A DIRECTION FRAMEWORK TO ADDRESS PROBLEMS IN REQUIREMENTS ENGINEERING EDUCATION

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ABSTRACT

Requirements Engineering (RE) is the most difficult stage of software development for students to learn and for lecturers to teach. Requirements Engineering Education (REE) problems are reported in several studies. The aim of this paper is to verify that REE problems presented in the literature really exist in practice especially in Malaysia and in Pakistan through an investigation study, and to provide suggestions on appropriate pedagogical approaches to be used in RE courses. Furthermore, we provided a list of strategic recommendations for RE course implementation and offered a direction framework that can assist in planning for effectual RE course execution. An investigation was performed on undergraduate software engineering students from the universities of Malaysia and Pakistan using a questionnaire. Results showed that many problems reported by students are quite similar to those presented by researchers in the literature. The students perceive RE as an important course and the problems reported by students that are less investigated must be explored in future REE research, and their interest in RE needs to be developed so that they become motivated to choose this as a profession. The REE problems presented in integrated view are then mapped with the REE pedagogical approaches suggested by researchers. Finally, the paper closes with a direction framework that can help to effectively deliver RE course and address REE problems.

Keywords: Requirements Engineering, Requirements Engineering education, Integrated View.

1.0 INTRODUCTION

Requirements Engineering (RE) is a complex discipline that has been broadly recognised as being critical to the success of development projects [1]. Armarego and Minor [2] reported that research into software development has found that the major failure cause of software projects is the poor fulfilment of RE activities by software engineers. According to the authors, the most common reason for this is the inadequate knowledge and skills of the software engineers working on these projects. This may be due to the lack of RE in most university programmes [3]. Requirements Engineering Education (REE) needs to be provided to students at university level, before they become software engineers and become part of the workforce [4].

According to Gibson [5], RE is the most difficult stage of software development for students to learn and for lecturers to teach. Problems in REE are frequently acknowledged within the REE community and reported in several studies, such as [1, 5-9]. These include REE problems faced by students and lecturers in universities, as well as the RE problems of industry. Due to the complex and theoretical nature of RE, students find it hard to understand and not perceive it as interesting or glamorous, and lecturers find it challenging to teach and to find the best ways to prepare students for RE activities with the limited time and resources available at institutions. In the literature, researchers have presented a significant number of REE problems in universities, as well as those RE problems in industries that can be addressed by providing REE in universities. However, none of them attempted to compile, review and analyse systematically all REE problems together in such a way that it would be possible to see the whole range of REE problems at once, as well as the groups and categories of problems and the relationships and dependencies between them. We call this analysis and presentation of the entire range of REE problems "an Integrated View (IV) of the problems." In order to design such an integrated representation, the literature search was performed in which the main problems associated with REE were identified and extracted from studies which have previously been conducted by researchers. The detailed

analysis of problems was performed in which they were arranged in groups by reference to similar issues, classified into categories and relationships were identified between them. Finally, an integrated representation was produced that have provided an overview of relevant information on REE problems. The formulation of an integrated view has comprehensively been discussed in [10].

The IV presents REE problems discussed in the literature. The problems were investigated further from undergraduate software engineering students along with their general perceptions about the RE course in order to verify that these problems really exist in practice especially in Malaysia and in Pakistan. The investigation was performed using a questionnaire to be completed by software engineering undergraduates who had taken the RE course. This study presents and analyses the investigation results and show that these results matches with the IV problems. Some suggestions and recommendations to address REE problems and to improve REE in universities are then provided. This paper makes the following contributions to RE discipline:

- It presents the design and results of a first of its kind study to verify REE problems.
- It provides information about how students perceive REE.
- It identifies further research topics (major REE problems) that need to be explored to support an effective and successful RE course.
- It identifies several pedagogical approaches that can help to address REE problems.
- It lists several strategic reommendations for RE course planning and implementation.
- It develops a direction framework that presents major REE problems and ways to effectively deliver RE course.

This paper begins by considering REE problems in section 2. Section 3 presents IV of REE problems. Section 4 defines the aim of the investigation study. Section 5 discusses the methodology and analysis results. Section 6 presents the answers of the research questions. Section 7 presents major REE problems through further analysis. Section 8 presents the suggested pedagogical approaches, proposed recommendations and a direction framework, and section 9 draws some conclusions.

2.0 BACKGROUND STUDIES

The REE literature presents the problems lecturers and students face in teaching and studying RE and the concerns of the industry that stem from a lack of REE teaching at universities.

RE is the most important stage of system development and this fact is recognized by academics [9]. However, students take less interest in RE [4] and fail to see the point in spending time on understanding business requirements [11]. In universities there is relatively light coverage of RE material [12], which has left students with a lack of essential skills needed to perform RE for real projects.

Students are seldom taught to analyse and structure the real problems of customers. Barnes, et al. [6] reported that newly-graduated engineering students had a critical competency gap; they could find solutions if they were given a well-structured problem, but they were unable to structure the real problems from user requirements. Furthermore, Smith and Gotel [7] state that students were unable to recognise the requirement problems, and Beatty and Agouridas [1] noted that students found it difficult to understand ill-structured problems. Gibson [5] reported that the step of moving from informal (understanding the problem) to formal (recording this understanding by creating a requirements document) methods was very difficult to teach and learn. They also reported the problem of teaching students to create Software Requirement Specifications (SRS), the deliverable of RE phase. In the RE course, moreover, students produced SRS documents that were of a poor quality [13]. Therefore, according to Hujis et al. [14], students should be taught to improve the quality of the SRS document.

