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# **Using T-Reqs As Teaching Solution For Requirements Engineering In Second Cycle University Courses**

## **Design Science Research**

Bachelor of Science Thesis in Software Engineering and Management

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# Using T-Reqs As Teaching Solution For Requirements Engineering In Second Cycle University Courses

Design Science Research

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**Abstract**—RE education should be realistic and reflect the progress reached within industry [1]. Recently, T-Reqs has been proposed as a simple, yet powerful tool to manage system requirements in large-scale Agile development within industry. This study will investigate whether T-Reqs can be used in RE education, by proposing a concept for using it in a Master level requirements engineering course. In order to achieve this, a design science research was performed. Multiple course stakeholders, instruments and artefacts will be involved in discovering the course challenges and addressing them with T-Reqs. The final decision incorporating new teaching evaluation and assessment directions will be given by the current RE team and discussed with other teachers. The first iteration of the study ends with a list of existing RE challenges, some of which have been addressed with T-Reqs and for which a student training material was produced. It is accompanied by teaching assessment remarks on how to didactically proceed with T-Reqs' introduction to the course. The results of the first iteration of this study suggest that T-Reqs can be introduced in the next instance of the RE Master course as a recommended auxiliary/helping RE tool. Consequently, students would try T-Reqs and provide further feedback in order to continue improving it.

**Keywords**—requirements engineering, RE, T-Reqs

## I. INTRODUCTION

Requirement engineering (RE) is continuously considered as an important software process, where it identifies and elaborates the needs of stakeholders, e.g., developers and users (including students, teachers and course administrators) [2] [3]. Moreover, the use of RE processes can lead into creating feasible software systems due to emphasising on stakeholders' needs [4].

Nowadays, numerous challenges have been revealed when applying RE in large-scale Agile system development [5] [6], where those challenges might affect RE working flow negatively, e.g., difficulty of getting feedback about user value during sprints.

An advantageous tool has been developed in order to solve certain challenges within industry work: T-Reqs [1]. This

tool represents a text-based requirements management solution based on Git version control system. It has been developed in order to provide solutions for the challenges within large-scale Agile system development, which serve Agile teams to perform CRUD operations (i.e., create, read, update and delete) and visualise the requirements [1]. Moreover, T-Reqs uses formatting in text files within Git, in order to manage the requirements. Within industry, Ericsson AB adopted T-Reqs due to heavy challenges regarding the visibility of requirements within the software development cycle, for which developers are not aware of change in requirements until a new iteration.

T-Reqs' strongest feature consists of its integration within the Git system. In order to use it, one should fork and/or clone the original repository. This would have positive repercussions on the students, as they would have a tool integrated in their daily version-control system. Moreover, students would all use a common tool which would collect their specifications and make them visible to the rest of the group/members. Other major improvements are in the organisational area which translates (i) for the teacher, a better control over the handed-in assignments and (ii) for the students/groups, a better task distribution. T-Reqs works within the terminal, executing several python scripts in order to check for traces within specified folders. At the moment, user stories, system requirements and test cases are implemented and can be referenced one with another. The open source project accepts external developers who would like to improve the system to use pull requests for pushing to the original remote.

### A. Statement Of The Problem

DAT231/DIT276 [1] is a 7.5 hp second-cycle course in requirements engineering, provided by both Chalmers and the University of Gothenburg, which focuses on teaching how to find and collect requirements from relevant sources, as

<sup>1</sup>[DAT231/DIT276 - Course Page](#)

well as addressing them using a provided template by the course responsible, both at the start and during a software development project. On one hand, the course gives students a way of managing requirements engineering, e.g., the students can identify stakeholders, as well as they can write the requirements alongside its specifications. But on the other hand, provided topics of the RE course are considered as new challenges for students that need to be addressed.

There are different ways of solving RE course related problems, as well as teaching students how to implement solutions for projects or assignments. In addition, new technologies could have significant impact on academic environments and how students can improve their knowledge and their understanding level of the course, alongside learning new tools. This could lead to have more advantages, while new challenges might be introduced in a parallel way.

Students should be able to define the requirements in their projects, regardless complexity or ambiguities, and even to be able to update and adapt their requirements within the course period, as well as using any tool. One of the challenges faced by the course teacher, is to use an appropriate pedagogical way (e.g., a tool) in order to remove learning obstacles, such as efficiently writing good requirements in software development projects.

Many commercial requirement tools are available on the market [7], but students do not have any idea of which tool can be used in a useful way of defining/updating requirements in their software development projects, since the RE course did not provide desired information of such tools. More specifically, multiple challenges found in the course need to be dealt with in an efficient way. Such challenges may include (i) lack of compiling a complete specification from different parts of the requirements, (ii) having inconsistencies when updating individual parts, (iii) lack of providing a change log and high quality content for each artefact while creating automatic feedback and (iv) lack of traceability among teams requirements when notifying about new changes.

### B. Purpose Of The Study

The purpose of the study is to find concrete solutions to commonly addressed problems within the software requirements engineering second-cycle course by bringing an innovative RE tool, which aims to have positive impact on development speed, management of requirements and spread of information. More specifically, the research stimulates an iterative qualitative study, which discovers course graduates' common issues regarding the current teaching tools, in order to check T-Reqs' performance into solving the challenges.

In this study, we introduce T-Reqs and its capabilities in managing requirements specification, in order to improve and modify the requirements engineering phase in software development projects. In addition, we remove challenges and obstacles in the way of defining requirements for software development projects, starting with the related course at the University of Gothenburg.

This research is conducted in order to contextualise T-Reqs' features, based on the challenges for defining the requirements in the RE course, and also to evaluate whether using this tool helps to solve ambiguity of defining requirements. In this way, we start decoupling T-Reqs usage from large-scale development and port it into educational environments.

We have identified a list of potential beneficiaries involved in different audiences:

Graduate students will have the possibility to understand requirements engineering principles and test their knowledge learning a tool used in industry. They will practically test and provide valuable feedback into continuing the tool's further evolution and development, finding new ways of applicability and bringing new updates.

T-Reqs features of managing requirements support simplifying the evaluation of requirement engineering concepts, thus teachers will be able to better understand the overall degree of acquired skills a student possesses. Therefore, the tool will be available to support the educational system regarding requirements engineering lectures, starting with the MSc Software Engineering and Management program at Gothenburg's University.

Researchers: Our study continues the research started by [5]. As an open-source project, T-Reqs will receive further contributions and updates from other practitioners and therefore enlarging the research material.

### C. Artefact

The artefact produced in this first iteration of the study can be seen as a usage concept, build from a learning and teaching perspective, based on T-Reqs and supporting tools, and referred to as *T-Reqs Edu*.

The learning concept is composed of a training material, including a T-Reqs user manual with guidelines on how to get up and running with the new RE tool and a set of exercises.

The teaching concept contains an evaluation and discussion over the feasibility of the tool to be introduced into teaching, taking into consideration the learning outcomes and the current features offered by T-Reqs. It will be submitted to the review of two professors affiliated with University of Gothenburg and Chalmers which are doing research in areas such as requirements engineering and traceability.

