Evaluating an Inspection Technique for Use Case Specifications
Quantitative and Qualitative Analysis

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Abstract: Usability inspections in early stages of the development process help revealing problems that can be corrected at a lower cost than at advanced stages of the development. The MIT 1 (Model Inspection Technique for Usability Evaluation) is a usability inspection technique, which aims to anticipate usability problems through the evaluation of use cases. This technique was evaluated using a controlled experiment aimed at measuring its efficiency and effectiveness, when compared to the Heuristic Evaluation (HEV) method. According to quantitative results, the MIT 1 exceeded the HEV in terms of effectiveness and obtained a similar performance in terms of efficiency. In other words, the MIT 1 allows finding more problems than the HEV. On the other hand, the subjects spent more time finding these problems using MIT 1. Moreover, the MIT 1 was considered easy to use and useful by the subjects of the study. We analysed the qualitative data using the procedures from the Grounded Theory (GT) method and results indicate improvement opportunities.

1 INTRODUCTION

The communities of HCI (Human Computer Interaction) and SE (Software Engineering) evolved separately and each developed their own methods to meet the needs of their respective customers and software users. However, in the last twenty years increasing attempts have been made to meet the gap between these communities (Juristo et al., 2007). Seffah et al., (2001) suggest ways in which software and usability engineers can learn from each other to facilitate and encourage the convergence of practices in both communities. It is very important to promote mutual understanding of the activities and responsibilities of the two communities to develop software with high degree of usability. Also, it is necessary to ensure that usability issues are adequately assured throughout the development cycle of a software product (Juristo et al., 2007).

In the context described above, it is essential to develop usability inspection techniques that can be applied to traditional SE artifacts. Recent researches aimed at ensuring a high degree of usability in the early stages of the development process of applications, called "Early Usability" (Hornbæk et al., 2007; Juristo et al., 2007). Part of the proposed techniques aims at ensuring usability through the inspection of models used during the design of the applications, leading to a higher user satisfaction.

Considering the importance of performing the inspections integrating SE and HCI perspectives, this paper presents a technique for usability evaluation in specified use cases. Use cases are important artifacts for developers, helping to both build the software and design the interactions between the system and the users.

The technique addressed in this paper is called MIT 1 (Valentim et al., 2012). Such technique is part of a set of techniques called Model Inspection Techniques for Usability Evaluation (MIT), composed by two other techniques: MIT 2 (for usability inspection in mockups) (Valentim and Conte, 2014b) and MIT 3 (for usability inspection in activity diagrams) (Valentim et al., 2013).

To support the development and validation of MIT 1 technique, we have adopted the experimental methodology presented in Shull et al., (2001). The methodology comprises four stages: (1) feasibility studies: to determine the usage possibility of the technology; (2) observational studies: to improve the understanding and the cost-effectiveness of the technology; (3) case studies in real lifecycle: to characterize the technology application during a real

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lifecycle; and (4) case studies in industry: to identify if the technology application fits into the industrial settings. The goal of the MIT 1 is to be easily adoptable by the industry. We expect that software engineers can use it to ensure the quality of their use cases. To achieve this goal, we carried out the first stage of the methodology by evaluating the feasibility of the proposed technique.

This paper presents a controlled experiment that aims to analyze the performance of the MIT 1 technique compared to one of the main usability inspection methods, the Heuristic Evaluation - HEV (Nielsen, 1994).

The remainder of this paper is organized as follows. Section 2 presents the basic concepts on usability evaluations. Section 3 presents the MIT 1. In Section 4, we describe the controlled experiment, while Section 5 presents its quantitative results. In Section 6 we present the analysis of user perception and in Section 7 we present the qualitative results and improvements. In Section 8 we discuss the threats to validity. Finally, Section 9 presents our conclusions and future work.

2 BACKGROUND

One of the most relevant quality criteria for the acceptability of the software is usability (Matera et al., 2002). According to the norm ISO/IEC 25010 (2011), usability is defined as: *“the capability of the software product to be understood, learned, operated, attractive to the user, and compliant to standards/guidelines, when used under specific conditions”*. Usability evaluation has become indispensable for HCI practice and research (Følstad et al., 2010). General usability evaluation methods can be divided into two broad categories (Conte et al., 2007): (1) Usability Inspections - evaluation methods based on Experts’ Analysis; and (2) Usability Tests - evaluation methods involving user’s participation.

The use of usability tests may not be cost-effective since they require a large amount of resources. Usability tests also need a full or partial implementation of the application, signifying that such evaluations are mainly moved to the last stages of the development process (Hornbæk et al., 2007). Inspection methods, on the other hand, allow usability evaluations to be performed on artifacts such as mockups, paper prototypes or user interface models. Usability inspections are naturally less expensive than evaluation methods that involve user participation, since they do not need, besides the inspectors, any special equipment or laboratories to be performed (Matera et al., 2002).

Different usability inspection techniques have been developed and used (Fernandez et al., 2011). One of the most popular methods is the Heuristic Evaluation, proposed by Nielsen (1994). This method aims at finding usability problems through a compliance analysis of the evaluated system using heuristics or quality standards. The 10 heuristics defined by Nielsen are described in Table 1.