Due to the lack of emphasis on RE in most academic programmes, software developers have to learn RE practices on the job. However, this can lead to the selection of techniques that are ill-suited to a particular project [3]. Rosca [15] and Al-Ani and Yusop [9] argue that there is a need to introduce students with foundations of RE knowledge, RE activities, methods and the tools which are available for eliciting, analysing, specifying, validating and managing requirements.

Another category of problems are those related to RE practices in industry. One of these is the communication barrier between developers and customers [13]. Connor, et al. [12] and Hujis, et al. [14] stressed that students should be taught communication skills in order to overcome this problem. Other concerns related to industry practices are lack of customer involvement [6] and dealing with their incomplete requirements [7], changing

needs [5] and unrealistic expectations [16]. The reseachers reported that such issues were often ignored in RE courses and suggested that students should be taught to deal with these challenges in order to overcome the problems.

In addition, students need to be provided with experience of real issues found in the workplace, which include dealing with ambiguity, uncertainty, confusion, fear, time pressure, collaboration and corporate politics [11], conflict resolution, scope definition, facilitating decisions, defining expected system behaviour with a combination of users, system and data states and producing outputs which is suitable for a diverse audience [1], insufficient rigour, inadequate development, an overemphasis on functional requirements, perceived impracticability, a lack of awareness, admitting mistakes, selling ideas to management, increased short-term costs and a lack of maturity and guidance [7]. Regev, et al. [11] suggested that students could only learn to deal with these industry related problems if they were provided with practical experience in REE.
All of these REE problems presented in the literature have been analysed and combined together into an integrated view and discussed in the next section.

3.0 INTEGRATED VIEW OF REE PROBLEMS

The researchers who have reported the REE problems were from various universities, as well as from industry. The university researchers mostly shared their experiences of teaching RE courses and reported the REE problems that their students faced. Meanwhile, the industry practitioners proposed approaches to training practitioners, along with presenting RE problems faced by the industry due to a lack of REE in universities. All REE problems reported in the previous section were analysed in detail, combined into groups, assigned frequencies, classified into categories and relationships were identified amongst them. Analysis results were then presented in an integrated view.

The steps towards designing an integrated view are discussed in detail below.

- Whilst analysing REE problems it was noted that many problems from selected studies were related to similar issues so that they were combined into groups under one common heading. The number of problems in each group was labelled as its frequency and each group was dealt with a single problem. The frequencies are presented by shadded and non-shadded ovals in IV. The problems with frequencies 3,4 and 5 are represented by shadded ovals, whilst non-shadded ovals designate problems with frequency 2. This shows that the problems in shadded ovals are considered more important as they have been emphasised more than those in non-shadded ovals.
- Most of the researchers reported a number of problems and focused on addressing one or more of these problems. The reported and investigated problems are shown separately in IV, investigated problems are linked with the box labelled investigated, and reported problems are linked with the box labelled reported to show that the reported problems are in the areas that require more attention and are yet to be examined.
- It was observed that problems refer to two different factors; some were related to the RE curriculum, whilst others were related to RE issues of practitioners. Therefore, problems are categorised into those related to RE curriculum (REc) and RE practice (REp). These two problem categories (REc and Rep) are presented by two big ovals in IV, and the small ovals present the problems in these categories.
- It was then observed that problems in RE practice (REp) occurred due to a lack of REE at university (REc). In IV, the high level dependeny between the two problem categories is presented by the arrow pointing from the REp problems in the oval to the REc problems in the oval showing the dependency of REp problems on REc problems.
- The dependency between the two problem categories is related to the fact that each REp problem is linked to one or more REc problems. Problems are dependent on others, or are the consequence of others. A significant number of these types of dependency exist between both categories. The detailed dependencies and their types have been presented by diamond boxes pointing towards REc problems, showing which REp problems are dependent on each REc problems and how they are dependent.

All of the results presented above have provided information about the detailed analysis and classification of REE problems, and now all of the resulting information needs to be collected and portrayed together in the IV of REE problems. The IV is illustrated in fig. 1.