### D. Significance of the Study

This study extends previous acquired knowledge about requirements engineering traceability. It specifically promotes T-Reqs, by expanding its industrial large-scale development usage for educational purposes. The augmentation nature has both substantive and theoretical significance. The substantive approach manifests the qualitative aspects of teaching using T-Reqs from the analysed data, while the theoretical approach reveals relevant short-term solutions in order to ameliorate the understanding of requirements engineering concepts through innovative teaching tools and their impact in the long-term. Thus, the results of the study have positive effects in practice, as it continues to bring industrial updates closer to

the academic world, diminishing the innovation gap between universities and industry. From a research point of view, T-Reqs introduction to teaching requires an updated revision of educational practices and course learning outcomes which would determine whether there is a possible fit inside educational tools.

The paper presents the following structure: Section III supports our design science study by collecting multiple trustworthy papers, split into [background](#) and [related work](#). The research methodology is outlined in Section III, including (i) research questions, (ii) research design, (iii) data collection, (iv) analysis and (v) validity threats. Results are presented in further detail in Section IV which exhibits the produced artefact and the data collected through interviews, workshop and questionnaire. It follows a discussion of our results with respect to other RE tools evaluations in V. Finally, Section VI hosts the the paper’s key concepts and findings, as well as proposing a way of taking this study further.

## II. LITERATURE REVIEW

### A. Background

In a recent study, Knauss discusses potential requirements engineering challenges within large-scale Agile system development [5]. Those challenges represent the main gaps of RE, meaning they prevent Agile teams to manage/update requirements when working on different projects. The paper obtained potential solutions that might positively address the challenges, which make it easier to significantly handle the RE of the large-scale Agile system development projects. The study concludes with the need for the research to be taken further i.e., the mentioned challenges need to be addressed by people, who are willing to come up with desired solution ideas in order to address the challenges in a reasonable way [5].

Furthermore, Inayat et al. [8] have discussed different challenges faced by Agile teams in order to understand how those challenges can be solved using Agile requirement engineering. The authors have concluded that the challenges within Agile development can be addressed using certain Agile RE practices which helps identifying the real problem of each challenge as well as finding a significant way to address it.

Knauss et al. [1] have developed a requirement tool named T-Reqs<sup>2</sup> in order to be used for managing RE artefacts in large-scale Agile system development. From a positive perspective, Agile teams can update/manage user stories, system requirements and test cases using T-Reqs, for example, the possibility of creating new templates for user stories, system requirements and test cases as well as traceability support among them. However, many challenges still exist and need to be addressed in order to get a cohesive work environment among development teams. For example, when multiple teams attempt to update the same requirements, undesired work conflict among teams is produced. Hence T-Reqs is a suitable tool to solve such problems since it allows teams to provide immediate feedback of the requirements by creating issues on

Github in order to whether keep the requirements as they are or changing them if needed.

T-Reqs is a RE text-based tool written in python. It uses “.md” markdown files (i.e., templates) which can be filled out with user stories (US), system requirements (SR) and test cases (TC) as text. In addition, T-Reqs supports traceability by providing each of US, SR and TC with different “IDs”, in order to check the consistency among them. After filling out the templates, the user executes T-Reqs by typing “treqs” on the terminal in order to check the change log file, which presents the gaps between US, its SR and its TC, e.g., lack of traceability between user story A and system requirement B, duplicate user stories and/or system requirements etc.

Furthermore, Ericsson AB [1] uses T-Reqs in their projects in order to managing the RE of those projects using Git and Gerrit. The authors have concluded that T-Reqs is a desired tool to be used to address some of the mentioned challenges, cited by Knauss [5], as well as it can be improved to handle and address other RE challenges in different environments.

### B. Related Work

This section shows related work concerning RE tools, RE tool comparison frameworks and RE tool surveys.

The current state of art suggests that the worldwide marketplace is saturated with information about RE engineering tools from major tool vendors. A further assessment of such tools has been carried out by Juan M. Carrillo de Gea et al. [7], who used the ISO/IEC TR 24766 framework in order to verify whether claimed features support real RE activities. As the authors did not find any correlation between average cost per licence and the global score achieved by the tools, customers and practitioners would have to research into open-source applications which may have satisfying solutions.

Eady and Lockyer [9] have conducted multiple challenges of implementing technology into teaching approach. The challenges faced by teachers are critical issues that lead to have a lack of using technology within teaching. An example of the mentioned challenges is implementing a new technology into teaching, where teachers find it hard to understand the tool/application. Therefore, most of the scheduled time would be wasted on learning the technology by teachers rather than teaching it to students. The authors have concluded that technology is changing all the time, meaning it is important for teachers to keep themselves updated when it comes to the technology phase. Thus the teachers will be able to teach students more efficiently.

Knauss et al. [10], have presented a useful Heuristic Requirements Assistant tool called HeRa, which helps identifying the main challenges of RE, as well as providing analysts with important data from various feedback facilities. In addition, HeRa Heuristic feedback grants capturing high-quality requirements on user goal level, identifying contradictions to other users requirements, and aligning user goals with the intended business process quickly. Moreover, HeRa analyzes the input and warns the user whether it detects ambiguities or incomplete specifications. Additionally, it generates UML

<sup>2</sup>[T-Reqs repository](#)

Use Case Diagrams that show how the current user goals relate to the business goal. The authors have concluded that gathering immediate feedback, provided by HeRa is valuable in order to modify the requirements as well as enhancing UML Use Case Diagrams. In their research paper [11], Benot. R, Alfredo. C, and Nicolas. G present Messir, a tool support based on textual domain-specific languages developed for their relatively mature RE tool based on UML, named Excalibur [12]. Together, they act as an integrated tool which follows an iterative process in covering requirements & analysis phases, and read-only visualisation of the requirements. Furthermore, text cases requirements are formally simulated, and complete requirements analysis documents are generated in L<sup>A</sup>T<sub>E</sub>X [13]. Due to their extensibility, maturity and open-source availability [14], Eclipse frameworks (i.e., XText and Sirius) have been used respectively for the design of Messir features (including syntax highlighting, auto-completion and validation rules) and for generating read-only graphical views from the requirements model elements. This approach was partially and similarly used by Ericsson which successfully customized T-Reqs by adding model support.

Some of the areas where Excalibur shines is the definition of fifty custom validation/error and warning rules which act as guidelines for students during the elicitation phase. In terms of UML notation, their views are using the syntax of use-case diagrams, sequence diagrams and class diagrams. However, the presence of bugs is one of the main caveats of the tool.

ReqT is an open-source, flexible and scalable requirements modelling tool for system analysts, developers and engineering students, developed within an educational context in 2010 at Lund University. According to Regnell. B [15], ReqT offers useful features such as analysis, visualisation and prioritisation of requirements, besides modelling. It also combines natural language with formal structure, and provides L<sup>A</sup>T<sub>E</sub>X document generation [16]. Requirements and test specifications are integrated and models can be imported/exported in different formats. Similarly to Messir, the modelling of requirements is represented in a textual DSL and manipulated using scripts written in Scala programming language. However, this RE tool is designed for students enrolled in the MSc Computer Science program and requires some decent programming knowledge of Scala to manage requirements, which in our case, it may discourage MSc Software Engineering and Management students.

Table I assembles some of the functional differences among the related educational tools. We can clearly see that T-Reqs' competitiveness suffers, as it is currently lacking essential features, mostly within the modelling area. However, the tool provides basic RE functionality, which, together with the Github integration, improve its versatility and potential to be developed further. The choice of the tool is also taking into consideration its fit in relation to the RE course challenges and learning outcomes.

