

# Teaching and Learning Software Requirements Engineering: Our Experience, Reflection and Improvement

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**Abstract**—One problem faced by lecturers in teaching software requirements engineering subject is that it covers vast domain across multidisciplinary fields ranging from Social Science to Computer Science. Additionally, the not too practical but mainly theoretical exaggeration of the subject matter has made learning to be boring as seen by many Malaysian students. This paper shares the experience of teaching and learning software requirements engineering in Faculty of Computing and Informatics, Multimedia University under the Malaysian Software Testing Board Academic Outreach Program. Students' feedback on the contents of reading materials, provided as complimentary for learning the software requirements engineering subject, are gathered and their comments are noted for improvement. The lecturers conducted a detailed analysis on the contents of reading materials and several suggestions for improvement on reading materials are presented. We believe that with further improvement on the contents of reading materials and certification examination together with our proposed Internet of Thing (IoT)-aware requirements engineering model, this academic outreach cum industry-link program shall continue to flourish in its effort to develop the nation with more professionals in requirements engineering. This is in-line with the 11th Malaysia Plan's strategy of accelerating human capital development for an advanced nation, particularly in the era of IoT.

**Index Terms**—Academic Outreach Program; Certified Professional for Requirements Engineering; Internet of Things; Software Requirements Engineering.

## I. INTRODUCTION

Multimedia University (MMU), located at Cyberjaya, Malaysia, is one of the pilot universities which since June 2014, has joined the Malaysian Software Testing Board (MSTB) Academic Outreach Program for Requirements Engineering. This program provides an opportunity for MMU's lecturers to gain more knowledge and exposure from industry and experts in the software requirements engineering field. This academic outreach program has also provided the opportunity for our undergraduate students to participate in Certified Professional for Requirements Engineering-Foundation Level (CPRE-FL) training and after passing the certification examination, be certified as professionals in requirements engineering. This paper presents a study that embarks on looking for improvements to enhance further the MSTB academic outreach program and the certification examination. Especially in this era of Internet of Things (IoT), the academia has to be in par with the industry.

A systematic review carried out by [1] revealed that 30 published papers were found in the literature where lecturers

shared their personal experiences to teach requirements engineering subject. Many lecturers faced common challenges due to the nature of requirements engineering that covered multidisciplinary fields ranging from computer science to social science [2]. In addition, a survey conducted by [3] showed that majority students in Malaysian universities perceived software requirements engineering as boring subject due to exaggerate on theoretical rather than practical and subsequently led to failure in applying the theoretical knowledge in real world. The result also highlighted that students did not use specialized requirements engineering tools and they faced problems in preparing requirements specification. So, various strategies were proposed to teach requirements engineering such as role play [4], game play [5], global team [6], improvisation theatre techniques [2] and others. Since every country has different university resources, this paper presents a strategic-partnership approach to teach software requirements engineering in Malaysian university.

## II. BACKGROUND

This section provides a narration of the events in chronological order that lead to this study.

### A. Malaysian Software Testing Board

Malaysian Software Testing Board (MSTB) is incorporated in June 2008 and this national body aimed to nurture the important of software testing and software quality assurance in local industry especially those developing products and services related to Internet of Things. MSTB is also a member of International Software Testing Qualification Board (ISTQB) and actively promoting professional certification among local practitioners.

Beside certified tester schemes, MSTB acknowledged that a good fundamental knowledge of software requirements engineering is a requisite among practitioners in local industry. Thus, MSTB partnered with International Requirements Engineering Board (IREB) to promote certified requirements engineering schemes.

MSTB also initiated a partnership with Government of Malaysia in order to push the growth of competent knowledge workers that are able to meet the local industry requirements. Under this initiative, MSTB works closely with Malaysian universities through academic outreach program such as train-the-trainer workshop, training and certification examination for students.

### B. Train-the-trainer Workshops

In March and May 2015, Professor Dr. Klaus Pohl (Prof. Pohl) conducted two workshops respectively for Malaysian university lecturers under the MSTB academic outreach program. Prof. Pohl is a German computer scientist and Professor for Software Systems Engineering at the University of Duisburg-Essen. Being one of the founding members of IREB, Prof. Pohl is well known for his work in Requirements Engineering. He has vast research interests that include but not limited to digital systems, connected systems, service-based systems and software product line engineering.

