions where EER was given similar recognition and importance as engineering research in India and USA, and the faculty members in these institutions inclined toward conducting EER were the research participants. Another study [8], which aimed at understanding the computer programming self-efficacy of electrical engineering students in India, had the electrical and electronics engineering program as the research site, and all the students (freshmen to senior) in this program were the research participants. It is important to correctly identify the research site and participants to get the answers to the defined research questions. It is a good practice to reach out to as many participants as possible from the population to have an increased number of responses so that the results obtained from the research study are generalizable.

VII. Collect data by sending out surveys

Once the survey is updated based on the content experts' and potential participants' feedback, and the research site and research participants are finalized, the next step is to administer the survey. For ethical reasons, it is a must to collect consent from the research participants such that they are willing to participate in this study and they permit the use of their responses for research and publication purposes. Also, the participant's participation in the survey must be voluntary and the participant must be given the freedom to choose to not respond to a particular question for ethical reasons i.e., the survey must not include mandatory questions. One of the major problems witnessed in quantitative studies is the low response rate and hence reaching out to a larger sample of the population is a wise decision.

There are different ways of approaching participants to respond to the survey such as (a) sending personalized emails to participants, (b) sending a regular text message or a WhatsApp message, (c) advertising the study on notice boards with a link to the survey (or a QR code), (d) contacting the department chair or institution head and requesting them to ask the potential participants to complete the survey, etc. Researchers can use one or more of the above-suggested approaches (or any other approach) based on the requirement of the study and what best suits the design of the study. Generally, first, an invitation is sent to the participants to participate in the study, and then a follow-up reminder invitation is sent to have an increased number of responses. The time lag between the first and the reminder invitation completely depends on the design and timeline of the study. For example, in a study that collects participants' data for six consecutive weeks (one survey per week), then it is advised to send the first invitation on Monday and the reminder on a Wednesday. If a study requires the data collection only once from the participants, then you may send a reminder invitation after a week of the first invitation.

VIII. Analyse the collected data

Analysing the collected data is one of the most important phases in any research as the outcome of this phase provides answers to the research questions. The first step after collecting the data is to clean the data and bring it to an acceptable format required to conduct a statistical analysis. Cleaning the data

ensures improved efficiency of the data analysis as inaccurate information will be deleted from the data. Some of the common things to focus on when cleaning the data are (a) deleting responses that have the same answers to all the questions (for example, a participant has responded 'strongly agree' to all the questions on a five-point Likert scale with possible options as 'strongly agree', 'agree', 'neither agree nor disagree', 'disagree', and 'strongly disagree'), (b) deleting responses that have missed more than half of the questions on the survey (you may choose a specific threshold based on your study), (c) deleting responses of ineligible participants, (d) deleting duplicate responses, etc. Following the above steps, the data may include some missing values and imputation is a method used to replace the missing values with substituted values [16]. The process of imputation makes use of the existing data points to calculate the value to be substituted for the missing values. There are two types if imputations: single imputation and multiple imputations [16-18]. Single imputation uses 'sample means substitution' in which the missing value is replaced by the overall sample mean, 'group means substitution' in which the missing values are replaced by the overall group mean, and 'regression-based imputation' in which missing values are replaced by the score calculated through multiple regression using the non-missing values. There are different methods available for multiple imputations such as full information maximum likelihood (FIML), Markov Chain Monte Carlo (MCMC), and an expectation-maximization (EM) [17].

