A Case Study of Critical System Heuristics in a Student Project Setting

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Abstract

This thesis aims to study the use of Critical System Heuristic (CSH) in the requirements engineering (RE) process of a student software project. We have studied a software project within the framework of the TDDD96 course at Linköping University. The project consisted of a group of computer science students working with a representative from a company. As part of the course, the students had done the sustainability exercise SusAF, in which they evaluated their project based on multiple sustainability metrics. We have conducted one round of interviews with the RE student, the company representative, and an expert in the area. The answers were encoded and mapped to 12 CSH questions before being presented in the Ideal map table. The results produced by CSH show the many benefits of integrating CSH into the course. We have proposed different ways of integrating CSH with the SusAF exercise. From the result, we realized the importance of consulting a third party that could provide an outside perspective on different issues. However, an essential aspect of using CSH is to consult the appropriate party. To this end, we found that CSH could be used internally to point in the right direction.

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1 Introduction

1.1 Motivation

Software systems are the cornerstone of today's society and an integral part of most people's day-to-day life. Whether it be education, communication, retail, banking, entertainment, or any other sector, software of different kind is being used to facilitate and streamline the process. That means that a lot of power and responsibility is placed on the shoulder of software engineers to design ethical software systems [1]. However, questions regarding ethics have, for the most part, been ignored by the tech industry [5].

One reason is the strive for ever greater profits, driven by shareholder interest. One well-known example is the Facebook-Cambridge Analytical data scandal, in which Cambridge Analytical paid Facebook to collect millions of Facebook users' data without their consent. From this example, we can also observe a conflict of interest. On the one hand, we have the interest of shareholders, which value profits, while on the other hand, we have the interest of the system's users, which values privacy, integrity, mental health and so on.

Another reason the tech industry has overlooked ethics in the past is the lack of a standardized framework for reflecting on ethical issues. However, one framework that could solve this issue is *Critical System Heuristics (CSH)*. CSH is a framework for critically reflecting on the *Requirements Engineering (RE)* process, thus providing software engineers with a tool for revealing and resolving conflicts between concerned stakeholders. The lack of ethical requirements in software engineering is usually due to the fact that the interests of various stakeholders have not been taken into account. However, since CSH does consider the various stakeholder's interests, the framework could help software engineers to define ethical requirements [4]. This offers a long-awaited help for software engineers who lack the foundational education in ethics, social science, and policy necessary to make ethical decisions about software systems and their implications on society.

This thesis builds upon [1]. However, unlike [1], this thesis tries to investigate the role of CSH in the *TDDD96* course at Linköping University. What would be the result of implementing CSH in the setting of the TDDD96 course?

1.2 Background

1.2.1 Course setting

Seven computer science students are working as a team on a real-world software project within the framework of the course TDDD96 at Linköping University. The course is a bachelor project in software engineering of 15 credits. Each group member has been randomly selected and has a supervisor and an examiner. Students of the course are supposed to work on the project individually and in groups with regular supervision from the supervisor. The students have been free to choose projects based on a list of available project proposals from the university department. Project proposals have been submitted by internal clients from within the university and external clients from the business sector. The course intends to recreate a real-world simulation of the business sector by letting a representative from the university department or a real-world business act as a 'customer.'

1.2.2 TDDD96 learning outcomes

For the course TDDD96, there are some defined *intended learning outcomes* students are expected to get out of the course [8]. The intended learning outcomes relevant for CSH are:

1. The students are expected to demonstrate the ability to formulate problems by developing requirements corresponding to the customer's real needs and define a project within given time frames
2. The students are expected to do assessments, taking into account relevant scientific, societal, ethical, and sustainability aspects

1.2.3 Project setting

This thesis is based on *ARCH*, a software used for modeling different kinds of houses. ARCH is developed by the Swedish start-up company *Buildility* which aims to simplify a cumbersome and complicated building permit process. ARCH will allow private individuals without prior experience to draw and visualize their homes in 3D. The visualization will then be turned into a drawing in 2D, which could be used as a basis for a Swedish building permit. The individual acting as a customer for the ARCH project is a representative from Buildility. Since this thesis is based on ARCH, we will focus on the specific conditions concerning the ARCH project.

Apart from being responsible for the ARCH project as a whole, each student has a main area of responsibility. The students have worked on the project using Agile development methodology. ARCH has been in intense development for the last two years. Therefore, the students had to read up on the existing source code before writing any code. The students and the customer have kept in touch through email and regularly scheduled online meetings through Microsoft Teams.