During these workshops, Prof. Pohl had willingly shared out his experience and teaching materials for teaching software requirements engineering. Much discussion and interaction between Prof. Pohl and the lecturers were carried out on important software requirements engineering concepts based on the teaching materials (a book by Prof. Pohl) which covered 28 different topics including fundamental, system context, core activities, requirements artifacts, validation and management. Prior to these workshops, the lecturers had gone through formal training in software requirements engineering and obtained CPRE-FL from IREB.

At the end of the workshops, MSTB supplied each university with a set of teaching materials, which included lecture slides and lab exercises. Due to differences in teaching policy and coursework assessment among Malaysian universities, all lecturers were given the flexibilities to customize the content of teaching materials accordingly. In other words, the same teaching materials were used across different universities but the lecturers were allowed to re-arrange delivery of lecture contents with their subject assessments, emphasize certain lecture contents in order to fulfill their subject learning outcomes, and add supplementary materials such as additional examples if necessary.

### C. Software Requirements Engineering Subject

The Faculty of Computing and Informatics (FCI) of MMU, through this academic outreach program, offered the software requirements engineering subject (SWRE) where syllabus was tailored to follow twenty-eight topics of teaching materials used in the Train-the-trainer workshops. This SWRE subject was offered for fourteen weeks from 16 November 2015 until 28 February 2016. The students were evaluated based on four assessment criteria, namely mid-term test, lab activity, project and final examination.

For the project, the students worked in groups with each group consisting of seven members. The students took two different roles (requirements engineer and stakeholder) as they progressed through three core activities of requirements engineering, such as elicitation, documentation and negotiation. The lecturer assigned each group with respective stakeholders that demanded a new IT system for their company. The first step required the students to produce a short video clip that summarizes elicitation techniques used in their project. Then, the students were asked to deliver software requirements specification (SRS) and system requirements specification (SyRS) for their respective stakeholders. After that, the students negotiated with their respective stakeholders based on validation of SRS and SyRS. At the end, the students managed changes of SRS and SyRS. Occasionally, the lecturer reorganized sequence in delivery of lecture contents so that the students can complete their group project with the different roles to play in time.

### D. CPRE-FL Training and Certification Examination

Twenty-six students from the class of SWRE participated in a three-days (June 21-23 2016) CPRE-FL training and then sat for certification examination on 24 June 2016. Although MSTB covered all training and examination expenses, the students were given only one attempt to pass the certification examination. To preserve full confidentiality of the contractual agreement with MSTB, this paper can only reveal that a small number of them passed the CPRE-FL examination and being certified as professionals in requirements engineering.

A survey was conducted to determine whether the reading materials provided for SWRE subject and CPRE-FL training are useful for the preparation of certification examination. The survey consists of two open ended questions to allow students to response either a positive or negative answer with justification. The first question being "Do you think the study materials such as text book, lecture slides, lab exercises, and so on provided for the subject SWRE subject is useful and help you in preparation for the CPRE-FL examination?", the second question is "Do you think the study materials such as text books, lecture slides, lab exercises, and so on provided for the CPRE-FL training is useful and help you in preparation for the CPRE-FL examination?". The third is opinion gathering for students to provide comments and suggestion for improvement concerning the SWRE subject, the CPRE-FL training and examination. Majority of them responded positively that all reading materials provided do help them in preparing for CPRE-FL examination. Further discussion on this could be found in section III.

## III. STUDENTS' FEEDBACK

For the SWRE subject, students are given a set of reading materials with exercises in hardcopy. These reading materials contain lecture slides for twenty-eight chapters. These reading materials are: Study Guide Part 1 [7] and Study Guide Part 2 [8]. The contents of these reading materials are based on a textbook authored by Prof. Pohl [9].

For CPRE-FL training, additional reading materials are provided for the students as follows: A Study Guide for CPRE-FL Exam [10], CPRE Foundation Slide [11], CPRE-FL Syllabus Guide with Training Questions [12].