Exploratory factor analysis (EFA) can now be applied to the cleaned data to determine the factor structure and the associated items in each factor resulting from the survey. Some of the assumptions that need to be met before conducting EFA are (1) variables must be approximately normally distributed, (2) variables must be correlated, and (3) sufficiently large sample size i.e., it is recommended to have at least five to ten participants per variable (survey item) [14]. The overview of EFA is explained in five steps in this section. First, Bartlett's test of sphericity must be used ($p<0.05$) to examine the suitability of the items for factor analysis. To ensure that the factors extracted from the EFA account for large variance, Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy must be used ($KMO > 0.8$) [14]. Second, find the number of factors to be extracted from the collected data and there are three approaches to do this: scree plot, parallel analysis, and Kaiser's criterion [14]. Out of the three approaches, parallel analysis is considered the 'gold standard' as the suggestion by scree plots is subjective and Kaiser's criterion is influenced by the number of items. Care must be taken to not identify too many factors or too few factors, instead, the number of factors must be well-informed by theory. You might come across a situation wherein the number of factors suggested by the three different approaches does not match, under such circumstances determine the number of factors using parallel analysis and confirm it with either scree plot and/or Kaiser's criterion [14]. Third, determine the extraction technique; principal component analysis (PCA) or principal axis factoring (PAF) [14]. These two techniques differ concerning the use of communalities, in PCA the initial communalities are assumed to be 1.0 (i.e., no measurement error) and in PAF the error can be measured. PCA is computationally faster but is biased with high factor loadings. The solutions with both PAF and PCA are similar for large data sets, however, PAF is generally preferred over PCA unless you have a strong reason to not use PAF [14]. Fourth, determine the rotation technique; orthogonal or oblique. Rotation helps optimize the loadings by making the location of factors fit the actual data points better thereby improving the interpretation of the factors. Orthogonal rotation assumes that the factors are not correlated, and oblique rotation assumes that they are correlated. It is advised to start with oblique rotation and examine the factors correlations, if the factors correlations are greater than 0.33, you may continue with oblique rotation otherwise use the orthogonal rotation technique. Finally, execute factor analysis following all the previous steps described, delete items that do not load highly on any of the factors, and then interpret the factors. Understanding the interpretation of factor loadings is important to proceed further in the analysis. Some of the ranges for high factor loadings are the magnitude of the factor loading greater than 0.6 is considered as the gold standard, and a magnitude greater than 0.4 is considered acceptable. Generally, the items that do not have a factor loading magnitude greater than 0.4 on any of the factors, then such items are deleted from the analysis. The items that cross-load (an item with a factor loading magnitude greater than 0.3 on more than one factor) on other items are also removed. Repetition of steps in EFA is to be expected as EFA is an iterative process. Readers are directed to references [2] and [19] for more details on EFA. Confirmatory factor analysis (CFA) is used to verify/confirm the factor structure in which the factor structure is pre-

determined and hypothesis testing is performed to see if it is true. Generally, EFA is done first to generate a hypothesized factor structure and then a new sample of data is used in CFA to confirm the factor structure. Readers are directed to the articles [19-22] for more details on how a CFA can be used in quantitative research studies.

After determining the factor structure and the associated items in each factor, you may be interested in understanding how a certain section of participants performs in a test/exam in comparison with others, what parameters influence the participants' abilities in completing a certain task, etc. To do so, different statistical tests are available such as independent samples t-test, one-way ANOVA, two-way ANOVA, repeated measures of ANOVA, simple linear regression, multiple linear regression, path analysis, multi-level modelling, etc. Depending on the design study and the research questions, the appropriate statistical tests must be chosen, and below are a few examples summarizing when some of these statistical tests could be used.

Independent samples t-test is used to compare two groups (with smaller sample sizes) of independent variables on the dependent variable. Some examples of research studies in which independent samples t-test could be used are (1) a team of researchers is interested in determining whether incorporating flipped classroom pedagogy enhances undergraduate engineering students learning. The researchers wish to consider two groups, one, students learning through a conventional teaching approach and the other group through flipped classroom approach. (2) a researcher wishes to investigate whether the number of years of industry experience (i.e., $\leqslant 5$ years and > 5 years) influences engineering faculty members' approach to teaching undergraduate engineering students. In both the studies described above, the researchers have used surveys to collect quantitative data.

One-way ANOVA is used to compare two or more groups of independent variables on the dependent variable. Some examples of research studies in which one-way ANOVA could be used are (1) a group of researchers developed a course for freshman engineering students focused on project-based learning (PBL). This course aims at increasing the students' engineering design skills among other skills. The students for this study belong to three groups. Group 1 students follow the entire curriculum using the PBL pedagogy. Group 2 students follow the partial curriculum using the PBL approach and Group 3 students follow the entire curriculum without the PBL approach. (2) a researcher is interested in investigating the effectiveness of students learning in a core course for undergraduate engineering students at the sophomore level. The course is offered in three versions. In version 1, the students learn the content of the course through the in-person teaching-learning approach. In version 2, the content is taught completely through an online medium, and in version 3, the content is taught using both in-person and online teaching.

Two-way ANOVA is used when there are two independent variables and one quantitative dependent variable. Some examples of research studies in which two-way ANOVA could be used are (1) a researcher is interested in investigating the process followed by the researchers who are actively involved in research-related activities. The researcher is trying to determine whether the teaching experience and industry experience influence the faculty engagement in research. (2) a team of researchers is interested in determining the undergraduate engineering students' satisfaction. They are planning to consider 'student grades' and 'student learning' to come up with a conclusion for this study.

Repeated measures of ANOVA are used when the participants from a random sample respond to the same survey under three or more conditions. Some examples of research studies in which repeated measures of ANOVA could be used are (1) a team of researchers is interested in understanding the change in undergraduate engineering students' confidence in computer programming skills as they progress in their degree from freshmen to senior level. The researchers have designed a survey instrument and they plan to administer it at the end of each year starting from freshmen to senior year. (2) a researcher plans to determine whether undergraduate engineering students' critical thinking skills change over a semester. The researcher plans to collect data at three different point times; at the beginning of the semester, during the mid-semester, and at the end of the semester. In both these studies, the same participants respond to the same survey at different time points.