	HeRa	Messir+Excalibur	ReqT	T-Reqs
<b>Management of Requirements</b>	Requirements Visualisation	Requirements Analysis & Visualisation	- Requirements Visualisation - Test cases - Simulation	- System Requirements - User stories - Test cases
<b>Traceability</b>	Yes	Yes	Yes	Yes
<b>Modelling</b>	Yes - UML use case diagrams - Epc-generation - use case points - Visualisation of Use Cases(EPC)	Yes - UML use case diagrams - Environment - Conceptual - Operations	Yes - Entities - Attributes - Relations	Under development
<b>Embedded DSL</b>	/	- XText(textual) - Sirius(graphical)	Scala	/
<b>Specification/Validation</b>	- Input validation - Incomplete specification - feedback(improved rules)	- Validation rules - Specification Simulation	Yes - export toHTML - Semantic check	Yes - Changelog
<b>Documentation</b>	Yes	Yes - Online Tutorials	Yes - Online Tutorials	Yes - Starting Templates - User manual
<b>Document Generation</b>	No	Pdf	Latex	GitPages
<b>Other</b>	- Compute Use Case Points(estimation of project cost) - Glossary	- Eclipse Integration	- Export to graphviz, html, spreadsheet	- Github Integration

TABLE I: Requirements Tools - Functional Comparison

### III. RESEARCH METHODOLOGY

#### A. Research Questions

The execution of the study consists of the investigation of three research questions stated below:

**RQ1:** *What are the challenges of DIT276 RE second-cycle course stakeholders that relate to the use of tooling?*

The first part of the study is to identify the current problems in the RE course, regarding the use of educational tools. We begin the investigation by extracting applicable challenges from the course material within the context of the related work and background, and combine them with information provided by the course stakeholders i.e., teacher, supervisors, students. In other words, this research question urges us to dig further and learn about the problem.

**RQ2:** *How could the provided challenges be addressed using T-Reqs?*

The results from RQ1 serve as input for generating a list of challenges to address with T-Reqs solutions. After ranking the solutions according to the expected benefits and in relation to the discovered challenges, the most promising ones will be addressed through the instantiation of a workshop. Investigating this research question, allows us to introduce T-Reqs as a teaching tool, as well as presenting its principles and its concrete academic applicability. For this purpose, a start-up manual is being designed, together with guidelines and exercises, in order to provide the basic knowledge for starting to use T-Reqs. In this way, T-Reqs' fit into academical context is being evaluated and qualitative data is extrapolated, which will give shape to the student concept of how to use T-Reqs.

**RQ3:** *What is the impact of T-Reqs on the course learning outcomes?*

The second part of the artefact consists of a teaching concept, made out from guidelines established in cooperation with the current course teacher. The RE teacher staff analyses

the contents of the workshop given to students and discuss strengths and weaknesses. This concept will be discussed separately with two affiliate professors at University of Gothenburg, in terms of traceability and requirements engineering. This discussion will contain feedback which will be used as part of the overall T-Reqs Edu evaluation.

Role	Number Count	Responsibility
Ex-RE Course Master Students	77	Course Evaluation Data → RQ1
	2	Workshop Respondent → RQ2
	2	Interviewee → RQ1 & Workshop Respondent → RQ2
Ex-RE Course Master Student & Ex-RE Course Teacher Assistant	1	Interviewees → RQ1
Phd Student & Ex-RE Course Teacher Assistant	1	
Ericsson AB Employer	1	(Industrial T-Reqs Overview & Presentation) → Background
RE Expert	1	Teaching Concept Approval → RQ3
RE Expert	1	Teaching Concept Approval & RE Course Responsible & 2nd Workshop Participant → RQ3
Teaching Staff (RE Team)	1	2nd Workshop Participant & Ex-Re Student → RQ3
Teaching Staff (RE Team)	1	2nd Workshop Participant & Ex-Re Course Responsible → RQ3

TABLE II: Stakeholders involved in our study

### B. Research Design

The research will follow the shape of a design science methodology, allowing us to construct a new deliverable which originates from understanding what are the concrete problems, propose a candidate solution, and validate the solution candidate/s by checking whether the problem has been solved. In our case, we are already inclined to continue the study on T-Reqs and therefore to choose it as our candidate. An optimal solution would include more than one iteration, although time constraints will allow at least one.

At first we define the problem and bring motivation into understanding what are the concrete issues to address to: we want to investigate the challenges of course stakeholders regarding the teaching tools in requirements engineering. We start by reviewing background and related work, together with artefacts (i.e., requirements engineering course materials), such as student evaluations, experience reports and evaluation forms, which would provide the concrete insights into the actual problems within the teaching of the course, on which we prepare and tailor T-Reqs. Semi-structured interviews with other students and researchers complement the study and expand its perspectives. Thus, we get an overall idea of stakeholders' views in order to enforce the benefits of using of the final deliverable. (Refer to Table [7](#)).

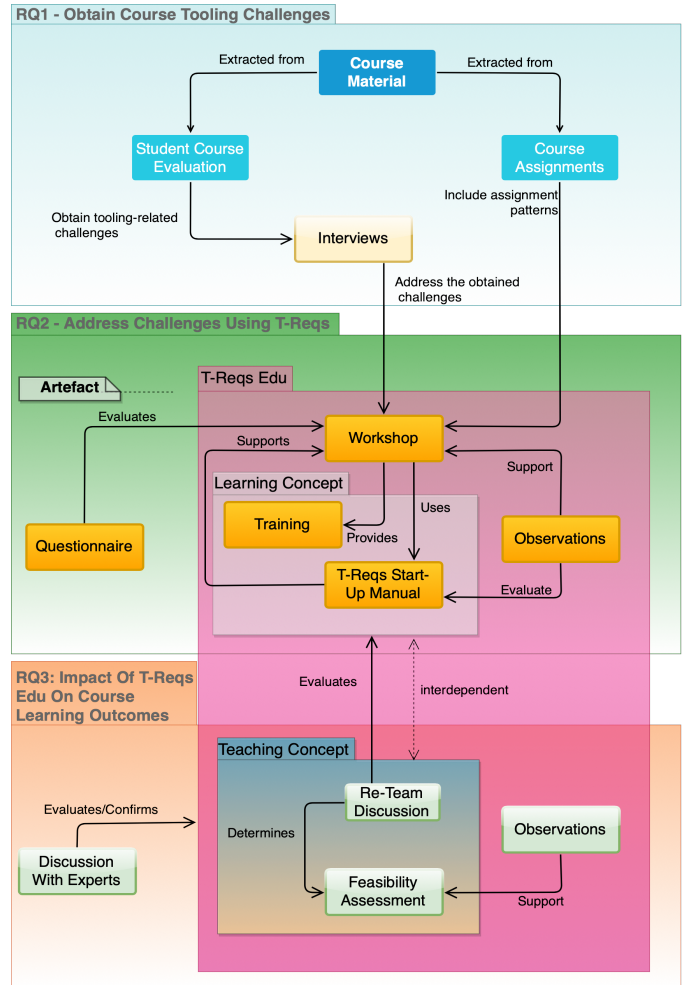


Fig. 1: Research Design

The second step of the study aims to use T-Reqs to address the challenges found with the interviews. Data produced through interviews will define a list of challenges which in turn will be triangulated with the learning outcomes and other related course material. Furthermore, any correlation between the tools capabilities and its suitability for teaching purposes are made in order to extrapolate the advantages and disadvantages the tool would produce in a teaching environment. We determine which features would address the challenges found in RQ1 and list them according to the benefits they would produce. The features are then addressed during a workshop to RE master students in order to evaluate whether using T-Reqs solves the encountered challenges. A workshop is instantiated, where we show T-Reqs' capabilities and benefits in addressing the stated challenges, discovered in RQ1. It covers two parts: a theoretical presentation of the findings and how T-Reqs generally addresses the discovered issues, and two practical scenarios covering multiple tasks similar to their assignments, where students will have the opportunity to test whether T-Reqs' features concretely help addressing the issues. The main purpose of the workshop is to indirectly provide a first training



session with T-Reqs, which will be then replicated during the first lectures of the RE master course. A start-up manual is also to be designed and tested within a workshop which supports its evaluation. The authors assume the role of ‘observers as participants’, aiming to assist the whole experience which is then evaluated through a final questionnaire.