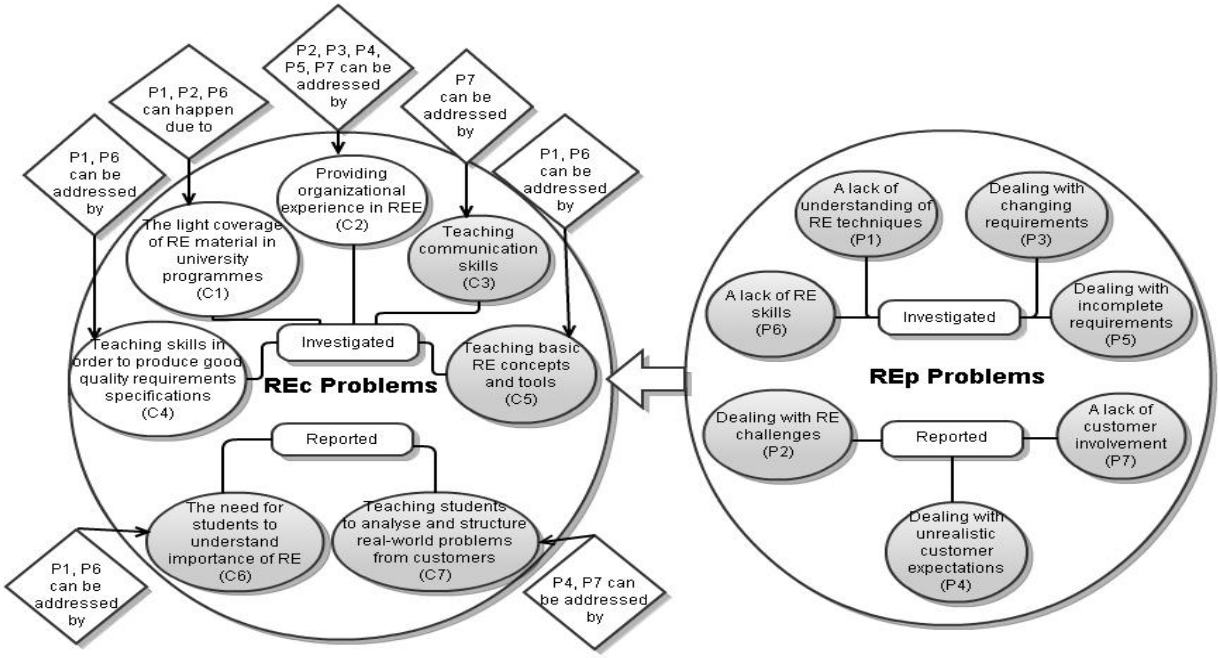

Fig. 1 Integrated view of REE problems

4.0 THE INVESTIGATION STUDY

This study aimed at investigating REE problems presented in IV of Fig. 1 in order to confirm that these problems really exist in practice and students are facing these problems. In order to achieve this aim, an investigation study was designed and performed as an application of IV on undergraduate software engineering students. Using the GQM template, the goal of the study was defined as follows.

Table 1 GQM defining goal of the study

Analyse	Requirements Engineering Education problems
For the purpose of	Verifying
With respect to	Integrated view
From the point of view of	Researchers
In the context of	Software engineering undergraduates who had taken RE course

The problems in the REc (Fig. 1) category are referred to as RE elements and those in the REp (Fig. 1) category of IV are referred to as RE challenges. They are investigated separately due to the difference in the nature of problems. However, collectively, all problems are called RE issues. The two problems in the REc category that are a light coverage of RE material in university programs and the need for students to understand the importance of RE are investigated separately. It is also necessary to understand the difficulties students are facing whilst studying RE, in order to compare their opinions with those presented in the IV, and their suggestions for improving the course, which will help identify the problems that need to be investigated further. The study, therefore, is focused on addressing the following research questions with the expectation that answers of these questions will verify the problems presented in IV.

1) How sufficiently have the RE elements and challenges reported in the IV been taught to students in universities?
2) Which RE issues did students find most difficult to understand?
3) Are students satisfied with the current methods of teaching RE?
4) Do students consider RE an important subject to be taught at univeristy?

5) What kind of difficulties do students face?
6) What suggestions do they have to overcome these difficulties?

5.0 METHODOLOGY

The investigation study seeks to investigate students' perceptions of REE problems presented in IV and of RE course taught to them, in order to explore the REE problems they are facing. An investigation was performed using questionnaire which includes quantitative as well as qualitative questions. This section describes the questionnaire used, the procedure and results.

5.1 Questionnaire

The quantitative part of the questionnaire was composed of 42 questions. Student answers to questions corresponding to each element and challenge were graded independently on a five-point scale. The three sections of closed questions were as follows:

1. RE elements and challenges were listed and students asked whether these were taught to them in class. If they had been, could they sufficiently perform them in real projects?
2. RE issues were listed and students asked to highlight those they found difficult to understand.
3. Students' were asked their perceptions of the RE course using different questions (7 items, e.g.: "How do you find the Requirements Engineering course?", "Do you feel that you have been taught the Requirements Engineering course in sufficient depth in class?", "Which approaches has your lecturer used to teach the RE course?"). Answers were graded on three or five-scale rating depending on the question.

With regard to qualitative aspects, the following two open questions were asked:

1. Which problems you faced during the Requirements Engineering course?
2. What are your suggestions for improving the Requirements Engineering course?

These questions resulted in a good range of qualitative comments by participants about REE problems.

5.2 Participants

Software engineering undergraduates were selected as subjects for this study. These students were selected based on the fact that in most Bachelor of Science in Software Engineering (BSc SE) programs, the RE course is offered as a core module. The core module normally covers all aspects of RE, such as RE concepts (e.g., elicitation, analysis, modelling, documentation, verification, conflict resolution, team communication, problem identification), RE tools (e.g., IBM Rational RequisitePro, the Organisation Modelling Environment [OME]) and RE techniques (e.g., dealing with incomplete requirements provided by the customer, changes to the customer's requirements, involving the customer in each phase of the project). Therefore, it is assumed that these students can better respond to the questions related to REE problems.

Two groups of students were involved in the study. One group consisted of 45 students from the University of Malaya (UM), Malaysia, and the other group consisted of 44 students from Mehran University of Engineering & Technology (MUET) and University of Sindh (US), Pakistan.

5.3 Procedure

The questionnaire was distributed amongst the students from UM, and it took around two weeks to complete the study. While an online questionnaire was made available to the students of Pakistan, it took around 3–4 weeks to receive responses. The average time to complete the questionnaire was 20 min.

5.4 Analysis and results

The data was gathered from participants' responses to the questionnaire. The following sections describe the quantitative (closed questions) as well as qualitative (open questions) data, the analysis and results.

5.4.1 Closed questions of questionnaire

The quantitative part consisted of closed questions with rating level of 1–5 (1=Yes, very sufficient; 5=No). Descriptive analysis was used to analyse the data. Fig. 2 shows the students' responses to the first section, which is on RE elements and challenges.