Table 1: Heuristic Evaluation (Nielsen, 1994).

Heuristic 1. Visibility of system status
The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
Heuristic 2. Match between system and the real world
The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
Heuristic 3. User control and freedom
Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
Heuristic 4. Consistency and standards
Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
Heuristic 5. Error prevention
Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
Heuristic 6. Recognition rather than recall
Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
Heuristic 7. Flexibility and efficiency of use
Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
Heuristic 8. Aesthetic and minimalist design
Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
Heuristic 9. Help users recognize, diagnose, and recover from errors
Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
Heuristic 10. Help and documentation
Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

3 INSPECTION TECHNIQUE FOR USABILITY EVALUATION IN USE CASES

One of the artifacts often available in early stages of the development is the use case. It is an important artifact for both software development and for the design of user interfaces. Moreover, it has been suggested as a valuable artifact for including usability attributes directly in the software development process (Hornbæk et al., 2007). Therefore, uses cases are an important artifact for assessing the system's usability.

We propose a usability inspection technique for use case specification, the MIT 1. MIT 1, partially illustrated in Table 2, aims to increase the effectiveness of inspections, providing guidelines that can be used by inspectors to analyse the use cases and identify usability defects. Therefore, MIT 1 has verification items that serve as a guide to interpret Nielsen's heuristics, when applied to use cases.

MIT 1 is divided into high and low detailed level, respectively for use cases with high and low level of details. The MIT 1 – High Detailed Level is used for inspecting use cases that present information such as error messages, informational texts, warnings, name of screen, name of fields, among others. The MIT 1 – Low Detailed, on the other hand, is used for inspecting use cases that do not present such information. The advantage of having such division is that inspectors do not have to waste time reading verification items that will not help them finding problems for a particular type of use case. The full version of MIT 1 is available online in a technical report (Valentim and Conte, 2014a).

The steps of the inspection process of the MIT 1 technique are shown in Figure 1. These steps are: (1) to evaluate the use case and (2) to identify usability problems. In order to illustrate the MIT 1's inspection process, we have used it to evaluate the usability of a use case specification. That specification describes one functionality of an online system for showing indicators of research and development in Brazil. This specification is used in the system to manage courses. In the next paragraphs we describe how we applied the inspection process steps to perform a simple inspection of the use case specification of that system.

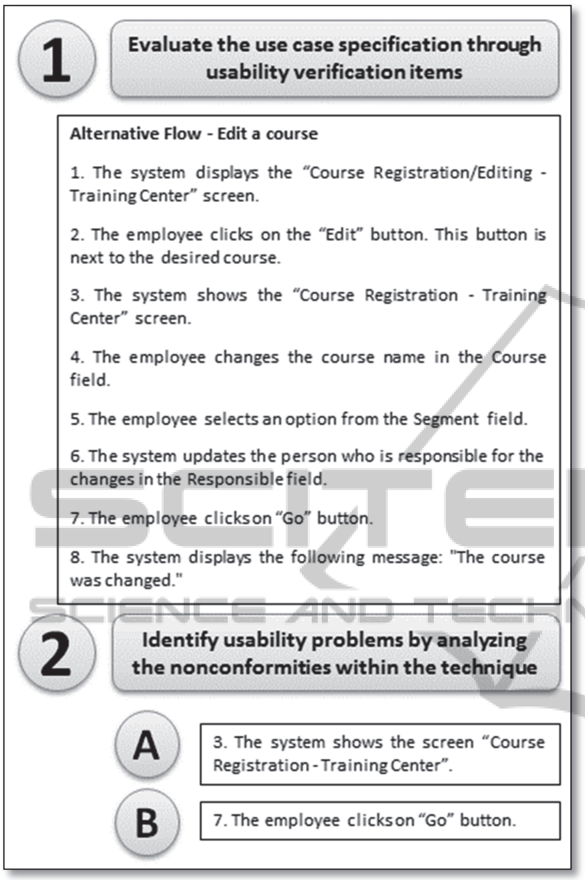
The first step for the identification of usability problems is to proceed with the evaluation of the usability verification items. In other words, the inspectors must check if the use case specification meets each of the usability verification items. Table 2 shows six examples of the usability verification items.

Table 2: Example of verification items of the MIT 1 (Valentim and Conte, 2014a).

MIT-1AA. Heuristic Visibility of system status	
Verification Item MIT 1AA1	Verify if there are some text in the Main, Alternative and Exception Flows which informs where in the system the user is;
Verification Item MIT 1AA2	Verify if there are some text in the Main, Alternative and Exception Flows which informs the user what was done after data persistence. For example, when changing or deleting something, a text message is displayed.
MIT-1AB. Match between system and the real world	
Verification Item MIT 1AB1	Verify if the names of fields, screens, buttons, links, error messages and informational texts in the Main, Alternative, Exception Flows and Business Rules have familiar concepts to users, ie, follows the conventions of the real world;
Verification Item MIT 1AB2	Verify if the options, screens or fields reported by the system in the Main, Alternative and Exception Flows are presented in a natural and logical order according to the concepts of the problem domain.
MIT-1AE. Heuristic Error prevention	
Verification Item MIT 1AE1	Verify if the Main, Alternative and Exception Flows describe warnings from the system that alert the user via messages (or informational texts) that the actions he/she is performing may be inappropriate at that moment.
Verification Item MIT 1AE2	Verify if all options, buttons and links that are present in the application have names that clearly define which results or states will be achieved. This must be verified in the Main, Alternative and Exception Flows and in the Business Rules

In order to identify usability problems (second step), inspectors must point in the use case specification which part did not meet the usability verification items. If we look at Figure 1 and Table 2 simultaneously, we can relate the nonconformity of the usability verification items in Table 2 with the augmented element A and B in Figure 1.