The students created the requirements specification in tight collaboration with the customer. The students had the freedom to propose the initial requirements, which the customer would provide feedback on based on factors such as time constraints and appropriateness. The requirements specification for the project was settled after some iterations.

1.2.4 Other investigated projects

In addition to the ARCH project, we studied other projects in the TDDD96 course, such as *Traste, The Dashboard, The market platform*, and *The visualization software*.

Traste is a project aiming to develop a smartphone application for waste processing facilities. Through the Traste app, waste processing facilities will be able to record the amount and type of waste that is processed through their facilities, making the waste handing process more transparent and effective.

The company *Personalkollen* is providing a web-based software (with the same name) which keeps track of salaries and employee data for the hotel and restaurant sector. Personalkollen uses the DevOps software *Gitlab* for version control and collaboration among developers. To streamline the development process, the company is developing The Dashboard as an internal tool for collecting and displaying development data.

The market platform is a website developed by the B2B company *Zoezi*. Zoezi customers are companies that provide training services of different kinds. The market platform should be able to display all the available training services that Zoezi's customers currently offer.

The visualization software is a standardized application intended to help companies in the construction industry draw and visualize large-scale construction buildings. The application aims at constructing a coherent chain consisting of architects, project planners, designers, construction managers, and property managers.

1.3 Research question

- What role could CSH play in the RE process of a student software project implemented in the TDDD96 course?

1.4 Delimitations

Although CSH is broadly applicable to the business sector in general, we will mainly focus on the application of CSH within the TDDD96 course at Linköping University. This is mainly due to the unique settings of the TDDD96 course, especially with regard to the sustainability exercise, SusAF used in the course. In addition, CSH and its effectiveness have already been demonstrated in [1]. Therefore, in order to contribute new knowledge to the field, we have chosen to limit the scope of this thesis to the TDDD96 course. However, since CSH is broadly applicable to the business sector in general, a lot of the insights brought up in this thesis will also apply to the general usage of CSH.

2 Theory

2.1 Critical System Heuristics

Critical System Heuristics "is a framework for reflective practice based on practical philosophy and system thinking" (Ulrich, W, 2005, 1) [4]. First, the aim is to improve the *critical* reasoning of professionals and ordinary people. *System* thinking, in turn, consists of the prior judgments about the relevant 'whole' system to consider. *At last, we have Heuristics* support, which offers questions and argumentation tools for practically applying critical thinking.

CSH calls these judgments, *Boundary judgments* which play a central part in the CSH [4]. According to Ulrich, W (2005, 3)

> Boundary judgments determine which empirical observations and value considerations count as relevant and which others are left out or considered less important. Because they condition both 'facts' and 'values', boundary judgments play an essential role in assessing the meaning and merits of a claim [4].

That is, a boundary judgment will make up the reference system or perceived context in which a specific claim will be evaluated.

Four *boundary issues* make up the CSH questions. These are *sources of motivation, sources of control, sources of knowledge*, and *sources of legitimacy* [4]. The four boundary issues are characterized based on the effects each produces, which need to be examined from a pragmatic view. Without these boundary issues, it would be hard to evaluate a claim's meaning and validity as a basis for action.

The CSH questions are also divided into three different *categories* [4]. The first category involves *Stakeholders,* which consists of the people concerned by a certain system. The second category involves *Stakes* which describes what aspects of the problem certain stakeholders consider relevant. Lastly, the third category involves *Stakeholding Issues* which define how to handle conflicts between stakeholders.

CSH questions can also be in two different modes, the '*is*' mode (what is the case?) or the '*ought*' mode (what should be the case?) [4]. By asking questions in 'ought' mode, we can assess the validity of a claim made in 'is' mode. Furthermore, differences in the response from a 'is' and 'ought' question could be a way to detect unresolved boundary issues.

2.2   Ideal Map

An *Ideal map* presents the Ideal scenario of CSH. It encompasses the vision and possibilities for the future. The information presented in the Ideal map is intended to guide developers to an optimal solution for all the concerned stakeholders. By comparing the result in the Ideal map with the current situation, we can identify areas that has been overlooked or misunderstood.

In [1], Duboc L. et al. explain the CSH process as "iterative cycles of critical RE practice followed by reflection". The critical RE practice is aided by the use of 12 CSH questions which helps us think critically about the system. The answers for each CSH question will be added iteratively to the *Ideal map* table which in turn, is divided into multiple rows, each row representing a new consulted party.