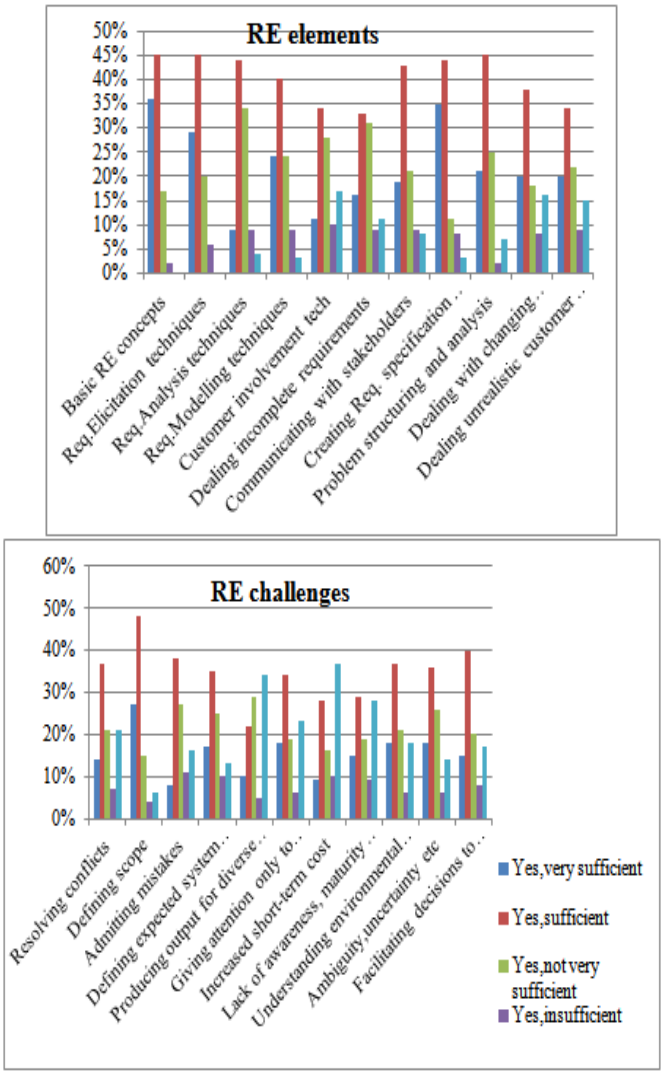

Fig. 2 Students' responses to RE elements and challenges

The overall results showed that RE elements scored a mean of 2.52, and RE challenges scored a mean of 2.83 for all recipients out of 89. This shows that, on average, for RE elements students' responses are more towards the positive side ("yes, very sufficient" and "yes, suffcient") than the negative side ("yes, not very sufficient", "yes, insufficient" and "No"), whereas for RE challenges responses are more towards the negative side ("yes, not very sufficient", "yes, insufficient" and "No") than the positive side ("yes, very sufficient" and "yes, suffcient"). From the results of the first section, it can be observed that almost all the students reported being taught RE elements in the class, and on average more than half felt they had sufficient skills to perform these in real projects, whilst the rest did not believe they were sufficiently equipped with these skills. Around a quarter of students reported that they had not been taught to deal with RE challenges. On average half felt they had sufficient skills, whilst the rest felt they did not have sufficient skills to face the RE challenges of real projects.

Fig. 3 shows the students' responses to the second section of closed question, which is on RE issues.

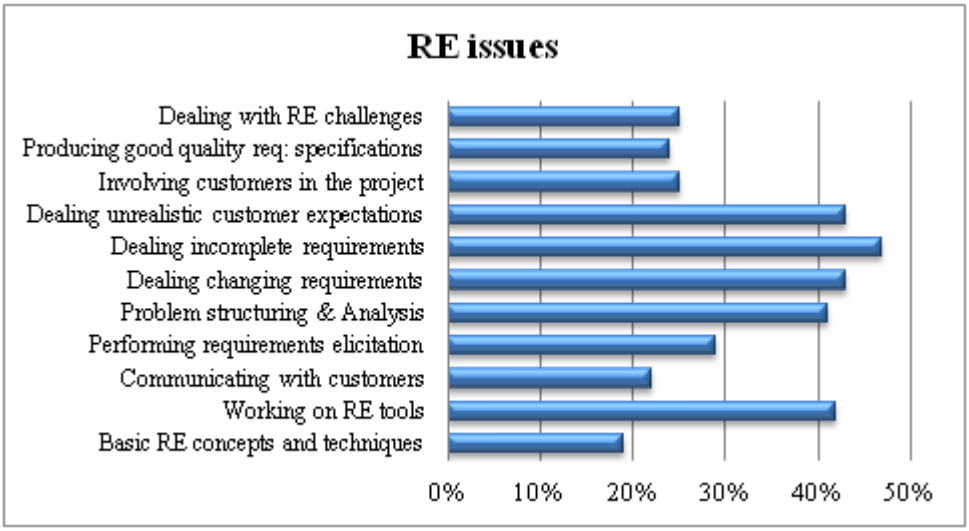

Fig. 3 Students' responses to RE isues they found difficult to understand

From the results, it can be observed that students had difficulties in understanding many issues. The issues they selected were working on RE tools, analysing and structuring real-world problems from customers and dealing with changing requirements, incomplete requirements and customers' unrealistic expectations. However, many students also found other issues difficult to understand.

In the third section of the closed questions, students were asked a number of questions in order to ascertain their perceptions of the RE course, and the results are summarised below.

- The course is taught by means of lectures (selected by all the students), laboratories (63%), presentations (58%) and group discussions (41%). A few students mentioned other approaches, namely class assignments, tutorials and quizzes.
- 40% of students reported that they had not worked on any RE tool, and 60% worked on IBM requisite pro, Rational rose, MS visio and openome.
- The students considered RE an interesting course (51%), average (39%) or boring (10%) .
- Almost all the students felt that RE was an important subject to be taught in universities.
- Most of the students (75%) did not have any industrial experience of performing RE, whilst 25% of them had experience.
- 35% of students wanted to choose RE as a profession; 28% did not; and 37% responded with "don't know".
- Overall, 61% of students responded with "very sufficient" and "sufficient" when they were asked whether they felt the RE course had been taught to them sufficiently, whilst 39% were not satisfied and responded with "not very sufficient" and "insufficient".