The learning concept is evaluated by running the workshop with the RE teaching staff, in order to be examined from a teaching perspective. The evaluation is complemented with a critical RE-teaching team discussion which determines the feasibility assessment of the tool. The definition of a teaching concept requires the RE teaching team to revisit the workshop, including constructive criticism about the tool and its user manual. The RE team discussion is backed observations collected by the authors which will support our results and discussion.

The first iteration of this study ends with a final discussion with course responsible and an external teacher with knowledge in the requirements engineering domain. The scope of the discussion is to evaluate the whole teaching concept, by establishing the impact T-Reqs Edu would have on the course learning outcomes.

As the flexible research design permits evolving during the research process, slightly modifications to data collection and analysis may occur without affecting the study scope.

Figure 1 shows the illustrated process of gathering data through the various instruments, connected with the respective research question/s they are used for. Based on the course evaluation, we start with obtaining the course challenges through interviews. In parallel, we analyse the shape and content of two of the assignments we have got access to. This will serve to gain knowledge about the context we are conducting research, in order to be able to replicate similar scenarios.

We show how T-reqs addresses some of the discovered challenges, through a workshop based on the course material. The workshop consists of tasks within scenarios and it automatically evaluates whether we have successfully addressed the challenges. Furthermore, this is an opportunity to evaluate the user manual and the scenario guidelines and to present our first impressions on how students are dealing with T-Reqs in practice through active observations made by the authors. It also represents a potential training session which may be replicated during the first lectures of the RE course. A questionnaire will summarise the overall experience of the workshop and the data will shape the student concept. The second part of the artefact contains the teaching guideline, which takes into consideration the results of this first iteration in order to decide the feasibility to concretely introduce T-Reqs from the upcoming semester.

The artefact is produced sequentially, depending on how we obtain data. The learning concept is to be confirmed after the workshop, and from it, the RE teaching team derives an evaluation and produces a teaching concept.

### C. Data Collection

1) *Course Material:* We have started this study by requesting access to course material. We have individuated two documents to inspect. The student course-evaluation, which contained the general challenges about the course, and two examples of past projects. From the first artefact we have extracted those challenges which may be related to the use of tooling. The interview questions are built starting from these challenges. The inspection of the second artefact, i.e., course assignments, helps guiding us to address the challenges in a format/context known to students. Therefore we try to replicate tasks similarly to the course assignments, in order to reduce inconsistencies between the old and new teaching concept, especially when taking into consideration the evaluation of such exercises. The course evaluation contained the constructive criticism of 77 respondents to eleven questions about the course performance. As for the assignments, only two of the course assignments have been inspected.

2) *Interviews:* We have prepared a semi-structured interview session with ex-RE students, in order to get a more in-depth qualitative understanding of the general challenges found in the course evaluation. It covers a total of twenty-two questions structured in the following setup: ten questions about the general trending of the course, regarding tooling; four questions were dedicated to feedback gathering and pre-expectations setup; and an extra set of eight questions were dedicated to the ex-supervisors of the previous RE course. The interview lasted on average from twenty to thirty minutes, depending on the degree of ease questions were understood by recipients and on the quality and amount of information received. All interviews have been recorded. Convenience sample was used. The population sample of the interview round consists of five people. Four students (three from Gothenburg University and one from Chalmers University) who have taken the Requirements Engineering graduate course as part of the Software Engineering and Management MSc. The fifth recipient is one of the ideators and developers of T-Reqs, besides having a three-year experience as teacher assistant. In total we have heard three student-opinions and two supervisor-opinions.

3) *Workshop:* In order to achieve our study’s objective, a workshop has been designed with the purpose to provide RE students with some insights of how to use T-Reqs as a requirement tool in practice and verify the degree with which the challenges discovered with the interviews are addressed. Due to the lack of students in the first workshop, it has been later replicated to other two students. The workshop’s flow has been designed as the following:

- An appropriate presentation<sup>3</sup> which consist of a main steps of the workshop: the objective of the workshop, brief and concise introduction of T-Reqs, the tasks to be executed, the work mechanism, the estimated time of the workshop and desired user manuals of how to use T-Reqs.
- First interview recipients will have to complete two differ-

<sup>3</sup>Presentation Slides

ent scenarios<sup>4</sup>, including tasks addressing the challenges found and collected from the requirement engineering course evaluation.

- Useful user manuals<sup>5</sup> and guidelines will be provided in order to aid the students with their tasks.
- A structured questionnaire<sup>6</sup> which will collect desired data from students in order to evaluate the workshop materials.

*Participants:* a total of four students (two for each workshop), who took the requirements engineering course have participated in the workshop. Two of them have also been recipients to the first interview session. Moreover, the students have worked as groups, where each student have represented a group him/herself i.e., first student has acted as *Group A* and the second student has acted as *Group B*.

*Workshop's duration:* The tasks have been previously piloted by the authors, and an estimated time of 90 minutes was then allocated for the workshop, divided as the following: 10 minutes for the presentation, 30 minutes for Scenario 1, 5 minutes for the break, 35 minutes for Scenario 2 and 10 minutes for the questionnaire.

*Scenarios and tasks:* two scenarios made up by several tasks are provided and written down in a reasonable way of achieving the workshop's goal:

*Scenario 1* is considered as a warm-up for students in order to get familiar with T-Reqs (what it is, how it works). In addition, it contains multiple tasks which help addressing different challenges, faced by students during DAT231/DIT276 second-cycle course in requirements engineering. Those tasks are supported with useful user manuals of T-Reqs. The main purpose of these user manuals is to aid students getting the knowledge of T-Reqs, as well as completing their tasks successfully.

*Scenario 2* when students get to know how to work with T-Reqs using Scenario 1, they will now be able to create templates on their own, as well as writing user stories, system requirements and test cases into these templates. Moreover, the students will run T-Reqs in order to check the traceability between the implemented user stories, their requirements and their test cases. Finally, the groups will push their work into Github in order to peer review their work of whether accepting the requirements as they are or asking for changes if needed by creating *pull requests*.

The provided tasks help addressing the most important challenges, for instance, related to the provided template during RE course, T-Reqs provides a freedom of creating templates according to the students' needs (see Table IV). As a conclusion, the provided exercises (scenarios and tasks) serve the workshop's purpose in a meaningful way of introducing a tool which could be used in the near future.

(Please refer to Appendix B).