The Verification Item MIT 1AB2 suggests to verify if the options, screens or fields are presented in a natural and logical order according to the concepts of the problem domain. However, the screen "Course Registration – Training Center" does not present the concepts of the problem domain (seFigure Figure 1 element A). In other words, this alternative flow specifies the functionality "Edit" and the name of screen does not represent this functionality. This is an example of a usability problem.


1
Evaluate the use case specification through usability verification items

Alternative Flow - Edit a course

1. The system displays the "Course Registration/Editing - Training Center" screen.

2. The employee clicks on the "Edit" button. This button is next to the desired course.

3. The system shows the "Course Registration - Training Center" screen.

4. The employee changes the course name in the Course field.

5. The employee selects an option from the Segment field.

6. The system updates the person who is responsible for the changes in the Responsible field.

7. The employee clicks on "Go" button.

8. The system displays the following message: "The course was changed."

2
Identify usability problems by analyzing the nonconformities within the technique
A
B

3. The system shows the screen "Course Registration - Training Center".

7. The employee clicks on "Go" button.

Figure 1: Example of the Inspection Process of the MIT 1.

The Verification Item MIT 1AE2 suggests that all options, buttons and links that are present in the application should have names that clearly define which results will be reached or which states will be achieved. However, the "Go" button does not have a name that clearly indicates what is achieved by selecting it (see Figure 1 element B). In other words, the name of the Go button is not representative for the user. This is another example of a usability problem.

4 CONTROLLED EXPERIMENT

In order to test the version 2 of the MIT 1 before transfer it to the software industry, we performed a feasibility study, using only the high detailed level technique. MIT 1 was evaluated in comparison to HEV, because: (a) HEV is an inspection method widely used in industry (Fernandez et al., 2012); (b) MIT 1 is derived from HEV and, thus, to compare them is important to verify whether the derivation (MIT 1) is better than the original method (HEV); (c) the inspectors had a base knowledge in usability principles, which allowed them to use the HEV.

4.1 Hypotheses

The study was planned and conducted in order to test the following hypotheses (null and alternative, respectively):

- H01: There is no difference between the MIT 1 and HEV techniques regarding the efficiency indicator.
- HA1: There is a difference in the efficiency indicator when comparing the MIT 1 and the HEV techniques.
- H02: There is no difference between the MIT 1 and HEV techniques regarding the effectiveness indicator.
- HA2: There is a difference in the effectiveness indicator when comparing the MIT 1 and the HEV techniques.

4.2 Context

We carried out the study with one of the use cases of the online system for showing indicators of research and development in Brazil (see an extract of such use case in Figure 1). The experiment was conducted with senior-level undergraduate students of the Computer Science course at Federal University of Amazonas. The students had already attended two introductory classes about "Software Engineering" and "Human Computer Interaction" and were attending the "Design and Analysis of Software Systems" class (2nd Semester/2013).

4.3 Variables Selection

The independent variables were the usability evaluation techniques (MIT 1 e HEV) and the dependent variables were the efficiency and effectiveness indicators of the techniques. Efficiency and effectiveness were calculated for each subject as: (a) the ratio between the number of defects detected and the time spent in the inspection process; and (b) the ratio between the number of detected defects and the total number of existing (known) defects, respectively.

4.4 Selection of Subjects

Eighteen subjects signed a consent form and filled out a characterization form that measured their expertise with usability evaluation and software development. The characterization form was employed to categorize the subjects as having: none, low, medium or high experience regarding usability evaluation and software development. We considered: (a) high experienced, subjects who had participated in more than 5 usability projects/evaluations in industry; (b) medium experienced, subjects who had participated from 1 to 4 usability projects/evaluations in industry; (c) low experienced, subjects who participated in at least one usability project/evaluation in the classroom; and (d) with no experience, subjects who had no prior knowledge about usability or who had some usability concepts acquired through lectures/speeches but no practical experience. Analogously, the subjects' expertise in software development was classified following the same standards. Table 3 (second and third columns) shows each subject's categorization.

4.5 Experimental Design

Subjects were divided in two groups, which would inspect the same use case: the MIT's group and the HEV's group. The subjects were assigned to each technique using completely randomized design. Each group was composed by 9 subjects.

4.6 Instrumentation

Several artifacts were defined to support the experiment: characterization and consent forms, specification of HEV and MIT 1 techniques, instructions for the inspection, a worksheet for the annotation of the identified discrepancies and a post-inspection questionnaire. In addition, we used a use case that is part of the specification of a real system from a Training Center that manages courses (see part of use case specification in Figure 1). All artifacts were validated by the authors of this paper.