We will start the RE process by asking a set of appropriate CSH questions to the requirements engineer. The answers will be added to the first row of the Ideal map, namely Ideal map 1. After engaging in critical reflection, we will consult an appropriate stakeholder for the next iteration of the Ideal map. We will ask the stakeholder a set of suitable CSH questions (which may or may not be the same), and the answers will be inserted into Ideal map 2 (which will be the next row in the Ideal map), and so on. In this way, the CSH process will repeatedly alternate between RE practice and critical reflection [1].

2.3   Requirements Engineering

Software development consists of different stages such as planning, analysis, design, development, testing, deployment, and maintenance. The design process starts with Requirements Engineering, which is the act of defining and documenting requirements in the design stage of a software system [3]. The requirements will determine what the system should do, the service it should provide, and the constraints it should operate on. By combining the content and structure of RE and the framework for critical reflection of CSH, we can achieve a critical RE practice that will aid professionals in building ethical systems.

2.4   Sustainability dimensions

In [2], Becker, C et al. investigate RE from a sustainability viewpoint. The authors define requirements based on five dimensions: the individual, social, economic, technical, and environmental dimension. The individual dimensions consist of aspects concerning human dignity and fulfillment, individual freedom, and individual agency, while the social dimension consists of relationships between individuals and the collective. In addition, capital growth, liquidity, investments, and financials are covered in the economic dimension, while the technical dimension is concerned with questions regarding the maintainability and evolution of technological systems. Finally, an environmental dimension includes aspects such as climate change, waste handling, natural resources, and energy consumption.

2.5   Sustainability Awareness Framework

As a part of TDDD96 course, the students got to learn and apply the sustainability awareness framework *SusAF*. The SusAF exercise encouraged the students to reflect on the implications of their project based on the sustainability dimensions mentioned above. This was done by writing

down causes and effects on post-it notes and sorting them into different sustainability buckets and diagrams.

3 Method

3.1 Project selection

We conducted interviews with students and customers for the projects ARCH, Traste, The Dashboard, The market platform, and The visualization software. To implement CSH, we had to interview different parties related to the same project. In addition, enough data needed to be collected to identify conflicts between different parties. Therefore, we selected projects based on two criteria:

1. The amount of data
2. The availability of interviewees working on the same project

The customer for the Traste project was of Australian origin, unlike the other interviewee (who were of Swedish origin). Hence, the customer interview had to be conducted in English. The flow of the interview was affected by the fact that English is not our native language. Thus, less information was gathered compared to the other interviews, resulting in the first criterion not being met. Furthermore, the Traste project was intended to be used by Australian waste facilities. Therefore, an Australian expert on waste disposals had to be consulted, which was not an easy task as Sweden's and Australia's time zones differ greatly. Thus, we believe the second criterion was not met either.

The students and customer for The Dashboard project were not working on the same project as previously thought. Hence, we considered the second criterion not fulfilled. However, a lot of data was collected from the interviews with the requirements student and the customer, thus fulfilling the first criterion.

We gathered a lot of data from the interviews with the customer for The market platform and The visualization software. Thus, both of these projects met the first criterion. However, the requirements student for both of these projects could not attend an interview for unknown reasons. Therefore, we believe that both of these projects did not meet the second criterion.

None of the aforementioned projects were considered to meet both criteria unlike the ARCH project. Therefore, the ARCH project was chosen as the basis for this thesis.

3.2   Interview question formation

Data for this study was based on interviews conducted with the student responsible for the requirements specification of ARCH, the customer of ARCH, and an outside expert on building permits. We interviewed students and customers approximately three months into the course. Thus, the requirements specification had already been created when the interviews were conducted.

We created different set of questions for the requirements student, the customer, and the building permit expert based on prior knowledge, experience, background, and context. The set of questions was constructed to answer the CSH questions directly (by asking the CSH questions) or indirectly (by asking general open-ended questions about the project). To facilitate understanding, we rephrased the CSH questions to a simpler version (see Figure 1). In addition, we asked appropriate follow-up questions throughout the interviews to dig deeper.

CSH questions asked in the 'is' mode would be most appropriate for parties inside the project (such as the student and customer), while CSH questions in the 'ought' mode would be most suitable for parties outside the project (such as the expert). Therefore, we chose to frame CSH questions for the student, and customer in the 'is' mode and CSH questions for the expert in the 'ought' mode.