*T-Reqs User Manual:* The authors have created three user manuals of how to use T-Reqs requirement tool (the main manual contains all chapters alongside with Ubuntu configurations, the sub manual contains Windows configurations and a manual which contains important notes regarding the workshop). The main user manual is divided into six chapters which covers the features of T-Reqs and the way of using them. The manual is structured as the following:

*Chapter 1* presents T-Reqs requirement tool as well as allowing the user to explore the tools repository on Github.

*Chapter 2* presents the main steps of how to clone and execute T-Reqs.

*Chapter 3* focuses on giving guidance to students about how to write user stories as well as system requirements to be used in T-Reqs.

*Chapter 4* introduces the way of filling out an existent different templates of user stories with their requirements, as well as checking the traceability among the templates and the way of creating a new template for both.

*Chapter 5* presents the main instruction of how to create a test case for a certain user story, as well as checking the traceability among them.

*Chapter 6* shows the way of how to pull request the changes by users on Github, how to create an issue for a user story, how to create an issue for a future request and how to create an issue for a task.

*Questionnaire:* The authors have worked together on the questionnaire design and carried it out up to three revision cycles, after having carefully discussed the formulation criteria of the questions that should be asked. The questions were made as simple, clear and concise as possible. Open-ended and likert-scales questions focusing on the efficiency of T-Reqs features were produced, in order to assure whether challenges have been addressed correctly.

4) *Feasibility Assessment:* In order to support our study with more data, the workshop executed for the students has been revisited with three participants who are members of RE teaching staff. A preliminary discussion with the RE teacher staff is required, in order to get them up to date with T-Reqs and our research.

The tasks have been successfully completed by the participants. However, some difficulties were encountered during the workshop, e.g. installing python3 and executing T-Reqs on Windows operating system (OS).

Authors have collected desired observations, in order to improve the flow of the workshop, and by taking into consideration that the main purpose of this workshop is to check whether T-Reqs is suitable requirement tool to be used in next MSc RE course.

5) *Discussion with RE Experts:* The discussion with the RE experts included an associate professor knowledgeable of requirements engineering and traceability, besides the course

<sup>4</sup>Workshop Scenarios

<sup>5</sup>T-Reqs user manual

<sup>6</sup>Questionnaire

teacher, both affiliated with university of Gothenburg and Chalmers. The objective of the discussion is to verify the feasibility of the teaching concept, considering T-Reqs' links to learning outcomes, benefits and current state of the tool. After a short presentation about the tool-subject of our research, an evaluation of the current teaching and learning approaches against the course learning outcomes is produced, following the arguments which can be found in Appendix C.

This meeting would also complement the RE teaching-team discussion with an external teacher, in order to unveil other potential obstacles between the current version of T-Reqs and its introduction as a learning tool.

#### D. Data Analysis

1) *Course Material*: The course evaluation presented a series of highs and lows regarding the academic performance of the RE course. The challenges have been extracted from the document by highlighting the difficulties faced by students during the RE course regarding tooling, listed and filtered by relevance to possible solutions in T-Reqs. The course assignments brought us more into understanding the problem, this time focusing more on the format of the document.

2) *Interview*: After the interview data has been collected, we prioritize the challenges obtained by ranking them according to development effort and their estimated educational value. At the same time, we want to contextualise some of the challenges that are already addressed within T-Reqs original features. Feature prioritisation takes into account the institutional vision with all stakeholders needs, therefore it is very important to clearly select the features that work at their best interest. For this purpose we have cross-referenced the interview results through triangulation with experience reports, course evaluation and teacher discussions. Both scores follow a low-medium-high scale, where we prioritise the challenges to be addressed with T-Reqs first and the ones with less importance.

3) *Workshop*: The workshop is supported by observations where authors take notes, considering variables such as team cooperation, communication, ease of finding documentation, etc. The questionnaire evaluates the workshop and the student guide, and its outcome will influence the decision of whether introducing T-Reqs as educational tool the next semester.

#### E. Validity Threats

The limitations of this study were taken into consideration by defining the impact of the discovered threats of validity and a strategy for mitigating them as following:

1) *Threats to internal validity*: The difference in expertise of the subjects(e.g., workshop participants, RE experts and the teacher of the course); the results might be extensive and very differentiated. To mitigate this threat, we have analysed the results of each of three groups (the teacher, students and the RE experts each) separately to combine similar results together, in order to avoid any conflict of interest and derive us into a solution which satisfies the stakeholders alike.

2) *Threats to external validity*: Having qualitative study instruments (e.g., interviews and workshop) with limited people is considered as a threat to external validity, where the size of population might be limited, hence the collected data might also be limited and will not be enough to serve strong claims. To mitigate this threat, we have differentiated the recipients by involving students from both universities, having different RE expertise both as student-only or as teacher assistants, in order to confirm further challenges. We have started our study with analysing the course evaluation of 77 RE Master Students. On top of the artefact, a variety of instruments has been used to gather data, together with a variety of respondents, each with different roles and abilities, and thus mitigating the overall external validity of the research.

Conducting the qualitative study (solving the challenges by addressing them with features of T-Reqs) only in University of Gothenburg is also considered as one of threats to external validity, where the popularity of the tool is limited to GU University only and therefore, the tool might not be trusted by other IT departments and/or universities. To mitigate this threat, we have invited ex-RE course students from Chalmers university to attend the workshop, in order to help increasing the popularity of T-Reqs, as well as recognizing the tool with its beneficial features and how it would be practical to use the tool in RE courses, thus T-Reqs would serve the pedagogical approach in an efficient way.

3) *Threats to construct validity*: We are now discussing the artefact validity which also depends on the instruments used to create it.

The teacher concept is discussed with the RE team composed of teacher, teacher assistants and other associate professors. The outcome of it will have to be evaluated by external professors with knowledge in the RE and related domains. The student concept, however, depends on the decisions of the RE team, as further evaluation of whether T-Reqs should be introduced is still in progress. This makes the artefact strongly dependable on the RE team decisions who are also going to the same procedures students went(with the tasks within the workshop). Due to time impediments, a further and required evaluation of the student concept can be enacted during the next semester by proposing the use of T-Reqs in the RE course, in order to obtain more data.

4) *Threats to conclusion validity*: Our study was based on instruments with low population sample. However, the multiple instruments used are evaluating each-other and data is traceable. Moreover, our study takes input from different sources at different levels. Students, Teacher Assistants, as well as Associate Professors contributed to the research either through direct feedback or by connecting with their own research interests. We can say that our conclusions will take into consideration multiple and different inputs and validations from multiple sources and therefore establish a solid foundation for being able to generalise the findings at least locally (within University of Gothenburg/Chalmers).

## IV. RESULTS

### A. Artefact

The outcome of this first iteration of the study is an artefact (Table III) identified as a usage concept for T-Reqs, which can be seen from a student and teacher perspectives. The student concept (i.e., learning concept) takes into consideration whether students can decide their own templates and workflow within the course. Moreover, it relates to a starting-guide and user manual for T-Reqs, so that students can get comfortable with tool within the first week of the course.

The second part of the artefact includes a teaching concept, which defines the relation between the course learning outcomes and the features provided by T-Reqs. It implies important and strategic decisions regarding the final steps into concretely adopting T-Reqs into the course. This could have some repercussions, regarding the alignment of the learning outcomes with the actual tooling of the course, besides the grading scheme and work assessment. The use of T-Reqs in the first semester of its use will have to be supported by training and supervision sessions, which should aid students in executing their assignments using the new tool. The drafting of the T-Reqs manual has undergone a process of refinement and validation within the workshop. This includes also an extra set of instructions for Windows users.