4.7 Preparation

All subjects received two-hour training on usability evaluation. Additionally, for each group, we made a 15-min presentation about the technique that the group would apply. Similar examples were shown on how to use both techniques (MIT1 and Heuristic Evaluation).

4.8 Execution

At the beginning of the study, a researcher acted as moderator, being responsible for passing the information from the evaluation to the inspectors. Then, we divided the subjects into groups for each technique and each group went to a different room. Each subject received the artifacts described in Subsection 4.6. During the inspection, each subject filled out a worksheet with the find defects. All subjects returned the worksheet containing the possible defects and the total time spent in the inspection. They also delivered the filled out follow up questionnaires. Each inspector carried out the problem detection activity individually. During the detection activity, inspectors did not receive any assistance from the researchers involved in the study. Altogether, there were 9 inspectors using the MIT 1 technique and 9 inspectors using the HEV technique.

4.9 Discrimination

After the execution, the lists of individual discrepancies were integrated into a single list, removing the reference to the inspector who found the discrepancy and the technique he/she had applied. A team formed by one software engineer (the author of the use case) and two usability experts reviewed such list. This team decided which of the discrepancies were unique and which were duplicated (equivalent discrepancies pointed out by more than one inspector). Also, the team decided which discrepancies were real defects or false positives.

5 QUANTITATIVE RESULTS

Table 3 shows the overall results of the usability evaluation in use cases. We can see that inspectors who used MIT 1 managed to find between 9 and 19 defects spending about 0.58 and 1.52 hours. On the other hand, the inspectors that used HEV employed between 0.38 and 1 hour, however they found between 4 and 14 defects.

Table 3: Summary of inspection result per subject.

Sub.	UE	SD	# Disc.	# FP	# Def.	Time (hour)	Def./ Hour
S01	L	N	26	7	19	1.40	13.57
S02	L	N	12	1	11	0.97	11.38
S03	M	L	14	2	12	0.63	18.95
S04	L	N	14	1	13	1.02	12.79
S05	L	N	18	2	16	1.52	10.55
S06	L	L	12	0	12	0.58	20.57
S07	L	N	20	5	15	0.83	18.00

Table 3: Summary of inspection result per subject. (cont.)

S08	L	N	14	2	12	0.92	13.90
S09	N	N	11	2	9	1.12	8.06
S10	L	N	12	2	10	0.42	24.00
S11	L	N	17	3	14	0.62	22.70
S12	L	N	11	3	8	1.00	8.00
S13	L	N	9	3	6	0.83	7.20
S14	L	N	4	0	4	0.50	8.00
S15	L	L	13	5	8	0.38	20.87
S16	M	N	8	0	8	0.45	17.78
S17	L	N	9	4	5	0.87	5.77
S18	L	N	9	2	7	0.50	14.00

Legend:
Sub – subject; **UE -** Experience in Usability Evaluation; **SD -** Experience in Software Development; **H - High; M** - Medium; **L -** Low; **N -** None; **Disc -** Number of discrepancies; **FP -** Number of false positives; **Def -** Number of Defects.

Overall, the inspections resulted a set of 40 usability defects, including the 11 seeded ones. Defects were seeded because there was the need to have more defects to be found. Table 4 presents the average effectiveness and efficiency.

Table 4: Effectiveness and efficiency per technique.

Technique	MIT 1	HEV
Total Defects	119	70
Average Defects	13.22	7.78
Effectiveness	33.06%	19.44%
Average Time (min)	59.89	37.11
Efficiency (defects/hour)	13.25	12.57

We performed an analysis using the non-parametric Mann-Whitney test (Mann and Whitney, 1947), given the limited sample size. We present the summary of the results using a boxplot graph. The statistical analysis was carried out using the statistical tool SPSS V. 19, and α = 0.10. This choice of statistical significance was motivated by the small sample size used in this experiment. Figure 2 shows the boxplot graph with the distribution of efficiency per technique.

From Figure 2(a), it can be observed that the MIT 1’s group had almost the same efficiency as the HEV’s group. When we compared the two samples using the Mann-Whitney test, we found no significant differences between the two groups (p = 0.895). These results support the null hypothesis H01 that states that there is no difference in the efficiency indicator between the MIT 1 and HEV.

The same analysis was applied to determine whether there was a significant difference comparing the effectiveness indicator of the two techniques in detecting usability defects. The boxplots graph with the distribution of effectiveness per technique (see Figure 2(b)) shows that the MIT 1's group was much more effective than HEV's group when inspecting the usability of the use case. Also, MIT 1's group median is much higher than HEV's group median, and all of the MIT 1's group boxplot is above HEV's group third boxplot quartile. Furthermore, the Mann-Whitney test confirmed that MIT 1’s effectiveness was significantly higher than HEV’s effectiveness (p = 0.002). These results suggest that the MIT 1 technique was more effective than HEV when used to inspect the specification of a use case in this study (support the hypothesis HA2).