### A. Students' Feedback on Reading Materials

Table 1 is a summary of the feedbacks from the students regarding the reading materials.

In short, the students agreed that Study Guide Part 1 and Part 2 covered wider scope than Study Guides provided for CPRE-FL training and exam. They proposed to have Study Guide Part 1 and Part 2 in softcopy because the hardcopies were too heavy for them to bring along every week.

### B. Students' Feedback on Training and Examination

Students also provided feedbacks concerning the CPRE-FL training and certification examination. Table 2 displays the summary of the feedbacks.

In sum, the students preferred to enroll for CPRE-FL training and examination immediately after they completed SWRE subject. If the time gap is too long, some students may face difficulty to recall the knowledge learned during SWRE subject. They also need more mock exam exercises due to the unique CPRE-FL exam marking scheme. For instance, the

student's mark is deducted for a multiple-choice question especially when he/she picked 1 wrong answer. Due to consecutive 3 full-days training, they also suggested a rest-day gap between training and certification examination.

Table 1  
Student' Feedback on Reading Materials

Item#	Students' Feedback
1	The SWRE reading materials [7-9] are very detailed and cover a wider scope than what is required for the certification examination.
2	They [7-8] serve as an early or pre-preparation for the certification examination.
3	Video tutorials would be more comprehensive and slides [7-8] could be made available online in pdf format. Online reading materials shall be less burdensome than the on loan-basis thick and heavy hardcopy reading materials.
4	Even though the lecturer had made the effort of announcing to class what reading materials to bring one week before every lecture class. The study guides [10-12] are not so detailed but provide enough information for preparation of the certification examination.
6	The study guide [10-12] serves as a re-fresher course and especially useful are the mock test questions.

Table 3  
Improvement Suggestions for Reading Materials

Item#	Item Description	Improvement Suggestion
1	Natural Language Template (NLT) UML Activity Diagram (UML AD)	All reading materials of [7-10] provide explanation on the use of Natural Language Template for requirement construction. However, detailed steps in how it could be applied are only provided in page 53-57 of reading material [10]. From experience, including these detailed steps in using NLT shall enhance further learning.
2	UML Activity Diagram (UML AD)	Page 187-189 of reading material [9] and page 79-82 of [10] provide explanation on usage of UML Activity Diagram. These details are missing in reading materials [7-8]. As this is part of the syllabus for certification examination, it is suggested to include details of UML AD in all reading materials.
3	Tools Support	The topic on Tools Support is explained on page 139-147 of reading material [10] quite substantially while in [9], it is discussed generally and not as a whole topic by itself. However, this part of the topic is missing in reading materials [7-8]. Since questions are asked about this topic in certification examination, it is suggested that reading materials [7-8] should cover this topic as well.
4	Requirement Validation Techniques	Although there are a number of slides in reading materials [7-8] for explanation on requirement validation techniques, they are not as detailed as in chapters 28 and 29 of [9] and page 97-104 of [10]. It is recommended to have detailed explanation on requirement validation techniques in reading materials [7-8] as well because it is stated in the syllabus as an important topic.
5	Elicitation Techniques	All reading materials provide explanation on elicitation techniques in detail but page 24-30 of reading material [10] give a good account of each technique under its specific category. This categorization helps students to understand better which technique to use with respect to different situations.
6	Entity-Relationship Diagrams (ERD)	Page 71-73 of reading materials [10] display ERDs based on Chen [13] notation on cardinality constraint whereas ERDs on page 227 of reading material [9] and page 11, slide 22, L1-11 of [7] use another standard notation standard. Standardizing ERDs notation shall avoid confusion for all readers.
7	Class Diagram for Generalization Set	Symbols used to represent generalization set in class diagrams differ on page 228-229 of reading material [9] and page 10-11, slides 19-22 of L-12 of [7] while these class diagrams are not used in reading materials [10]. There should be one standard type of symbols used across all reading materials to avoid confusion.
8	Page and Slides Numbering	The page and slide numbering system for reading materials [7-8] are quite confusing as the lecturer has experienced that students are not referring to the correct page and slide because the slide and page numbers given are the same. There should be a better way in numbering the slides and page numbers.