	Students	Teacher
Training	<ul style="list-style-type: none"> <li>Workshop</li> </ul>	<ul style="list-style-type: none"> <li>Workshop</li> </ul>
Features		<ul style="list-style-type: none"> <li>Initial T-Reqs Features</li> <li>(Gitlab Integration)</li> </ul>
Usage Concept	<ul style="list-style-type: none"> <li>Own Templates</li> <li>Own Workflow</li> <li>T-Reqs Guideline</li> </ul>	<ul style="list-style-type: none"> <li>Alignment with:               <ol style="list-style-type: none"> <li>Course templates</li> <li>Learning objectives</li> <li>Assessment(upload)</li> </ol> </li> <li>Provide concrete examples</li> <li>Assess workload</li> </ul>
Decision	<i>Use T-Reqs?</i>	

TABLE III: Artefact: two concepts (for students and for teachers), including training, tool features, usage concepts and decision support

### B. Tooling Challenges

The interview has shown slightly different areas of interest where students perceived the challenges. However, the obtained results<sup>7</sup> match with the overall course evaluation the interview has been built on. We have made sure all participants have been active throughout the course, in order to improve the reliability of our results. It emerged that students use an unorganised set of tools which typically includes an external modelling tool, an online editor and a document preparation system. This is considered to be one of the main cores of the problem, together with the rigidity of the template, often *too enforced*. These two issues have negative repercussions on the course learning outcomes, which tends to enlarge timeliness and effort spent

<sup>7</sup>Coded Interviews

on assignments. Even if the current tooling setup does not have strong impact on communication, students are looking for a packaged solution-tool which would improve their work efficiency. Among the expected features, a dedicated RE tool should give some degree of flexibility in choosing or adapting a template while offering traceability features among produced RE artefacts. All these features are partially offered by T-Reqs, to an extent that is being defined and evaluated within this first iteration of the study.

Table IV presents the main challenges, collected from the interviewees, alongside with its impacts and its relevance. In addition, Table IV also presents T-Reqs features which have addressed most of the important challenges faced by students during requirements engineering course, showing the efficiency of T-Reqs and its importance as a requirements tool to might be used in teaching environment, in order to provide the students with desired knowledge of usability, efficiency and traceability when dealing with requirements engineering aspect.

The traceability between the challenges and T-Reqs features can be described as the following: we have investigated the functionality of T-Reqs and its features carefully; the scenarios and tasks have been created to be compatible with T-Reqs features; we have then run the workshop by us before students, in order to check whether the challenges are solved, the students then have attended the workshop. As a result, the students have confirmed that T-Reqs features have addressed the most important mentioned challenges.

Challenges	Consequences/Impact	Relevance	T-Reqs features (addressing the challenges)
Excessive template enforcement	<ul style="list-style-type: none"> <li>Restricting learning potential.</li> <li>Limiting learning outcomes</li> <li>Limiting further experimentation(in supervision sessions).</li> </ul>	High	<ul style="list-style-type: none"> <li>Creating flexible templates for user stories (US), system requirements (SR) and test cases (TC).</li> </ul>
Template not flexible	<ul style="list-style-type: none"> <li>Further ways of documenting requirements not explored.</li> </ul>	High	<ul style="list-style-type: none"> <li>Providing a user manual of how to create templates freely.</li> </ul>
Template too broad, Efficiency guidelines missing	<ul style="list-style-type: none"> <li>Poor understandability.</li> <li>Difficult supervisions.</li> <li>Theory-practice un-match.</li> </ul>	High	
Un-appropriate traceability features offered by the given tools(GoogleDocs/MS Word)	<ul style="list-style-type: none"> <li>Difficult maintenance of requirements.</li> <li>Difficult to supervise/grade requirement documents</li> </ul>	High	<ul style="list-style-type: none"> <li>Supporting traceability among US, SR and TC.</li> </ul>
Lack of immediate feedback	<ul style="list-style-type: none"> <li>Waste of time.</li> </ul>	Medium	<ul style="list-style-type: none"> <li>Allow providing immediate feedback on Github using pull requests.</li> </ul>
Traceability between models and other RE artefacts	<ul style="list-style-type: none"> <li>Difficult maintenance of requirements.</li> </ul>	Medium	N/A
Models not connected with requirements	<ul style="list-style-type: none"> <li>Waste of time, no version control or editing features → remake the work.</li> </ul>	Medium	

TABLE IV: RE challenges addressed by T-Reqs features

### C. Workshop

This section shows results, collected from the students who participated in the workshop:

Based on the majority of agreement on the quality of workshop materials, students have found that the workshop was easy-going, and the tool (T-Reqs) is overall decent and user friendly. In addition, the students have found that the workshops' scenarios, tasks and the manuals are well structured and easy to understand. However, *Student B* and *Student C* have complained about the instruction by arguing that the instructions are long and they are too much, meaning the workshop is long and it might be shorter at their points of view. The majority of students were satisfied with the time of the workshop to some extent.

As for the efficiency of T-Reqs, students were asked to propose their impression about T-Reqs. *Student A* liked the tool, underlying that T-Reqs is a user friendly tool with a great traceability feature. *Student B* was neutral. *Student C* and *Student D* have found that T-Reqs is a good requirement tool. The majority of students have agreed on that T-Reqs documentation is easy to understand, its features are useful, it provides a potent level of traceability among requirements, user stories and test cases and it supports providing an immediate feedback. Additionally, the majority of the students recommended the following: T-Reqs should be proposed to future RE students, as well as using the tool instead of Google Docs/MS Word would be desirable when it come to traceability.

On the other hand, *Student B* and *Student C* weren't sure whether T-Reqs would be an efficient tool for RE in general, since *Student C* believes that the tool needs to be tested before introducing it to the future students, while *Student B* have argued that the tool is too technical and would disagree on using T-Reqs as a main requirement engineering tool in future RE course/s. T-Reqs requires Linux (Ubuntu) to be run, thus the students have faced a problem during the workshop since their knowledge of using Ubuntu was limited, they would be encourage more into the tool if it runs on another operating systems e.g. Windows. Hence, the authors have figured out a way of running T-Reqs on Windows, as well as creating a small additional manual of how to use T-Reqs on Windows.

Regarding the efficiency of scenarios, tasks, RE challenges and T-Reqs features, the students have agreed on that scenario 1 helped them getting familiar with the tool, as well as its tasks were easy to be done. Additionally, they have agreed on that the provided template for scenario 1 was not too broad, nor even not flexible. The students have worked on scenario 2 and they have agreed on that (i) the tasks of this scenario were easy to get done, (ii) it is easy and efficient to create a template on T-Reqs freely and (iii) the system requirements and the test cases were easy to be traced by its user stories.

The students have provided their opinions about whether

The majority of agreement on:	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	I don't know
The quality of workshop materials	0	0	0	3	1	0
The efficiency of T-Reqs	0	0	1	3	0	0
The efficiency of scenarios, tasks and T-Reqs features	0	0	1	2	1	0
The efficiency of T-Reqs guideline	0	0	0	4	0	0

Fig. 2: Evaluation Results From The Likert-scale Questions Done During The Workshop

T-Reqs has addressed the challenges faced during the previous RE course; some have argued that T-Reqs did address the challenges. Furthermore, the tool provides some level of traceability which is a step forward. The possibility to choose and make templates was also appreciated. However, they have also provided suggestions to improve the tool; where *Student A*, *Student B*, *Student C* and *Student D* have suggested configuring T-Reqs to be run on Windows since most of master students are familiar with this operating system, in addition, T-Reqs should have a user friendly interface which make it look like a more polished tool, ready to be used in the near future.