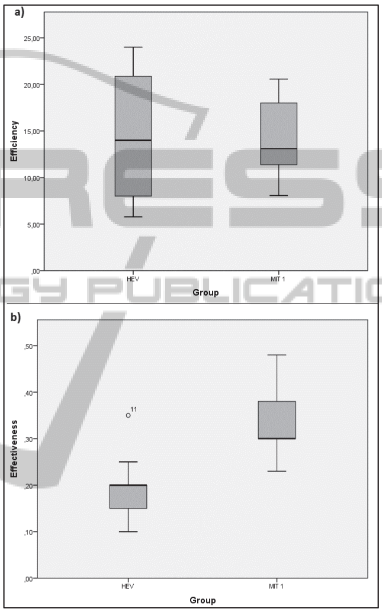


Figure 2: Boxplots for (a) efficiency and (b) effectiveness.

6 ANALYSIS OF USER PERCEPTION

After the quantitative analysis, the post-inspection questionnaires about technology acceptance concerning MIT 1 were analysed. Such questionnaires have been defined based on the indicators of Technology Acceptance Model - TAM (Davis, 1989). The indicators defined were: (i) perceived ease of use, which defines the degree in which a person believes that using a specific technology would be effortless, and (ii) perceived usefulness, which defines the degree in which a person believes that the technology could improve his/her performance at work. The reason for focusing on these indicators is that, according to Davis (1989), these aspects are strongly correlated to user acceptance.

Subjects provided their answers in a six-point scale, based on the questionnaires applied by Lanubile et al., (2003). The possible answers are: totally agree, almost totally agree, partially agree, partially disagree, almost totally disagree and totally disagree. In that questionnaire, the inspectors answered their degree of agreement with the statements regarding ease of use and usefulness.

6.1 Perceived Ease of Use

Figure 3 presents the perceptions of the subjects regarding the ease of use of the MIT 1. The X-axis of the graphs in Figure 3 refers to the possible answers of the post-inspection questionnaire and the Y-axis refers to the number of subjects. The P01, P02 and other codes represent the subjects presented in Table 3.

It can be seen in Figure 3 that 7 out of 9 subjects totally agreed with the statement *"I understood what was happening in my interaction with MIT 1"*, given confidence that the subjects understood what was happening when they were using the MIT 1.

Another statement with which more than half of the subjects totally agreed was *"It was easy to learn to use the MIT 1",* showing that the subjects did not have much difficulty learning to use the MIT. It should be noticed that subject S05 partially disagreed with this statement *"it was easy to learn to use the MIT 1"*, showing that MIT 1 is not so easy to learn.