We conducted the interviews in Swedish. However, to present the data in this thesis, the results have been translated into English using Google Translate along with regular manual checks of the translated material. Interviews with the student and the customer were conducted through Microsoft Teams, while the interview with the expert was conducted through a phone call. Except for the customer interview for the ARCH project, we recorded all other interviews to facilitate a smooth conversation. We later transcribed the recorded interviews to capture all of the necessary information. Unfortunately, we did not record the customer interview for the ARCH project due to a lack of preparation. However, we took extensive notes throughout the interview.

3.2.1 Student's set of questions

The set of questions for the requirements student was mainly based on simple general questions because of the student's limited knowledge and experience of software development. Out of the CSH questions, we asked questions one and two. In addition, we asked questions related to the SusAF exercise that the student had done on ARCH 2 months earlier [7].

3.2.2 Customer's set of questions

Because of the customer's extensive experience and knowledge of software development, we asked all of the 12 rephrased CSH questions. However, for some questions, an explanation was provided to aid understanding. Especially the difference between CSH question 3 and 9, which initially can be hard to differentiate. Although we asked all 12 CSH questions, most emphasis was placed on questions 1-9, as these are the questions the customer is expected to know.

3.2.3 Expert's set of questions

The building permit expert set of questions was created based on the most interesting information gathered after analyzing the data from the student and customer interviews. Especially interesting was information that did not make sense or seemed incorrect. In addition, we asked CSH question 10 and general questions about building permits to get an overview of the industry and the common problems and challenges that exist.

3.3 The mapping process

For the most part, we used the methods proposed by Alm, B in [6] as a basis for analyzing the data. However, instead of using the thematic mapping method proposed by Alm, B in [6], we mapped the answers to interview questions straight to the 12 CSH questions as appropriate. This approach made it easy to compare answers given by the student, customer, and expert on similar CSH questions in order to find similarities and differences.

We could map the answers provided by the student, customer, and expert to all of the 12 CSH questions. However, since the student, customer and expert have different level of knowledge and experience, only the appropriate mappings have been considered in the ideal map. Therefore, we choose to map the student's answers to CSH questions 1-3, the customer's answers to CSH questions 1-9, and the expert's answers to CSH questions 3 and 7-12.

3.4 CSH and rephrased CSH questions

The CSH framework is made up of 12 CSH questions that help us think critically about a certain system. For each of the 12 CSH questions, we have provided a rephrased version of the question.

CSH Questions and Rephrased CSH Questions (in Italics)		
Sources of Influence	Boundary Judgments for a System of Interest (S)	
	Social Roles (Stakeholders)	Specific Concerns (Stakes)	Key Problems (Stakeholding Issues)
Sources of Motivation	1) Who is/ought to be the intended beneficiary of S? *Who benefits from the system?*	2) Who is/ought to be the purpose of S? *What do you want to achieve with the system?*	3) What is/ought to be S's measure of success or improvement? *Which indicators do you use to measure the system's success?*
Sources of Control	4) Who is/ought to be the decision maker in control of the conditions of success for S? *Who is the decision-maker for the system?*	5) What resources, conditions of success, are/ought to be under the control of S's decision maker? *Which resources and success conditions does the decision-maker control?*	6) What conditions of success are/ought to be outside the control of S's decision maker, the decision environment? *Which resources and success conditions does the decision-maker not control?*
Sources of Knowledge	7) What experts are/ought to be providing the relevant knowledge and skills for S? *Which expert contributes relevant experience and expertise to the system?*	8) What are/ought to be the relevant (new) expertise, knowledge, and skills necessary for the operation of the S? *What information and skills do they contribute?*	9) What are/ought to be the assurances of successful implementation of S, i.e., what is its guarantor? *What is the guarantor of a successful implementation?*
Sources of Legitimacy	10) Who is/ought to be the witness representing the interests of those negatively affected by S, but not involved with S? *Who or what may be negatively affected by the system, and in which way?*	11) What are/ought to be the opportunities for emancipation, for the interests of those negatively affected to have expression and freedom in the worldview of the S? *Who can represent the victim's interests?*	12) What space is/ought to be available for reconciling different worldviews regarding S among those affected and involved? *How can one reconcile opposing Worldviews between those affected by the system and those behind the system?*

Figure 1: Original CSH questions from [1] with rephrased CSH questions in Italics

4   Result

4.1   Summary of interviews

4.1.1   The student interview

The requirements student interview provided a low level description of the ARCH project and the RE process. The most important requirement for the students were *ease-of-use*, which the students had limited experience with. The interview revealed that this requirement was initially brought up and emphasized by the customer. The student explained the importance of the ease-of-use requirement by saying that hard-to-use functionalities would require more time spent by the end user, which would discourage the end user from using the software and instead hire an architect. The student group created the requirements specification in tight collaboration with the customer. The students had a lot to say in the RE process and were free to implement whatever functionality they desired. The only condition from the customer was that the requirements had to fit into the customer's vision of the project and that the requirements would be able to be finished within the project's timeframe.