5.4.2 Open questions of the questionnaire

For analysis of the qualitative data of the questionnaire, an approach based on grounded theory [17] was adopted as the theoretical framework. In order to analyse and categorise two open questions, an inductive method based on "constant comparative method" [18] was employed.

The constant comparative method consists of the following five phases.

1) Immersion: All detectably different answers are recognised.
2) Categorisation: Detectably different answers are divided into categories.
3) Phenomenological reduction: Themes emerge from the categories.
4) Triangulation: The quotes are used to support the researcher's interpretation.

5) Interpretation: Researcher's interpretation based on supporting quotes is presented, and a complete explanation of outcomes carried out in connection to previous research and/or models. [17]

This method of analysis has been fruitfully adopted in an earlier research examining online music learning [19] and an e-learning as a university module [17].
The chosen method was applied to the results of the two open questions. The results of the first open question ("Which problems you faced during the RE course") are presented below. Fig. 4 reports the first three steps of the quatitative data and table 2 reports the results of the next two steps. In the immersion phase, the answers of the question were read and 64 different answers identified. Then, similar answers were grouped together into 20 categories in the categorisation phase. In the phenomenological redution phase, five themes emerged, which were understanding RE concepts, working on RE activities, lack of practical work, working on RE tools and facing RE challenges. In the triangulation phase, quotes from the answers to the questions were used to support the interpretation of themes.

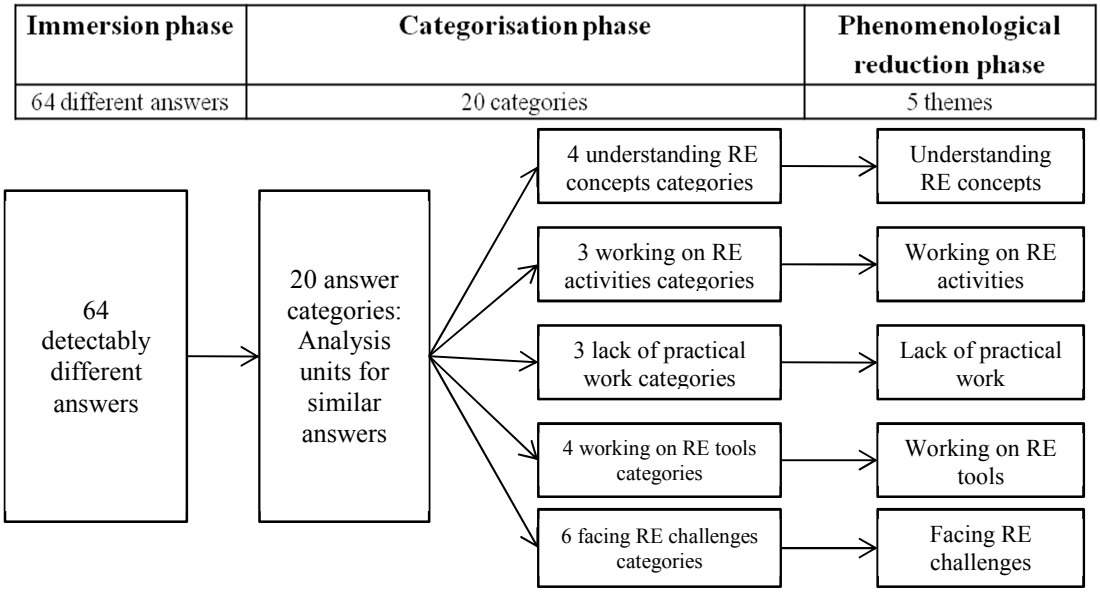

Fig. 4 Diagram of first three steps of the inductive analysis for qualitative part of the questionnaire(problems in RE courses taught in universities)

The results of the second open question ("What are your suggestions for improving the RE course") have been analysed using similar method and are presented below. Fig. 5 illustrates the first three steps of the quantitative data and table 3 shows the results of the next two steps. In the immersion phase, 64 different answers were identified. Subsequently, similar answers were grouped together into 18 categories in the categorisation phase. In the phenomenological redution phase, three themes emerged, which were interpreted as, improving teaching approaches, more practical work and working on RE tools. In the triangulation phase, quotes from the answers to the questions were used to support the interpretation of themes.

Table 2 Triangulation phase: Supporting quotes for the five themes of problems in the RE course taught in universities extracted from answers given by participants

Themes	Supporting quotes	Interpretation
Understanding RE concepts	"There is insufficient information provided during the course". "Difficult to understand information on RE, not fully understand what lecturer teaches". "Hard to understand the concept". "The theories are quite boring and difficult to remember".	These quotes support the reported peoblems faced by participants in understanding RE concepts due to the way RE course had been taught to them.
Working on RE activities	"Difficulty in eliciting requirements". "Not clear about the procedure to elicit or analyse requirements". "Requirements documentation is difficult and troublesome". "Understanding, analysing and structuring initially-presented customer requirements".	These quotes support the reported problems faced by participants whilst studying requirements elicitation, analysis and documentation.
Lack of practical work	"All theory, not much practice, and no involvement/experience of real world projects". "All we have studied is theory; there is a lack of practical experience". "Lack of practical training, all is based on theory". "It would have been better if taught in a practical way, but it was completely theoretical. So it was very difficult to understand the customer, user and requirements".	These quotes support the reported problems faced by participants due to a lack of practical work and inplementation of the RE concepts they had been taught.
Working on RE tools	"Superficial exposure to RE tools". "The creation of package, documents, etc. is not very clear as we had to learn it by ourselves. We need guidance in order to learn the tool, which is difficult to explore". "Difficult to use RE tools – tools are too complex to learn". "The basic problem I faced is the right implementation of the tools used for requirement engineering".	These quotes support the reported problems faced by participants whilst learning and using RE tools.
Facing RE challenges	"I have difficulties in understanding certain concepts in requirements elicitation, managing the changing requirements of stakeholders, and applying techniques to trace the problems". "Uncertain about whether the requirements that I have elicited are correct or complete or not". **"**Problem structuring and dealing with customers' changing and incomplete requirements are very difficult". "Facing uncooperative customers, dealing with their unrealistic expectations and satisfying their requirements seems very difficult".	These quotes support the reported problems faced by participants whilst learning to deal with RE challenges.