Readers are directed to different research studies that use regression analysis [8, 23-24], path analysis [25-27], and multi-level modelling [28-30]. Articles related to other statistical analyses can be found through a quick search in the literature.

As described previously, G*Power can be used to determine the required sample size when conducting a study, however, it can also be used to calculate the resultant power. This test is called post-hoc power analysis. It is good to have the power value greater than 80 percent as this ensures that we can detect the effects appropriately (if an effect exists). The G*Power tool can be used to calculate a priori and post-hoc power analysis for most of the statistical tests used in quantitative research studies [15].

IX. Document important findings

Presenting findings in a way that is easily understandable to both the reviewers and the readers is an important aspect of any type of research-related activities. Some of the important tips to consider when composing the section focusing on findings are (a) include an introductory paragraph to help the readers know what to expect in this section and it is particularly important to restate the research questions, methodology, and analysis used in the study, (b) present the findings in the form of charts, graphs, tables, etc. and data presented in this format needs to be explained in the text, (c) explain the data interpretation and how you reached a certain conclusion using the data, (d) connect the findings with the research questions stated earlier, (e) look for similar studies in the past and situate the findings in the existing body of literature, (f) explain and discuss the results, etc. In addition to the results and analysis section in the paper, it is advised to compose a section called 'Discussion' which focuses on discussing the findings by comparing and contrasting based on the findings in the existing literature. This will help the researchers position their work in the broader context of the knowledge base of the existing literature.

X. Publish results

It is important to publish your work and share it with the community so that other researchers interested in working in a similar or same area will be benefited. In addition, publishing research work helps individuals build a strong profile which can attract potential research funding opportunities and collaborations. Depending on the type of work and details included in the manuscript, a paper could be published in either a conference proceeding or a journal. Researchers are advised to explore the different options available for publishing their work (conferences and journals) and carefully read through the areas of research that are expected by the outlet, page limit, word count, etc.

5. Advantages and Disadvantages of Quantitative Research

In the research process, the use of statistical analysis and concrete figures found in quantitative research offers significant advantages [7][31].

- Can be tested and checked: Quantitative research necessitates meticulous experimental design as well as the capacity to duplicate both the test and the results by anybody. As a result, the data you collect will be more trustworthy and less subject to debate.

- Straight forward analysis: The sort of findings you get while collecting quantitative data will inform you which statistical tests to perform. As a consequence, evaluating your data and presenting your conclusions is simple and free of subjectivity and inaccuracy.

- Prestige: Because many individuals do not comprehend the mathematics involved, research that includes extensive statistics and data analysis is deemed worthwhile and remarkable. Quantitative research is linked to technological breakthroughs such as computer modelling, stock picking, portfolio evaluation, and other data-driven business choices. The reputation and value associated with quantitative research have numerous benefits.

However, quantitative research's emphasis on numbers may be restricted, resulting in a variety of disadvantages [7][31].

- False focus on numbers: Quantitative research can be constrained in its interest of particular, statistical relationships, causing researchers to miss out on larger themes and relationships. You run the danger of losing out on surprising or big-picture information that might help your research if you only focus on data.

- Difficulty setting up a research model: You must carefully construct a hypothesis and build up a model for collecting and interpreting data while conducting quantitative research. Any faults in your setup, bias on the side of the researcher, or execution issues can render all your results

incorrect. Even formulating a hypothesis can be subjective, particularly if you have a specific question that you wish to prove or deny.

- Can be misleading: Many individuals believe that quantitative research is more trustworthy or scientific than observational, qualitative research since it is based on numbers. Both types of study, however, can be subjective and deceptive. A researcher's prejudices and views are equally as likely to influence quantitative techniques in data collection. The influence of this bias is felt earlier in the quantitative research process than in the qualitative research process.

6. Summary

This paper attempts to summarize all the important steps required to successfully conduct quantitative research studies. The authors have identified ten important steps referring to the literature that will help novice researchers interested in conducting quantitative research as this document serves as a process guide. Several quantitative research-related examples have been included in different sections throughout the paper and the readers are directed to some important references that can further help them understand the overall process better.

A few quick and general suggestions for novice researchers include, if your native language is not English and if you have difficulties drafting your ideas, then you must seek help from the best possible available resources at your institution, it is a good practice to proof-read your document once it is complete and ready to avoid the obvious errors and mistakes in the document. Finally, take the help of writing centers at your institution to make your document read clear and to the point.

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