4.1.2   The customer interview

The customer interview provided a high level description of the ARCH project. The customer stressed the importance of the *number of features* as a requirement, which would lead to a finished product. A finished product would, in turn, make it available for the end user, thereby bringing in revenue for the company, which is crucial for the company's long-term survival. One of the resources available for the ARCH project is a technical leader with expert knowledge. The technical leader provides knowledge mainly concerning system architecture, design, and programming methodologies.

4.1.3   The expert interview

The interview with the building permit expert provided a high level outside perspective on the project, especially concerning established building standards and aesthetics. The building permit expert stressed the importance of deliberate design choices and established building standards and regulations. In particular concerning standard measurements, floor plan design, and the exterior design of buildings. The interview revealed that the aesthetic aspect requires an expert (such as an architect) to visit the physical location of the building to evaluate the building's

surroundings and conditions. Since the design needs to be determined case-by-case, only an expert with the relevant context can produce an appropriate drawing.

4.2   Issues of awareness

4.2.1   Narrow view of the system

A *narrow view of the system* leads to issues where some aspects of the system will not be considered. The students are responsible for implementing the system and thus have to consider the lower level aspects of the project as part of their job. However, nothing prevents the requirements student from identifying higher level aspects and implications of the system. After the student interview, it became clear that the student did not do so.

4.2.2   Inclusive view

An *inclusive view* of the system implies a view where all relevant stakeholder's view will be considered. For instance, it became apparent that the requirements student did not include the views of the customer and the building permit expert, as the student did not bring up requirements such as the number of features, *built-in artistic input*, and *industry-standard measurements*.

4.2.3   Biased view and source of misinformation

A *biased view* and *misinformation* could result from not including an expert from the building permit industry, especially since an industry expert would have a different background than the requirements student and the customer. A building permit expert would be able to stress test the business model by providing an outside perspective of the project. However, the customer interview revealed that the only expert providing expertise was the technical leader.

4.2.4   Incorrect guarantors of success

Test groups testing the service and input from the end user were considered *guarantors of success* by the customer. However, this was dismissed by the building permit expert, who only regarded building permit experts and architects as guarantors of success. The reason for this is that the ultimate goal of the system should be to simplify the building permit process for the end user in order to get a faster approval. Since it is the building permit expert's job to approve building permits, the ultimate guarantors of success would reasonably be the building permit expert themselves. In addition, building architects could also be considered guarantors of

success, as part of their job is to create building permit applications. A well-made permit will, therefore, almost always be approved by the building permit expert.

4.3 The encoding process

We encoded the transcribed interviews and notes by mapping the answers from each of the interviews to the 12 CSH questions. Sample questions and answers will be presented below, with an explanation of the encoding process. Questions are marked with bold while answers are indented.

4.3.1 Ideal map 1 – Requirements Engineer Student

"What is the most important thing you have had to learn in this project?"

> To get a more perspective on user-friendliness, which we have not worked with before. This is something we and our customer work towards and which our customer values highly. What makes a program easy to use and that the user understands how to use the program.

We chose to set *user-friendliness* as the measure of success. Mainly because the question asked reveals what the student values most and thus what makes the project successful.

4.3.2 Ideal map 2 – Customer

"What indicators do you use to measure the system's success, so-called Measure of success?"

> The success indicator from the small perspective is that you have more function in software. There are three different tasks that you want to achieve with this program. How well you achieve these are then the measures of success.

We chose to set the number of features as the measure of success. This interpretation was relatively straightforward since the answer provided is for a direct question about the matter.

4.3.3 Ideal map 3 – Building permit expert

"If we assume that the software is error-free. Are there any groups that can be negatively affected?"

No. The software must be tightly regulated for what individuals are allowed to draw so that they adhere to Swedish building standards. It must be done professionally otherwise there is no idea behind the product. The individual sits at home in their room and says, "oh, this is nice" but they have a hard time seeing a finished product. They have a hard time seeing how this would fit into the area and what the big picture looks like. An architect looks differently at it. They can see a finished product.