Table 3 Triangulation phase: Supporting quotes for the three themes of suggestions for improving the RE course taught in universities extracted from answers given by participants

Themes	Supporting quotes	Interpretation
Improve teaching approaches	"Provide detailed information and examples for each phase. Training should be provided so that students have sufficient knowledge about RE". "Make learning session more interesting and interactive, more group activity/discussion". "Apply what has been taught to real life practice; simulate, for example, how real companies gather and analyse requirements". "The course is good enough, but there should be more attention on different tasks, e.g. creating SRS documents and initial problem structure, as well as validating customer requirements".	These quotes support suggestions provided by participants on improving current methods of teaching the RE course.
More practical work	"Make RE course more realistic, like meeting customers and stakeholders for requirements, not only learning about the theoretical side". "Getting students to deal with real case scenarios instead of just listening to lectures" "Expose students to the industry and let them experience a real work environment" "Visits to the organisations mainly working in requirement engineering field should be arranged for students. This would help them to understand better this field". "Students should be provided the facilities to work on real projects of Industry.	These quotes support suggestions provided by participants on how to include pract ical work in the RE course.
Working on RE tools	"Step-by-step guide on using RE tools should be given". "Universities must provide requirement engineering tools to use". "Proper labs must be conducted to practically show the real projects scenarios so to enhance student's interest in this subject". "Students should be taught to work using RE Tools"	These quotes support suggestions provided by participants on using RE tools in the course.

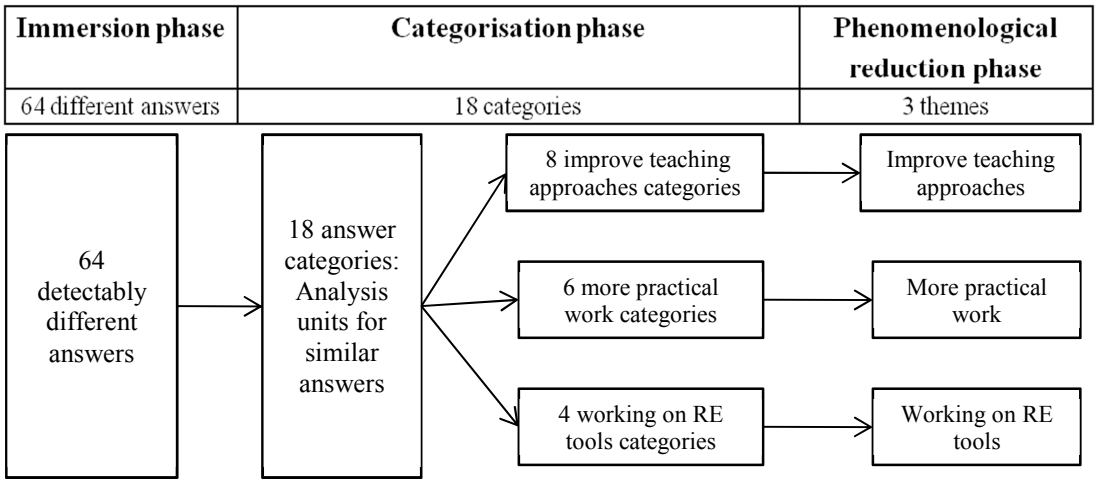

Fig. 5 Diagram of first three steps of inductive analysis for qualitative part of the questionnaire (suggestions for improving RE course taught in universities)

6.0 RESEARCH QUESTIONS REVISITED

The investigation results verified almost all the problems presented in IV. In this section, the answers of the research questions based on investigation results have been presented in comparison to those of the IV.

6.1 Answer to research question one

How suffifiently have the RE elements and challenges reported in the IV been taught to students in universities?

The first two sections of the closed questions are based on this question. The responses are shown in Fig. 2, and the results discussed in section 5.4.1. The results show that almost all the RE elements were taught to students in the class, and most of them felt they had sufficient skills to perform RE for real projects. A significant number of students reported that they had not been taught to deal with RE challenges in class, and many also say that they did not have sufficient skills to deal with those challenges.

From these results, it can be seen that in the teaching of RE courses, basic RE elements were emphasised mostly by the lecturers and taught to students effectively. However, RE challenges were taught less effectively. Therefore, a number of students felt they lacked the skills needed to deal with these challenges.

6.2 Answer to research question two

Which RE issues did students find most difficult to understand?

In total, 11 RE issues taken from IV were listed, and students were asked to check all they found difficult to understand. Their responses are shown in Fig. 3. The most difficult issues were "working on RE tools", "analysing and structuring real-world problems from customers", "dealing with changing requirements", "dealing with incomplete requirements" and "dealing with customers' unrealistic expectations". This result also confirms five of fourteen problems presented in the IV (Fig. 1).