Based on the majority of agreement on the efficiency of T-Reqs manual, most of the students have found that the provided manual has supported the workshop in an efficient way, it presented T-Reqs in as useful way as well as it provided a way of solving the tasks. *Student A* has found that T-Reqs manual was useful because it was well written i.e., well explained from basic to advance, *Student B* said that it was relatively useful, *Student C* and *Student D* have argued that it provides a general understandability of how to use the tool. But on the other hand, and according to the students, the manual needs to be improved, where they recommended to turn the chapters into short instructions. In addition, polishing the user manual a bit more to be crystal clear would be recommended in order to describe the tool clearer.

Figure 2 presents the final results of the workshop questionnaire; where the majority of the students have agreed on that the quality of the workshop materials is good i.e., the user manual of T-Reqs and the workshop scenarios are well designed, structured and easy to understand.

In addition, the majority of the students have agreed on that T-Reqs has achieved a good level of efficiency, where it provides a potent level of traceability and usability.

Furthermore, students have agreed on that the scenarios and tasks are efficient and easy to understand, most of the challenges have been addressed by T-Reqs features in a meaningful way.

Finally, the students have agreed on that the user manual of T-Reqs is well structured, easy to understand and served the workshop in efficient and useful way. Taking into account that the number of majority of students is highlighted with dark green.

#### D. RE Team Discussion (T-Reqs Assessment)

We have revisioned the workshop with participants of RE teaching staff; they have provided some suggestions for improving the workshop, as well as how the students should work with T-Reqs alongside with Github; their suggestions can be mentioned as the following:

- Supporting the workshop with a desired *FAQ* file, which consists of different questions regarding issues that may occur when using T-Reqs, especially when executing the tool on Windows OS. One of the issues faced by one of the participants was installing *python3* on a wrong path, thus *Git bash* would not allow installing *Pip* nor the virtual environment (*virtualenv*) which are required to execute T-Reqs.
- If the students decide to use T-Reqs during RE course, they should work on their own forks of the main T-Reqs repository. In addition, the students would work as groups of five inside the repository, where they can create their own branches. Furthermore, they should have at least three branches i.e., *Release 1*, *Release 2* and *Release 3*, where the main reason of having these branches is to review their work using pull request feature on Github, as well as it is the current workload of the RE course.

#### E. RE Experts Discussion (T-Reqs Edu Assessment)

From the discussion it emerged that generally, requirement engineering tools like T-Reqs, do not have a negative impact on the learning outcomes. The feasibility of T-Reqs' introduction as a learning RE tool has been discussed in relation to the impact on the learning outcomes contained in the course syllabus<sup>8</sup>.

As for "*Knowledge and Understanding*", T-Reqs helps students to describe the challenges involved in requirements engineering, as it is a tool made for this purpose (by nature). It is important to mention that the tool is not a technique; the technique is making requirements. (learning T-Reqs does not imply the learning of other techniques rather than producing requirements). Introducing T-Reqs for educational purposes could have a negative aspect on student perspectives about requirements engineering in Agile projects. It is important to avoid inducing students into continuing to associate Agile with artefacts, such as backlog and user stories, while forgetting that Agile means constant evolution and collaboration between teams.

Regarding "*Skills and Abilities*", T-Reqs helps to "*clearly document software requirements according to industry standards*". The state of the art, however, presents a very diverse and undefined picture where T-Reqs is just one of the many tools available on the market. T-Reqs offers more opportunities than Google Docs, regarding prioritisation of requirements. Is it possible to add "tag" in T-Reqs which would allow to prioritisation. The peer reviews in terms of pull requests are

definitely helping to "*assure the quality of requirements and requirements specifications*".

T-Reqs does not have any negative impact on other skills, such as elicitation of requirements or assessment of current requirements engineering practices. It does not help improving, nor has a negative impact on "*Judgement and Approach*" areas either.

According to the respondents, the tool can help teachers to assess assignments and to monitor the learning progress of students. Unfortunately, Git change history would not help the assessment, and in case students do not actively commit, such history cannot be reliable. Currently, students can send a pdf generated from the information on Github. That is a technical difference only. Git works well with feedback and reviewing but not for assessment.

The learning outcomes of the course do not include generating a template. Therefore students should have some starting templates to choose from at the beginning.

In order to support students into achieving the learning outcomes some of the following suggestions were produced:

- 1) Similarly to what happens in industry, high level user stories should be prioritised before proceeding to the definition of system requirements. We can then proceed with the system requirements. Currently this is achieved by using different folders and the markup language for in-file structuring.
- 2) The effort of the students in using the tool will come automatically. "*Students love tools, but do not like when they are forced to use one*" It becomes then relevant to have an extra lecture only about T-Reqs.
- 3) A couple of lectures explaining natural language and requirements in general would be good having before the introductory workshop with the students.

The discussion finished with suggesting to free the .md files from instructions, setup a specific seminar or lecture on how to use the tool, and making sure T-Reqs can run the basic functionality, including models and tag prioritisation of user stories.

## V. DISCUSSION

Considering the tools stated in the related work, the obtained challenges have shown that there are still some important areas where T-Reqs is currently lacking functionality. Further research made by Shah et. al. [17] analyses and evaluates different RE tools based on their functionality. Their results show that both commercial and open-source RE tools struggle in supporting traceability, graphical representation and tool integration. T-Reqs does not make exceptions to this trend, regarding the visualisation of requirements through models. However, T-Reqs is seen as an improvement over the actual tools used by students, in our case. In terms of functionality, T-Reqs is offering traceability features and the Git system which is build upon provides the versatility required to fix requirements prioritisation and visualisation.

By introducing T-Reqs in the related RE master course, we have been able to address some of the challenges offered by

<sup>8</sup>[Dit276 - Course Syllabus](#)

the current RE educational tools, in order to minimise the functionality gap between them. The artefact produced in this iteration, contributes to improve the current documentation of T-Reqs by offering training support and obtaining feedback, which have been already created in ReqT or Messir.

Taking into consideration the learning outcomes of the RE course, T-Reqs proposes a fairly good fit within the educational environment from a teacher perspective, without colliding negatively with any of the knowledge, skills, or judgement of the students. Overall, the introduction of T-Reqs in the RE course is feasible, with the condition that some other important features such as modelling and natural language will be revised before the RE course starts. This allows to align T-Reqs with the current trend of tools such as Messir and ReqT, which have been successfully introduced to software engineering students at Luxembourg and Lund University respectively. According to Longani et. al. [18] active learning, collaborative work among students, reflection from teachers and inspiration from industry can help students to better understand requirements elicitation. Having said that, T-Reqs' usage for educational purposes fosters the benefits offered by the tool in relation to the RE master course in an incomplete but promising package, from both student and teacher perspectives.

## VI. CONCLUSION

Our study has been made with respect to the requirement engineering field, and the main focus was on how to implement a RE tool (T-Reqs) into an educational environment.