These suggestions were presented at a post requirements engineering workshop on 5 September 2016 in conjunction with the 9th Software Testing Conference (SOFTEC Asia 2016). Prof Klaus Pohl welcomed these improvements and MSTB agreed that certain actions can be taken to improve the readability and quality of reading materials. On 22 February 2017, a revised version of reading materials was presented by MSTB which incorporated some of earlier suggestions. A reading guide was included so that students can use revised version of reading materials effectively and efficiently.

#### V. REFLECTION AND OTHER IMPROVEMENT

Based on teaching experience, another suggestion for improvement is to encourage students to read the case study

Table 2  
Student' Feedback on CPRE-FL Training and Certification Examination

Item#	Students' Feedback
1	Four or more -days training, instead of the 3-days, is preferred and there should be at least one day's gap between the CPRE-FL training and the certification examination.
2	The CPRE-FL training and certification examination should start not too long after the SWRE is completed so that what have been learnt in class is still fresh in mind. More practical exercises and mock exam-like questions would serve better in preparing the students for the certification examination. This shall help students to get more oriented towards a different question format of the examination.

#### IV. READING MATERIALS ANALYSIS FOR IMPROVEMENT

An analysis on the contents of all the reading materials is conducted by the lecturers and improvement suggestions are summarized as shown in Table 3. A consistency across all reading materials should be applied so that the students can learn the material effectively. Sometimes, detailed steps are needed to illustrate how a new concept can be used. A proper usage of page numbering in reading materials could allow the students to follow the lesson easily.

prior to start of the lab session. This shall avoid students not having enough time to complete the exercise due to their spending most of the time in the lab to read and understand each case study. During lab session, the students are asked to present their solutions and other students are encouraged to give constructive comments on the presented solutions. This peer learning approach [14] would let the students to become an effective communicator, which is also an important skill for requirements engineer.

Additionally, lecturers are encouraged to be selective and focus more on important content during lecture sessions. They also need to get familiarize with the teaching materials so that they can supplement additional materials in the future. Most students may not be able to focus their attention during lecture and lose their interest when they were not able to cope

up with fundamental concepts. A typical lecture class can be transformed into interactive classroom by encouraging the students using their mobile device [15]. Various mobile activities can be carried out to engage the students such as getting students' opinion and feedback, assessing students' learning outcome, and promoting group discussion.

The lecturers also need to gain more latest knowledge and researched more on requirements engineering topics. For example, gathering system requirements for IoTs may require more domain specific knowledge (e.g. Cloud, Mobile) and innovative elicitation techniques. Furthermore, lecturers can invite industry practitioners to share their work experiences, especially in requirements engineering, during one of the lecture sessions [16]. Sometimes, a company visit would expose the students on real working environments for requirements engineer.

Last but not least, there should be more support channels such as video conferencing, online discussion forum and online real-life practical examples for tutorials which could all be realized by IoTs to enable lecturers who would like to seek further knowledge with the experts, far or near.

### VI. EMPOWERING REQUIREMENT ENGINEERING TOWARDS IoT

According to [17], smart connectivity with existing network resources such as WiFi and 4G-LTE is an indispensable part of IoT. As such, the computing paradigm has to encompass the IoT's concept of being contextual, i.e. the software architectures and pervasive communication networks is to process and convey the contextual information to where it is relevant in real time for autonomous and intelligent behavior. Many of such smart and contextual-based IoT's devices and application are already exist in the market and more are still in the research mode. An example of existing IoT's device and application is the Nest's smart thermostat [18]. This smart system learns the user's habits and will fine-tune the room temperature based on user presence state, user activity state and others. This thus helps in managing power efficiency and saving on air conditioning bills. The embedded mobile application even allows users to monitor and alter the home temperature from remote. Additionally, users would be able to receive alerts when something has gone wrong with the heating or cooling system.

The Internet of things (IoT) technology, therefore, has given rise to another revolution in smart system development whereby the development and deployment processes for these smart systems shall be of shorter life cycle and more iterative and interactive in nature.