6.3 Answer to research question three

Are students satisfied with the current ways of teaching RE?

Students were asked which teaching approaches their lecturer used, and whether they felt that RE was taught to them sufficiently. Students' responses to these questions are presented in section 5.4.1. They were taught RE mostly in lectures, laboratories, presentations and group discussions. Also, a few students noted assignements, tutorials and quizzes as a means of teaching RE. Most responded that they had been taught RE in sufficient depth in class. This demonstrates that students are quite satisfied with the current ways of teaching the RE course.

6.4 Answer to research question four

Do students consider RE as an important subject to be taught in universities?

Students were asked whether they felt RE was an important subject, how they found the course and whether they would choose RE as a profession in the future. Their responses to these questions are presented in section 5.4.1. Students felt that RE is an important subject to be taught in universities; almost all of them considered it either as an "interesting" or "average" subject. However, the majority did not want to choose RE as a profession in the future, which shows that they still needed more motivation in order to understand its importance. This also confirms the problem presented in the IV ("The need for students to understand the importance of RE") (Fig. 1).

6.5 Answer to research question five

What kind of difficulties do students face?

The answers and analysis of this open question are presented in 5.4.2. The results show that students were facing difficulties in understanding RE concepts, working on RE activities (mainly in requirements elicitation, requirements analysis and requirements documentation), a lack of practical work, working on RE tools and RE challenges. These problems also confirms the rest of the problems presented in the IV (Fig.1).

6.6 Answer to research question six

What suggestions do they provide to overcome these difficulties?

The answers and analysis of this open question are presented in 5.4.2. Students suggested that three improvements should be made**:** improve teaching approaches, more practical work and working on RE tools.

7.0 MAJOR REE PROBLEMS

The investigation results verified almost all the problems presented in integrated view. In addition, the major problems faced by students in REE are extracted. The result of second part of questionnaire lead us to the five most difficult issues chosen by students from those presented, which they are "working on RE tools", "problem structuring and analysis", "dealing with changing requirements", "dealing with incomplete requirements" and "dealing with customers' unrealistic expectations". While the result and analysis of the open questions showed that students were facing difficulties and need improvements in understanding RE concepts, working on RE activities (mainly in requirements elicitation, requirements analysis and requirements documentation), a lack of practical work, working on RE tools and RE challenges. From both of these results, it can be noted that the problem of "Working on RE tools" is redundant and presented in both the results, so it will be presented only once. While the problems dealing with changing requirements, dealing with incomplete requirements and dealing with customers' unrealistic expectations comes under the category of "facing RE challenges" and will be addressed if the problem of facing RE challenges is addressed, therefore these three problems are not considered as major problems. This left us with six REE problems that are teaching problem structuring and analysis, working on RE tools, understanding RE concepts, working on RE activities, lack of practical work and facing RE challenges. These problems can be considered as major REE problems faced by students.

8.0 RECOMMENDATIONS

In an effort to help educators in adressing REE problems and effectively delivering RE course, the pedogogical approaches suggested by researchers are presented and mapped with REE problems, and list of recommendations are presented and a direction framework is proposed in this section.

8.1 Suggested pedagogical approaches to address REE problems

The researchers in their studies have suggested different pedagogical approaches to effectively deliver RE course. These researchers include [1, 3-7, 9, 11-16, 20-22]. The suggested strategies are mapped with the REE problems presented in IV to show which REE problem can be addresed by which pedogogical approach. The mapping is shown in table 4. These approaches can help educators in effectively delivering RE course and in addressing many REE problems. Such as giving group exercises in RE course through can help in addressing four IV problems that are the light coverage of RE material in university programs, teaching communication skills, the need for students to understand importance of RE and a lack of understanding of RE techniques.

Table 4 Mapping of suggested pedagogical approches with REE problems

REE problems / Pedagogical approaches to address REE problems	Problems relating to RE curriculum							Problems relating to RE practice						
	The light coverage of RE material in university programs	Providing organizational experience in RE	Teaching communication skills	Teaching skills to produce good quality requirements	Teaching basic RE concepts and tools	The need for students to understand importance of RE	Teaching students problem structuring and analysis	A lack of understanding of RE techniques	Dealing with RE challenges	Dealing with changing requirements	Dealing with unrealistic customer expectations	Dealing with incomplete requirements	A lack of RE skills	A lack of customer involvement
Lectures	1			1	1		1							
Labs					1			1					1	
Assignments	1				1									
Group exercises	1		1			1		1						
Online discussions			1		1	1								
Project-based learning			1	1				1	1				1	
Experiential learning		1	1	1				1	1	1	1	1	1	1
Improvisation theatre technique			1							1		1		
Role playing/ virtual stakeholders		1	1						1	1	1	1	1	1
Group work			1			1		1						
Facilitated requirements sessions		1	1						1	1	1	1	1	
Educational games	1		1			1		1	1	1		1	1	
Integrated RE into several courses	1				1	1		1						
Peer assessment		1	1						1				1	
Brainstorming meetings		1	1						1	1	1	1	1	
Case studies		1		1		1	1	1	1			1	1	

8.2 List of strategic recommendations for RE course delivery

In order to provide more rectification for REE problems, the list of recommendations have been suggested. The recommendations are geared solely to improve REE and to address REE problems.

In a report entitled "Software Engineering 2004–Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering" [23] by the ACM Education Board and the IEEE Computer Society Educational Activities Board, core software engineering topics are recommended and guidelines for curriculum delivery are provided to help the educators and universities to design and deliver suitable curriculum. From the guidelines presented in the report, those related to RE course and can help to address REE problems are extracted.
In addition, the REE problems presented in IV are investigated from lecturers teaching RE course and RE researchers through a survey and results are presented in [24]. The suggestions given by lecturers to address the REE problems and to improve RE course have been extracted. From the literature, the strategies proposed by the researchers in order to address the REE problems are also explored and extracted.