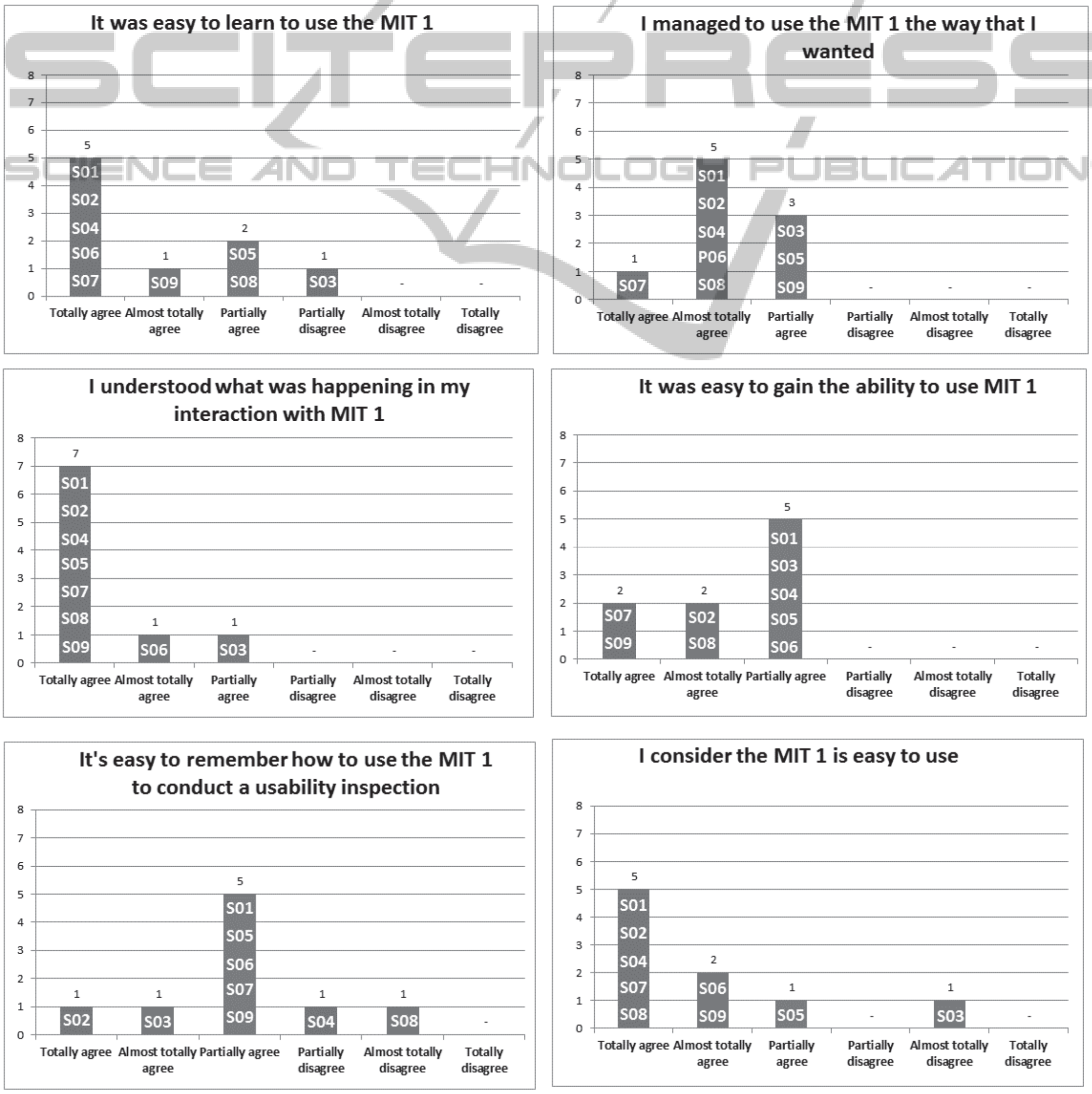


Figure 3: Subjects' perception on ease of use of the MIT 1.

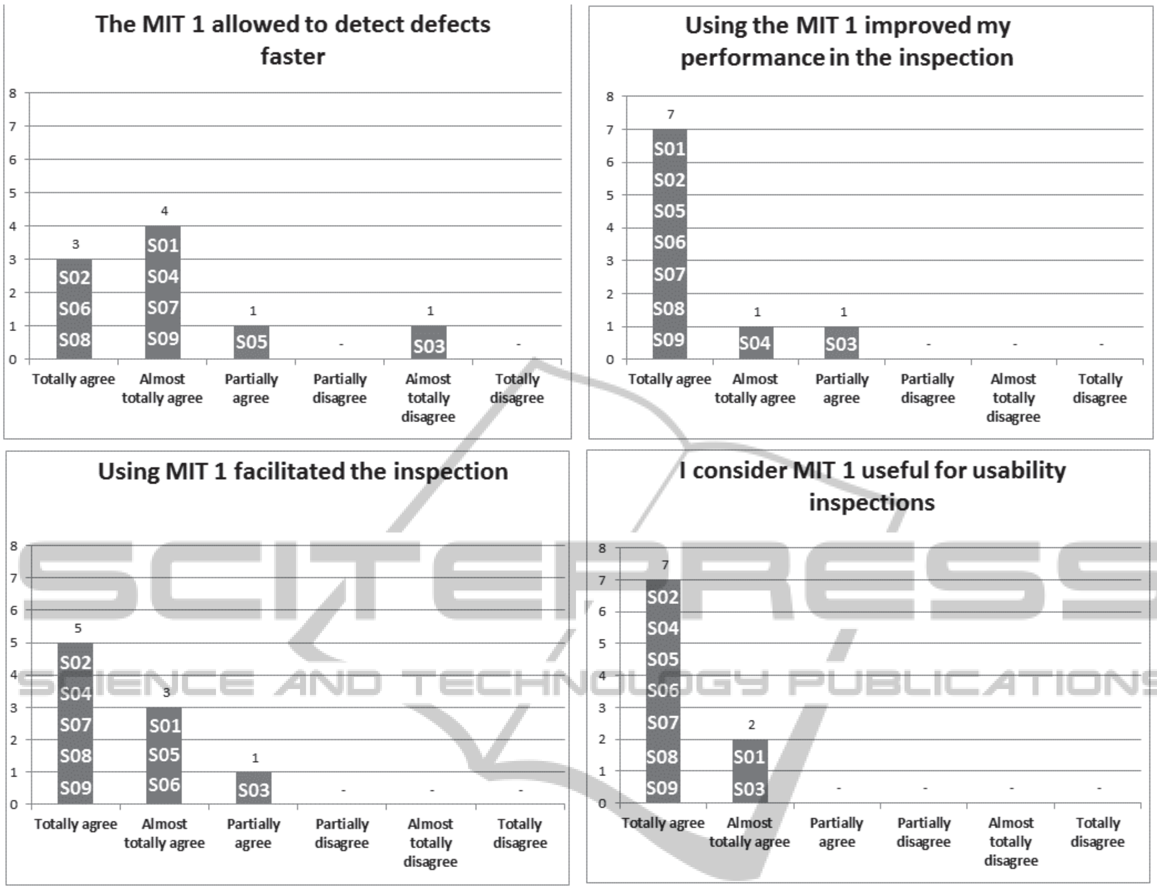


Figure 4: Subjects' perception on usefulness of the MIT 1.

Two of the nine subjects (S04 and S08) disagreed with the statement *"It's easy to remember how to use the MIT 1 to conduct a usability inspection"*, showing that MIT 1 is not so easy to remember. The subject S03 almost totally disagreed with the statement *"I consider that the MIT 1 is easy to use"*, highlighting the difficulty he had when using MIT 1. However, all inspectors agreed with the other statements, showing their acceptance regarding the MIT 1 technique.