We chose built-in industry standard measurements as a measure of success since the quote "The software must be tightly regulated for what private individuals are allowed to draw" clearly states that. Furthermore, the quote "they have a hard time seeing how this would fit into the area, and what does the big picture look like? An architect looks differently at it, they can see a finished product." indicates that built-in artistic input could be added as a measure of success. In addition, this implies that architects should be added as a *relevant expert* as they offer expertise that does not seems replaceable. From this quote, one can also claim that architects could be possible guarantors of success, considering their expertise in the area as well as the fact that architect is trained in designing buildings.

4.4 Ideal map

The most interesting data has been selected and inserted into the Ideal map. Each Ideal map represents an iteration of the CSH methodology. Ideal map 1,2,3 represent data gathered from interviews with the requirements student, the customer, and the building permit expert respectively.

Ideal map	Description: topics that refer to the CSH questions, in *italics*; issues of awareness commonly brought up by CSH, in **bold**
1	Ideal map 1 was created after a discussion with the requirements student for the ARCH project. The requirements were created by the student group in tight collaboration with the customer. The map identified individuals with limited time and money as the *intended beneficiary* of the system. It also set ease-of-use as the *measure of success.* Reflection showed that the ideal map was created based on the requirements student's low level of abstraction and thus, represents a **narrow view of the system**. In addition, major shortcomings in the **boundary judgment** were also revealed. The customer for the ARCH project was consulted to get a more **inclusive view** of the system.
2	Ideal map 2 was created after consulting the customer. The number of features was added as the main *measure of success,* along with ease-of-use. The map identified a hired consultant with the role of a technical leader as an *expert.* It was shown that the technical leader was providing technical knowledge in system architecture, design, and programming methodologies. The map identified user tests by different test groups and reconciliation with the end users as *guarantors of success.* Reflection raised concern about the reliability of the *expert* and the *guarantors of success.* **Biased views** could occur by not including experts from the building permit industry, which would be a **source of misinformation**. Thus, an expert in the area of building permits was consulted in order to verify the data.
3	Ideal map 3 included the views of an expert responsible for approving building permits. The map added built-in artistic input and built-in industry standard measurements as *measures of success.* The map also added architects as relevant experts, since only architects can provide *artistic knowledge* based on a certain location and context. In addition, test groups and reconciliation with the end users were shown to be **incorrect *guarantors of success*.** Instead, the map showed that the building permit experts should be regarded as *guarantors of success*, as they are responsible for approving building permit applications. In addition, legitimate architects could also be regarded as *guarantors of success.*

Figure 2: Iterations of the ideal map from [1] with topics referring to original CSH questions in italics and common issues brought up by CSH in bold

5 Discussion

5.1 Result

The result in the Ideal map shows typical situations where CSH could prove helpful for the RE process. For example, one situation is when a party provides information about a specific subject but misses to mention one or more essential aspects. An example of this is measure of success in Ideal map 1 and 2, in which the requirements student only mentions one measure of success (ease-of-use) compared to the customer who mentions two (ease-of-use and number of features). In these cases, CSH can help to identify relevant perspectives that have been disregarded by certain parties.

Another situation is when different parties provide conflicting perspectives. An example of this is guarantors of success in Ideal map 2, in which the customer considers *user test by different test groups* and *reconciliation with the end users* as guarantors of success. However, the building permit expert in Ideal map 3 sees themselves and architects as guarantors of success. In these cases, CSH can help to identify disagreements between different parties.

These points are no new findings as the benefits of CSH have already been demonstrated in [1]. However, it shows that CSH could produce valuable insights for the RE process, thus confirming the findings in [1].

The result shows that the customer and the students have not consulted either an architect or a building permit expert. Instead, it seems the customer and the students had defined the requirements based on information from end users combined with their own knowledge of the subject. The CSH framework could therefore prove to be a crucial resource for the customer of the ARCH project.

The results also suggest that the different parties view the project from different levels of abstraction. For instance, the requirements student talked about the importance of ease-of-use as a measure of success. Ease-of-use is a technical aspect of the software, which indicates that the student views the project requirements from a low level of abstraction. On the other hand, the customer emphasized the importance of the number of features (together with ease-of-use) as a measure of success since the relevant features had to be developed for the end user to use the

system. He further explained that this would eventually lead to revenue for the company, which is crucial for the long-term survival of the company. Therefore, we can assume that the customer views the project from a higher level of abstraction in relation to the student.