The lecturers and researchers' suggestions from the investigation results, the recommended RE curriculum and guidelines for course delivery and researcher's proposed strategies finally contribute to the following list of strategic recommendations which have been suggested and compiled to effectively deliver RE course and address REE problems.

- The curriculum designers and instructors
    - Should have sufficient knowledge of RE
    - Should have some real-world experience of RE
    - Shall be recognized publicly as knowledgeable in RE either by having a track record of publication or being active in an appropriate professional society
    - Should possess the motivation and the ability to keep up-to-date with developments in the discipline
- It is important to place the field of RE in context. Visiting lecturers should be invited from industry that can describe real world experiences, and give students a feel for what skills will be important if they find themselves drafted to define product requirements. [4]
- Software engineering is rapidly evolving; hence, most (if not all) courses or curricula can expect, over time, to become out of date. Institutions and instructors must therefore regularly review their courses and programs and make whatever changes are necessary. This guideline applies to curricula or courses developed by individual institutions and faculty. [23] Proper course outlines should be prepared keeping industrial needs in mind [24]
- RE should be taught early in the software engineering discipline through practical material so that students can begin to gain maturity by participating in real-world development experiences (in the work force or in student projects). Such experiences can also raise students' awareness regarding the importance of RE. [23]
- Students should learn to communicate well in all contexts: in writing, when giving presentations, when demonstrating (their own or others') software, and when conducting discussions with others. Students should also build listening, cooperation, and negotiation skills. [23]
- The curriculum must be taught so that students gain experience using appropriate and up-to-date tools. Appropriateness of tools must be carefully considered. A tool should not be too complex, too unreliable, too expensive, too hard to learn given the available time and resources whether in the educational context or in the work context [23]. The selection of efficient RE tools would support the process of learning [24].
- RE course should provide students practical experience by giving them practical examples, using real projects, letting them experience RE activities, providing lab exercises, involving them in industrial projects [24], showing them examples of the same principle in action elsewhere. [23]
- Incorporating real-world elements into the curriculum is necessary to enable effective learning of RE concepts. A program should be set up to incorporate at least some of the case studies, project-based classes (course should be set up to mimic typical projects in industry), practical exercises, student work experience (This could take the form of one or more internships, co-op work terms, or sandwich work terms) [23]
- In order to ensure that students embrace certain important ideas, care must be taken to motivate students by using interesting, concrete and convincing examples. The examples should be of sufficient size and complexity so as to demonstrate that using the material being taught has obvious benefits, and that failure to use the material would lead to undesirable consequences. [23]
- The most common approach to teaching software engineering material is the use of lectures, supplemented by laboratory sessions, tutorials, etc. However, alternative approaches can help students learn more effectively. Some of the approaches that might be considered to supplement or even largely replace the lecture format in certain cases, include:
    - Problem-based learning: RE must be taught as a problem oriented activity [23] and [24]
    - Just-in-time learning: Teaching fundamental material immediately before teaching the application of that material.
    - Learning by failure: Students are given a task that they will have difficulty with. They are then taught methods that would enable them in future to do the task more easily.
    - Self-study materials that students work through on their own schedule. This includes on-line and computer-based learning [23].

9.0 DIRECTION FRAMEWORK

Finally, we propose a direction framework to improve on the implementation of RE course. The direction framework is shown in Fig. 6. The left side of framework includes major REE problems that need to be addressed. While the right side of the framework highlights the recommended directions that can help in addressing REE problems and towards enriching and improving the implementation of RE course. Essentially,

most of the suggestions compiled from the students, lecturers and the literature point towards improvements in teaching & learning approaches, increasing the exposure to the industry-based software project and strengthening and nurturing the requirements analysis and communication skills among students, and improving the curriculum designers and instructors' skills.

Fig. 6 Direction framework

10.0 CONCLUSION

The results of the investigation showed that Malaysian and Pakistani students reported a significant number of problems they faced whilst studying RE. These problems are quite similar to those presented in the IV. Students perceived RE as an important course, but they did not want to choose it as a profession in the future. This may be because RE has been mainly taught theoretically focusing on lectures and, as a consequence; students do not have practical experience of this type of work. Students are taught basic RE elements sufficiently in the class, except, for example, providing them with experience of performing RE activities on industrial projects and techniques to involve customers, which are less discussed in class. Moreover, RE challenges are not emphasised. As a result, students find it difficult to understand many aspects of RE. The main problems reported by students are difficulties in understanding RE concepts, a lack of practical experience, working on RE activities and tools, analysing and structuring real-world problems from customers, and dealing with RE

challenges. Although several studies have investigated some of these challenges, some of them have not been explored such as, the difficulty of teaching students to analyse and structure real-world problems from customers, and the need for them to understand the importance of RE. The main contributions of this paper are to verify the existence of the reported REE in the literature empirically, to provide the mapping of suggested pedagogical approches with REE problems, to identify a list of strategic recommendations for RE course delivery, and to propose a direction framework for RE course implementation.

In conclusion, the teaching of RE should emphasise not only the basic elements or basic skills, but also how to deal with the emerging RE challenges. The RE curriculum designers need to pay attention to improving current teaching practices, and to provide industrial or practical experience in REE. For problems that researchers have investigated, it is needed to apply research results in practice for the use of academics. The problems reported by students that were not investigated properly must be explored in future, and their interest in RE needs to be developed further so that their motivation to choose RE as a leading profession is triggered.

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