As IoT will be transforming every technology product, there is a need to ensure that our students able to support requirements specification, design and development of new IoT technology in near future. To equip our students with right IoT knowledge and skills, FCI had offered a new undergraduate program which specialized on data science. This new program, integrating with the Cloudera Academic Partnership program, exposed the students to forefront data analytics skills and extensive Apache Hadoop-based training. At present, there are about 50 students enrolled under this data science program. With this fundamental knowledge, we believe that our students would be able to overcome the challenges required for implementing connected smart systems.

From the software engineering aspect, requirement engineering (RE) shall have to encompass the contextual element with shorter requirement engineering cycles and be more iterative and interactive in nature. We, therefore propose the RE processes to include design and prototyping activities to make the IoT system to be marketable at a short time frame to gain competitive advantage.

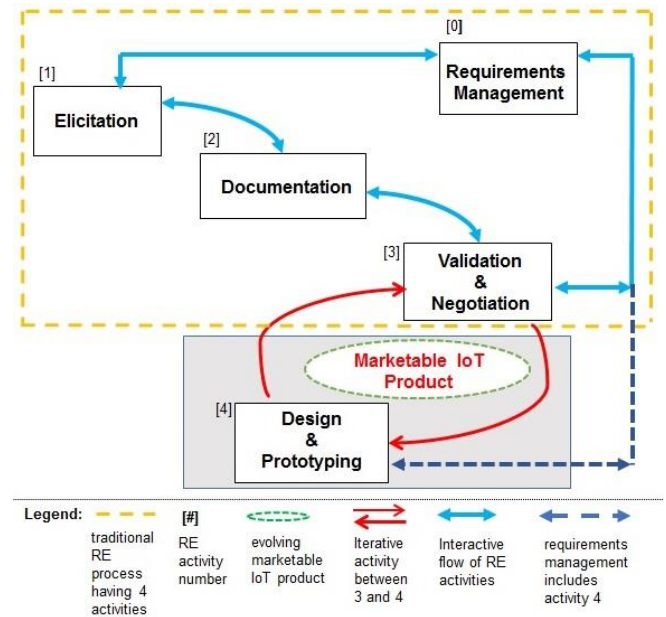


Figure 1: The IoT-awared requirements engineering cum development model

The traditional approach towards requirement engineering consists of four main activities of requirements management, elicitation, documentation, validation and negotiation [10]. In requirements engineering, the practice of gathering software or system requirements from the users, customers or other stakeholders is known as elicitation. Requirements gathered should then be documented adequately using natural language, diagramming or modeling tools. Validation and negotiation activity is to check if the requirements gathered meet certain quality criteria and to resolve any conflict thus arises. Changes to and implementation of requirement have to be managed properly and consistently. Referring to Figure 1, these four activities are numbered 0, 1, 2, and 3 in this order. However, they should not be executed sequentially but rather more iteratively and interactively in relatively concurrent manner. Under this proposed requirements engineering cum development model, the design and prototyping activity (Figure 1, activity number 4), which involves formalizing the requirements into software architecture or designs and at the same time realizing a product through prototyping, shall be iteratively going through many cycles and interactively with the validation and negotiation activity (Figure 1, activity number 3) until a marketable IoT product evolved. The requirements management activity is extended to include the design and prototyping activity so as to complete the whole cycle of requirements engineering cum development process. Thus, with this proposed requirements engineering cum development model, the marketable IoT product after being fully tested, could be realized and released to market at a shorter time frame.

## VII. CONCLUSION AND FUTURE WORK

Students and lecturers of FCI, MMU have benefited under this MSTB academic outreach program for requirements engineering. We believe that with further improvement on the contents of the reading materials and certification examination as suggested in this paper, this academic cum industry-link program shall continue to flourish in its effort to develop the nation with more professionals in requirements engineering especially in this era of IoTs. This is also in accordance with the 11th Malaysia Plan's strategy of accelerating human capital development for an advanced nation [19].