6.2 Perceived Usefulness

Figure 4 presents the subjects' perceptions regarding the usefulness of the MIT 1. We verified that only the subject S03 almost totally disagreed with the statement *"The MIT 1 allowed detecting defects faster"*, indicating that at some point the subject S03 found the use of the technique time-consuming. However, all inspectors agreed with the other statements, reinforcing that the MIT 1 is helpful in the inspection process.

7 QUALITATIVE RESULTS AND IMPROVEMENTS

Besides the analysis using the TAM model, we carried out a specific analysis of the qualitative data (additional comments from the inspectors) contained within the questionnaires. We carried out such analysis using the procedures of Grounded Theory (GT) method (Corbin and Strauss, 2008).

The qualitative data that was extracted from the post-inspection questionnaires was analyzed using a subset of the phases of the coding process suggested by Corbin and Strauss (2008) for the GT method: open coding (1st phase) and axial (2nd phase). To analyze the qualitative data, we created codes (concepts relevant to understanding the perception about the technique and its application process) related to the subjects' speech - open coding (1st phase). After that, the codes were grouped according to their properties, forming concepts that represent categories and subcategories. Finally, the codes were related to each other - axial coding (2nd phase). GT procedures aim at achieving a deeper analysis, by comparing and analyzing the relationship between these concepts. The purpose of the analysis in this study was to understand the perception of the inspectors on their experience using the MIT 1. Since we did not intend to create a theory, we did not perform the selective coding (3rd phase of GT method). The stages of open and axial coding were sufficient to the understanding the causes of some problems in the application of the MIT 1. The concepts related to the GT method are presented in detail in Conte et al., (2009).

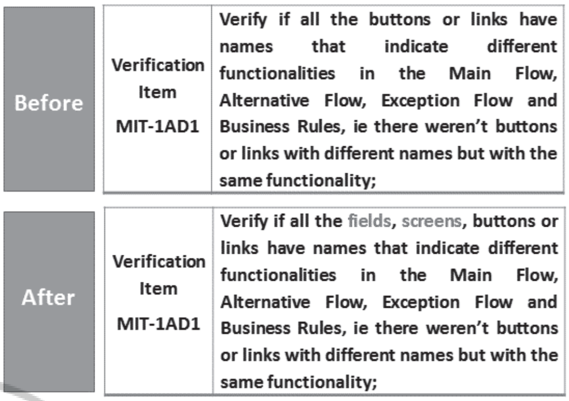
In this section, we discuss our qualitative results about MIT 1. Our implications from these results are described as follow.

7.1 Comments about Ease of Use of the MIT 1 and Initial Developed Improvements

This subsection provides information related to the difficulties and advantages of the use of the MIT 1 technique that were collected in the experiment. Some of the difficulties when using MIT 1 were: there are heuristics that are only applicable to some parts of the interface represented in the use case (see quotation from S01 below); there is a large number of verification items to evaluate the specification of the use case (see quotation from S02 below); it is difficult applying the MIT 1 (see quotation from S03 below); and it is difficult remembering the items of the technique (see quotation from S06 below).

> *"(...) There are heuristics that apply only to some [parts of the interface represented in the use case] (...)".* (Subject 1).
>
> *"There are many sub-items to assess, [which] may become a little confusing (...)".* (Subject 2).
>
> *"MIT 1 is a useful technique but difficult to apply".* (Subject 3).
>
> *"There are many types of [items] to be remembered, but with practice I might remember most (...)".* (Subject 6).

We can see that there were some difficulties and one of them should be highlighted: there are heuristics that are applied to only some parts of the interface represented in the use case. This happened in the verification item MIT-1AD1, because it suggests checking if there is a problem only in the name of the buttons or links. In order for this item to consider other parts of the interface, we added two other terms: "fields" and "screens" (see Figure 5).



Before	Verification Item MIT-1AD1	Verify if all the buttons or links have names that indicate different functionalities in the Main Flow, Alternative Flow, Exception Flow and Business Rules, ie there weren't buttons or links with different names but with the same functionality;
After	Verification Item MIT-1AD1	Verify if all the fields, screens, buttons or links have names that indicate different functionalities in the Main Flow, Alternative Flow, Exception Flow and Business Rules, ie there weren't buttons or links with different names but with the same functionality;

Figure 5: Verification Item MIT-1AD1.

Similarly, the terms "field", "option" and "screen" have been added in the verification item MIT-1AI1. With these improvements, we tried to make the technique more complete by considering other parts of the interface represented in the use case.

The subjects also had difficulties applying the technique. This was seen by the Perceived Ease of Use indicator (subsection 6.1) and by the responses to the post-inspection questionnaire. The goal of the MIT 1 is to help the inspector find the usability problems in the use case. However, if the inspector finds it difficult to use the technique, it is a sign that it still needs to be improved. A deeper analysis is being performed on each verification item so that improvements would be carried out in the future.

7.2 Comments about the Structure of MIT 1 and Initial Developed Improvements

This subsection provides the point of view of the subjects regarding the structure of the technique. During this experiment, some inadequacies in the structure of the technique were collected, such as: there are similar verification items (see quotation from S09 below) and that there are many heuristics not used (see quotation from S05 below). Also, one subject suggested grouping some heuristics (see quotation below from S01).