Finally, we have the building permit expert who talked a lot about the importance of a software that considers Swedish construction standards and regulations. In addition, the expert also highlighted the importance and role of the architect. The expert further explained that an architect (unlike software) could create a building permit that is visually pleasing and adapted to the surroundings. Neither the customer nor the student has brought up these points, which indicates that the building permit expert sees aspects missed by both the student and customer. Hence, we can interpret this as the expert viewing the project from an even higher level of abstraction than the student and the customer.

Even though Traste, The Dashboard, The market platform, and The visualization software were not selected as a basis for this thesis, we have learned a lot from the interviews with the students and customers involved in these projects. We learned that the students for the Traste project were not given much autonomy in the design of the requirements specification, unlike students from The Dashboard project, The market platform, and The visualization software. We learned that the students and the clients for the different projects used different mediums of communication to stay in touch. In The Dashboard, Traste, and The market platform, meetings took place mostly online while meetings for The visualization software for the most part took place in person. Moreover, from the customer interview for The visualization software, we learned that the customer had consulted numerous stakeholders before founding the project. However, we do not know the case for the other projects, as this was not investigated.

In the background chapter, two intended learning outcomes for the TDDD96 course are presented [8]. The first learning outcome touches on aspects of the business model, while the second learning outcome touches on aspects related to ethics, sustainability, and society.

Since CSH requires consulting multiple parties to get different points of view, CSH could be used to identify the customer's real needs. Therefore, we can assume that CSH could be used to address the first learning outcome. Furthermore, in cases where the customer has correctly identified their own real needs, CSH could be used to confirm that the needs are accurate, thus assuring that the customer has a solid business model.

Students usually miss essential ethical and societal aspects of a system due to hidden boundary judgments and values. Since, CSH is very effective at highlighting hidden boundary judgments and values, it could be used to detect overlooked ethical and societal aspects of a system. CSH would, however, not bring awareness to the sustainability aspects of a system in the same way as the SusAF exercise. Hence, we can conclude that CSH could be used to partly fulfill the second learning outcome.

Through the SusAF exercise, the students learn about the individual, social, economic, technical, and environmental sustainability dimensions. These dimensions do a good job of covering the societal and sustainability aspects of the second learning outcome. Thus, by combining SusAF with CSH, we can properly fulfill the second learning outcome.

Unlike CSH, SusAF does not require one to consult multiple stakeholders to get different points of view. Hence, the SusAF has no way to manage biases and misinformation that could arise. Moreover, in contrast to CSH, SusAF has no way to detect conflicts between concerned parties. Therefore, we can see that SusAF lacks elements that could affect the reliability of the results. However, by combining SusAF with the methodology of CSH, we can mitigate biases and misinformation while simultaneously detect conflicts. In particular, with regard to consulting a relevant third party that could offer an outside perspective on the project.

One way to combine SusAF with CSH is to ask CSH questions internally before performing the SusAF exercise. We would then ask a third party questions, about the most interesting aspects from the CSH and SusAF exercises. Another way to combine SusAF with CSH is to do as previously suggested but to exclude CSH questions for the third party.

The challenge with using CSH is recognizing the relevant partie(s) to interview. Relevant CSH questions internally can point in the right direction. However, it is also crucial to use critical reflection to ask the most relevant CSH questions and provide accurate answers to those questions.

5.2 Method

An appropriate methodology must be applied to produce valuable findings. As the conditions and limitations will vary for each case, the appropriate methodology for each case will vary. We reflected continuously on the used methodology to minimize prejudices and get the different party's actual views.

The interview questions consisted of directed questions in which the CSH questions were asked and undirected questions in which general questions about the project were asked. Both directed and undirected CSH questions entail certain advantages and disadvantages. The advantage of asking undirected CSH questions is that we are not guiding the interviewee to answer in a specific way, which would lead to less biased data. However, the disadvantage of this approach is that we would need to interpret the answers before mapping them to the appropriate CSH question, thereby increasing the risk of biased data.

The advantage of asking directed CSH questions is that no mapping was required (since the CSH question itself was asked), thereby removing the risk associated with interpreting the answers. However, the disadvantage of this approach is that it could lead the subject to answer in a specific way, which could result in more biased data.

Occasionally, the interviewees gave unexpected answers unrelated to the question at hand, which highlights another disadvantage of directed CSH questions. If we do not frame the question correctly or do not provide enough context, there is a high risk that the subject will misinterpret the question. The risk of misinterpretation is particularly high when the directed CSH question is of a more complex nature.