We have started the study by conducting a review of the literature, in order to get a clear vision of the current challenges within RE field, about the current state of art of RE tools including T-Reqs, and gather some insights about what the educational environment is and how the teaching concept can be affected when it comes to implementing new technologies into the teaching process (tooling).

We have then collected different challenges, faced by 82 master students during RE course; 77 of them have provided different challenges by making the course evaluation, and 5 of them have been interviewed in order to gain the most important challenges regarding tooling, templates and modelling.

A workshop has been taking a place during our study. The main purpose of the workshop was to provide students with an initial training session using T-Reqs, and see whether the tool is able to address the collected challenges, as well as whether T-Reqs should take a place in educational approach for the next RE course.

Finally, a discussion has been held with the RE teaching team, where we have introduced T-Reqs in order to collect valid observations about improving the tool alongside with checking whether it is suitable one to be used in teaching approach.

The evaluation of the different instruments used in this study shows that T-Reqs Edu presents satisfactory results, in terms of learning concept. However, it lacks important aspects such as modelling support. This aspect is currently investigated by master students at university of Chalmers.

The second iteration of this study would see a refinement of the basic features T-Reqs should offer in order to be successfully introduced as a RE learning tool. Therefore, and as a future work, T-Reqs should be developed further e.g., creating user friendly UI for T-Reqs so students can use it easily, as well as developing a modelling feature, where students can work on different models alongside with writing requirements and checking whether they are traced into each others. A polished version of T-Reqs, addressing the criticism produced in the final stage of the study would have to be tested and validated once again.

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## APPENDICES

### APPENDIX A

#### Interview Guide(RQ1)

##### Interviewees

- (A, B, C) Researcher/Student
- (D) Student (ex TA)
- (E) ex TA/researcher.

##### Intro questions

- 1) What is your current position? (student, TA, researcher) (*Get basic information about the interviewee*)
- 2) How frequent was your participation in this course? (*How are participants related to the course and what impact they have on it?*)
- 3) What is/was the current setup of tools in requirements engineering course? (*Try to reason about the current teaching climate in requirements engineering course*)
- 4) What are some clear issues with the requirements engineering course, regarding the current tool(Google Docs/word template) – from your perspective? Name 3 challenges related to the "tooling". (*Relate the actual problems with the course templates/artefacts*)
- 5) Do you think the course offered/forced you enough on applying RE aspects/topics in practice? Explain why/how.
- 6) Do you think the used tools gave you enough flexibility/information about the tasks/assignments to make?
- 7) Do you think the course material had enough structure(in terms of tools)? On a scale from 1 to 5 where 1 is very low and 5 is very much, where would you place the impact of the used tool over your knowledge acquisition and/or course learning outcomes?
- 8) Collaboration among groups: was the provided tool/template communication/collaboration friendly? How did you manage to collaborate with the other team-members? How have you managed the coordination of tasks.
- 9) Overall, has the "tooling" improved your work efficiency? Why? How?
- 10) Were you able to work remotely with the tool, maintaining similar efficiency levels?

**Propose T-Reqs(pre-expectations) - asking for suggestions**

- 1) What improvements do you think would provide more structure to the course, in terms of tooling?
- 2) Do you think having more/multiple templates would foster the learning path? How? Why?
- 3) Is it practical to use a text writing software for managing requirements artefacts? Do you think you should have a better system, capable of handling the course material?
- 4) Which would be 3 essential features such tool should have, in your opinion? (Ask for some suggestions about a potential solution)

##### *You have been a supervisor as well*

- 1) Define briefly your experience in teaching assistance. What are the main problems, in your opinion, regarding the tooling system used in RE course?
- 2) Has the structure of the course(focusing on tooling/template) given you any difficulties in supervising/understanding students needs?
- 3) Did you have the time to supervise all students assigned(or in need)?
- 4) What do you think students need more, regarding the tool?
- 5) In your experience, how are students coping with the workload? Do/did they know what to do/how to do?
- 6) Which is the part where they find more difficulties?(elicitation, specification, etc).
- 7) Was it difficult to supervise the students? Which part have you focused more on explaining?(Theory-concepts, Practical tasks, etc).
- 8) What would you change/implement tool-wise?

## APPENDIX B

### Workshop scenarios and tasks

#### Scenario 1

We want to have an android application named *Emergency Room*, where the purpose of this application is to book a time to visit a doctor regarding an emergent situation. Hence, the requirements of this application are:

##### *Requirements for users:*

- 1) The user shall register himself/herself to the application.
- 2) The user shall log-in in order to be able to use the app.
- 3) The user shall provide a brief description about his/her situation.
- 4) The user shall find an empty time and date to be booked.
- 5) The user shall get a notification about the doctors name, the rooms number and the date of visiting.

##### *Requirements for Doctors:*

- 1) The doctor shall log-in as an administrator.



- 2) The doctor shall check the list of his/her patients, including their names, ages, allergies, situations and their booked times.
- 3) The doctor shall send a notification message to the patients with details about the booking.

*Your tasks are the following:*

- 1) Read about T-Reqs in order to get familiar with the tool. **(Please refer to Chapter 1 of the user manual).**
- 2) Clone T-Reqs and run it. **(Please refer to Chapter 2 of the user manual).**
- 3) Come up with at least three user stories for the provided requirements. **(Please refer to Chapter 3 of the user manual).**
- 4) Write the user stories inside the provided template on T-Reqs. **(Please refer to Chapter 4 of the user manual).**
- 5) Add the requirements to the user stories, i.e., the requirements should be traced by their user stories. **(Please refer to Chapter 4 of the user manual).**
- 6) Run T-Reqs in order to check whether the system requirements as well as the user stories are traced with each others. **Hint: you can check the log files inside logs folder.**

## Scenario 2

We want to have a website named *Travel With Us*, where the purpose of this website is to buy a flying ticket to any city within Europe. The website works with multiple European travelling agencies (you are free to mention how many travelling agencies would the website deal with).

*Your tasks are the following:*

- 1) Come up with three user stories according to the scenario.
- 2) Come up with one/two system requirement/s for each of the user stories. **(Please refer to Chapter 3 of the user manual).**
- 3) Create two templates, one for the user stories and one for the system requirements. **(Please refer to Chapter 4 of the user manual).**
- 4) Write the user stories and their requirements inside their created templates on T-Reqs. **(Please refer to Chapter 4 of the user manual).**
- 5) Write two Test Cases for any of the user stories. **(Please refer to Chapter 5 of the user manual).**
- 6) Run T-Reqs in order to check whether the system requirements as well as the user stories are traced with each others. **Hint: you can check the log files in: logs folder.**
- 7) Group A will push his/her groups work into Github and create a new pull request, Group B will check the changes and provide and immediate feedback about requirements, user stories, test cases and the templates. **(Please refer to Chapter 6 of the user manual).**

**Note:** T-Reqs provides issues feature which works as a pull request, if you are interested, you can check chapter 6 of the user manual.

## APPENDIX C

### RE Experts questions(RQ3)

- 1) How do you think T-Reqs relies on the learning outcomes of this course? *(In terms of learning outcomes, abilities, skills).*
- 2) Which learning outcomes in addition would T-Reqs support: How do you intend to assess them? Start thinking about the assessment? *(constructive alignment).*
- 3) In case T-Reqs is not connected to the Learning Outcomes, how could we introduce it?
- 4) What can you do to support the students to achieve the learning outcomes?