Our future work shall include pilot testing our proposed IoT-awared requirements engineering cum development model in our software requirement engineering (SWRE) subject or the data science program for the development of an industry-linked IoT smart application. Challenges encountered during implementation and results of implementation on this proposed model can then be benchmarked for future improvement.

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## REFERENCES

- [1] S. Ouhbi, A. Idri, J. L. Fernández-Alemán, and A. Toval, "Requirements engineering education: a systematic mapping study," *Requirements Engineering*, vol. 20, no. 2, pp. 119-138, June 2015.
- [2] R. L. Quintanilla Portugal, P. Engiel, J. Pivatelli, and J. C. do Prado Leite, "Facing the challenges of teaching requirements engineering," in *Proc. of the 38th International Conference on Software Engineering Companion*, 2016, pp. 461-470.
- [3] R. N. Memon, R. Ahmad, and S. S. Salim. "Problems in requirements engineering education: a survey." in *FIT '10 Proceedings of the 8th International Conference on Frontiers of Information Technology*, 2010, pp. 1-6.
- [4] D. Zowghi, and S. Paryani, "Teaching requirements engineering through role playing: Lessons learnt," in *Proc. of the 11th IEEE International Requirements Engineering Conference*, 2003, pp. 233-241.
- [5] R. Smith, and O. Gotel, "Gameplay to introduce and reinforce requirements engineering practices", in *Proc. of 16th International Requirements Engineering*, 2008, pp. 95-104.
- [6] D. Damian, B. Al-Ani, D. Cubranic, and L. Robles, "Teaching requirements engineering in global software development: a report on a three-university collaboration," in *Proc. of 1st International Workshop on Requirements Engineering Education and Training*, 2005, pp. 1-7.
- [7] K. Pohl, *Engineering Foundation Level: Part 1 of 2*. Malaysian Software Testing Board (MSTB), 2015.
- [8] K. Pohl, *Engineering Foundation Level: Part 2 of 2*. Malaysian Software Testing Board (MSTB), 2015.
- [9] K. Pohl, *Requirements Engineering: Fundamentals, Principles, and Techniques*. Springer, 2010.
- [10] K. Pohl and C. Rupp, *Requirements Engineering Fundamentals: A Study Guide for the Certified Professional for Requirements Engineering Exam - Foundation Level/IREB Compliant*. Rocky Nook Computing, 2015.
- [11] Custommedia, "Certified Professional for Requirements Engineering Foundation Slide," Custommedia 2015, Authorized Training Provider, Malaysia.
- [12] Custommedia, "Certified Professional for Requirements Engineering Foundation Level (CPRE-FL) Syllabus Guide with Training Questions)," Custommedia 2015, Authorized Training Provider, Malaysia.
- [13] P. Chen, "The entity-relationship specification – toward a unified view of data," *ACM Transactions on Database Systems*, vol. 1, no. 1, pp. 9-38, 1976.
- [14] A. M. Connor, J. Buchan and K. Petrova. "Bridging the research-practice gap in requirements engineering through effective teaching and peer learning," in *2009 Sixth International Conference on Information Technology: New Generations*, 2009, pp. 678-683.
- [15] M. Tlhoale, A. Hoffman, A. Naido and K. Winnips, "Using clickers to facilitate interactive engagement activities in a lecture room for improved performance by students." *Innovations in Education and Teaching International*, vol. 51, no. 5, pp. 497-509, 2014.
- [16] A. Sivaji, S. S. Tzuaan and L. T. Yong, "Academic-industrial cooperation in Malaysia: A case study," in *Proc. of 4th International Conference on Computer Engineering and Mathematical Sciences, Science and Knowledge Research Society*, 2015.
- [17] J. Gubbi, R. Buyya, S. Marusic and M. Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions," *Future Generation Computer Systems*, vol. 29, pp. 1645-1660, 2013. "15 Examples of Internet of Things Technology in Use Today," Available at <https://beebom.com /examples-of-internet-of-things-technology>. [Retrieved April 2017].
- [18] *Economic Planning Unit, Eleventh Malaysia Plan 2016-2020 Anchoring Growth on People*. Economic Planning Unit, Prime Minister's Department, Malaysia, 2015.