> *"(...) There is some confusion in understanding which statements we really need to specify (...), since they contain similar specifications (...)".* (Subject 9).
>
> *"(...) there are many heuristics that are applied to different types of discrepancies and sometimes not all are used (...)".* (Subject 5).

> *“[The] heuristics could be grouped in order to assist in their identification using the field”.* (Subject 1).

We can see that there were some inadequacies in the structure of the technique, for instance: some items are identified as similar in technique. This probably generated questions during the use of MIT 1. Thus, an analysis of the frequency of use of each verification item is being made, as well as an analysis of the identified defects that were found by more than one verification item. These analyses will lead to the identification of verification items that may be combined or better described.

8 THREATS TO VALIDITY

As in all studies, there are threats that could affect the validity of our results. In this Section, we discuss those threats; categorizing them using the same approach as Wohlin et al., (2000): internal, external, conclusion and construct.

8.1 Internal Validity

In our experiment, we considered four main threats that represent a risk for an improper interpretation of the results: (1) training effects, (2) experience classification, (3) time measurement and (4) influence of the moderator. There might be a training effect if the training on the HEV technique had lower quality than the training on the MIT 1. We controlled training effects by preparing equivalent training courses with the same examples of discrepancies detection. Also, regarding subject experience classification, this was based on the subjects’ self-classification. They were classified according to the number and type of previous experiences (in usability evaluation and software development). Considering time measurement, we asked the subjects to be as precise as possible, and the moderator also checked the time noted by each subject when he/she delivered his/her worksheet. Finally, to reduce the threat regarding the influence of the moderator on the results of the study, a team of experts did an analysis over the identified discrepancies. Such team judged if the discrepancies were usability defects or not, without the interference from the moderator.

8.2 External Validity

Five issues were considered: (1) subjects were undergraduate students; (2) the study was conducted in an academic environment; (3) the validity of the evaluated model as a representative model; (4) the researcher seeded some defects in the model; and (5) subjects required training. Regarding Issue 1, few subjects had experience in industry since they were only senior-level undergraduate students. According to Carver et al., (2003), students who do not have experience in industry may have similar skills as less experienced inspectors. Regarding Issue 2, the inspected artifact (use case) is a model that is part of the specification of a real system. However, it is not possible to state that the model used within the inspection represents all types of use case (Issue 3). Regarding Issue 4, all seeded usability problems were found by both groups of subjects. Furthermore, the number of defects found by the inspectors in both groups was much larger than the number of defects seeded by the searcher. Finally, regarding Issue 5, it would be ideal if there was no training needed in order to apply the technique. However, the short time spent in training allows developers to use the technique without prior experience in usability evaluation.

8.3 Conclusion Validity

In this study, the main problem is the size and homogeneity of the sample. The small number of data points is not ideal from the statistical point of view and furthermore, the subjects are all students from the same institution. Sample size is a known problem in studies of IHC and ES (Conte et al., 2007; Fernandez et al., 2012). Due to these facts, there is a limitation in the results, which should be considered indicators and not conclusive ones.

8.4 Construct Validity

We measured efficiency and effectiveness that are two measures often used in studies that investigate defect detection techniques (Fernandez et al., 2012).

9 CONCLUSION AND FUTURE WORK

This paper presented a feasibility study aimed at comparing two techniques of usability inspection, MIT 1 and HEV (Nielsen, 1994), in terms of efficiency and effectiveness. Through the analysis of the quantitative results of the experiment, we verified that the MIT 1 showed slightly better efficiency than the HEV. However, no statistically significant difference was found. Regarding the effectiveness indicator, MIT 1 had a significantly higher performance than the group that used the HEV. These results were also confirmed by the Mann-Whitney test.

From the analysis of user perception we can see that, in general, most inspectors agreed with the statements regarding perceived ease of use and perceived usefulness of the technique. These results show evidence of ease of use when applying MIT 1. The fact that MIT 1 had a good acceptance from the inspectors of the experiment might indicate that this technique is also suitable for inspectors with low knowledge on usability inspections. Also, inspectors stated that the technique has verification items that are easier to understand and use.

The qualitative analysis enabled the identification of difficulties when using the MIT 1 in this feasibility study, such as: items that did not consider parts of the system described within the use case interface, the existence of similar items, among others. These qualitative results led to the initial improvement of the MIT 1 technique. Some of the improvements were the reviewing of the verification items, making them more complete. However, a deeper analysis of the verification items is being conducted to improve the technique.

As future work, we intend to carry out new empirical studies, to ensure the quality of the technique for its future transfer to industry. Furthermore, there is another usability evaluation technique proposed for use case in the literature, called Use Case Evaluation (Hornbæk et al., 2007). In the future, we intend to compare MIT 1 to this method and to conduct studies with industry subjects.

We expect that the results presented in this paper are useful for the promotion and improvement of the current practice and research in usability evaluation. We also hope that the proposed technique assists the evaluation of models that are employed in the early stage of the development process, improving their quality at a low cost.

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