In this thesis, the projects investigated were ARCH, Traste, The Dashboard, The market platform, and The visualization software. The projects were evaluated and selected based on criteria such as the amount of data and the availability of interviewees working on the same project. The result could be affected by the choice of criteria and the interpretation of the projects and related interviews in relation to those criteria. Another chosen project could, for instance, result in less data gathered, which would result in an entirely different Ideal map than the one presented in this thesis.

The interview with the requirements student contained questions about the SusAF exercise the student had done two months before the interview [7]. Thus, there is a high probability that the student's memory of the exercise is quite limited, which could result in inaccurate data. One way to mitigate this risk is to let the student redo the SusAF exercise. However, this was not appropriate to request as the student's time was limited due to other obligations in the course.

The more interviews we conducted, the more exciting material we obtained. Therefore, there is a risk that the interviews did not result in as much interesting data as if a more experienced interviewer had conducted the interviews. The finding is not surprising, as interviewing is a skill like any other, and the more you do it, the better you become at it. This risk could affect the number of contradictions detected amongst the different parties. However, it is not likely to impact the accuracy of the result, as comprehension and interpretation of the answers were not the challenging aspects. The obvious way to minimize this risk is to conduct several interviews in order to develop one's interview technique.

Each of the 12 CSH questions was rephrased to a simpler version in order to facilitate understanding. All questions were understood by the interviewing subjects. However, we did not ask any of the original CSH questions and therefore, cannot assess if the rephrasing process increased understanding or not.

We maintained email contact with C. Becker (one of the co-authors of [1]) during the implementation of the method. We asked how the authors of the article implemented their method. C. Becker provided a comprehensive answer, in which he revealed that CSH could be used in many modes. CSH could be used internally within a team to define an ideal, in a reflective form later to compare whether the ideal has been fulfilled, and in a more critical mode from an outside perspective. He continued to explain that the authors of [1] have been iterating through CSH multiple times, shifting the mode for each iteration.

5.3   In a wider context

This thesis has not included the identities behind the interviewing subjects. However, since each student has published a thesis related to their project, there is a risk that the identity of the students could be revealed. The risk of revealing the identity of the building permit experts should be relatively low, as there are many building permit experts residing in Sweden. The client for each of the projects reviewed in this report has consented to include their project, the company behind the project, and associated descriptions of the project and company in this thesis. Because of the limited number of workers in some of these companies, there is a risk that this information could reveal the customer's identity. However, these risks should not be an issue as the topic discussed in the thesis is not of sensitive or controversial nature.

We recorded all interviews (except the interview with the ARCH customer) before transcribing them. After transcribing the interviews, we deleted all recordings to preserve privacy. Before each recorded interview, the interviewee was asked to give their consent before the recording started.

CSH can help analyze a particular system based on the interests of different stakeholders. Thus, conflicts of interest between stakeholders can be identified and resolved. By implementing CSH, developers can become more aware of ethical, sustainable, and societal aspects of a technical system. As software systems become increasingly important for individuals and societies in the 21st century, adopting CSH as standard practice in the tech industry could result in a more inclusive, considerate, and fair society.

6 Conclusion

The purpose of this thesis was to explore the role CSH could play in the RE process of a student software project implemented in the TDDD96 course of Linköping University. To this end, the thesis does a good job of answering the research question. CSH produced interesting results, presented in the Ideal map table (see Figure 2). The results show that CSH can help to identify disagreements between different parties and relevant perspectives that have been disregarded by certain parties. As expected, CSH fulfills the same function in a student software project as in a project in the business world. In addition, the results show that CSH was sufficient to fulfill the first intended learning outcomes. However, the second learning outcome was only partly fulfilled by CSH. The second learning outcome could nonetheless be fulfilled by using CSH in combination with SusAF.

When using CSH, it is particularly important to consult a relevant third party that could offer an outside perspective on the project. Thus, different biases, misinformation, and conflicts that exist could be revealed and examined. One challenge with CSH is identifying the relevant partie(s) to interview. Asking internal CSH questions together with critical reflection could address this issue.

6.1 Future work

This thesis claims that using CSH in combination with SusAF could fully fulfill the second learning outcome. However, it would be interesting to see if the claim holds in other similar settings. Another option for future work could be to explore alternative ways to use CSH in combination with SusAF and the effectiveness of each of these different approaches. Moreover, it would be exciting to investigate how additional time spent on each approach would affect the results.

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