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THE VALUE OF T-GIUESE-SUPPORTING USABILITY EVALUATION PRACTICES DURING DEVELOPMENT PRODUCT: A CONTROLLED EXPERIMENT

[1]FOUAD ABDULAMEER SALMAN, [2]AZIZ BIN DERAMAN, [3]MASITA BINTI ABDUL JALIL
School of Informatics and Applied Mathematics
University Malaysia Terengganu (UMT)
21030 K. Terengganu, Terengganu Malaysia
E-mail: [1]fouarese@gmail.com, [2]a.d@umt.edu.my, [3]masita@umt.edu.my

ABSTRACT

Despite having different underlying concepts, both agile methods and usability evaluation ultimately aim at producing high quality software. This paper presents the results of an empirical study on incorporating usability evaluation activities within an agile development plan. The study includes an experiment testing the effectiveness and efficiency of the proposed tool in implementing the quality aspect of usability. 32 novice participants were divided equally into a group using the conceptual tool and another using ISO standards. Both groups conducted a usability evaluation based on the same project (registered students system). It is concluded that the conceptual tool significantly helps inexperienced software teams to incorporate usability work within an agile environment.

Keywords: *Controlled experiment, Usability Evaluation, Software Development Process, ISO Standards*

1. INTRODUCTION

High-level usability is acknowledged as a significant feature of interactive software systems. Conversely, poor usability and inefficient end product design are prevalent causes for failed software products [1, 2, 3]. Thus, usability evaluation activities are crucial in software development, especially for agile approaches during the design and development stages for efficient feedback collection. Usability evaluation is applied in software projects to improve product usability and overall quality while reducing risk of failure and long term costs [4]. However, the time- and effort intensive nature of usability evaluations discourage agile software teams from implementation despite the promise of valuable feedback [5]. Therefore, an integration based approach toward tests is gaining interest in agile environments.

There are many reported approaches to integrating usability in agile environments, from various aspects. [6] advocates including the Big Design Up Front (BDUF) approach in agile development, where the design details are presented before coding and testing programmes so to minimize later revisions. In contrast, the Extreme Scenario-based Design (XSBD) proposed by [7] relies on a centralized design record (CDR) which facilitates communication between the major stakeholders (namely the agile experts, usability specialists and management), and acts as a reference for usability experts for usability testing and design matters. The storyboarding approach described by [8] is an iterative and low reliability agile prototyping technique that can revamp software design without involving extensive coding of modules. Another methodology, the U-SCRUM attempts to streamline the evaluation process based on the needs of the end user, which are divided into functionality- or usability-focused. This approach proposed by [9] differs from its predecessor, SCRUM by catering to more than one product owner and has been reported to produce better improvements in usability. Most of these approaches are feasible on an operational level, yet suffer from low transferability to other practical situations due to highly specific activities and methods. A more abstract view of integration is worthy of further investigation.

The International Organization for Standardization (ISO) has defined the standard guidelines to deal with different aspects of human-computer interaction (HCI) and usability

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evaluation. Specifically, the ISO 9241-11 [10] provides guidance on user-oriented design processes. Other relevant ISO standard guides are ISO/IEC 14598 [11] and ISO TR 16982 [12]. The standards serve to define predictable and repeatable processes and form a common knowledge base, both of which greatly help software development teams in timely and effective identification and planning of usability activities alongside ongoing software design processes.

Unfortunately, international standards are perceived by agile development teams as impractical for supporting software development teams in agile environments, and thus are not implemented to reap the above mentioned benefits [13]. We propose a conceptual tool as a guide derived from international standards for potential incorporation points (activities, and artifacts) between usability evaluation and software development process (T-GIUESE), which enables the quality aspect of usability to be implemented smoothly, as well as educate and persuade the understanding and usage of standards related usability evaluation. This tool comprises the fundamental activities and artifacts from UE relevant to usability evaluation and similar features from SE that is pertinent to the development process. Potential incorporation points were highlighted. Activities were also linked with artifacts to show dependencies and relationships. Convergence artifacts of both disciplines were identified and shown. (See Figure 1)

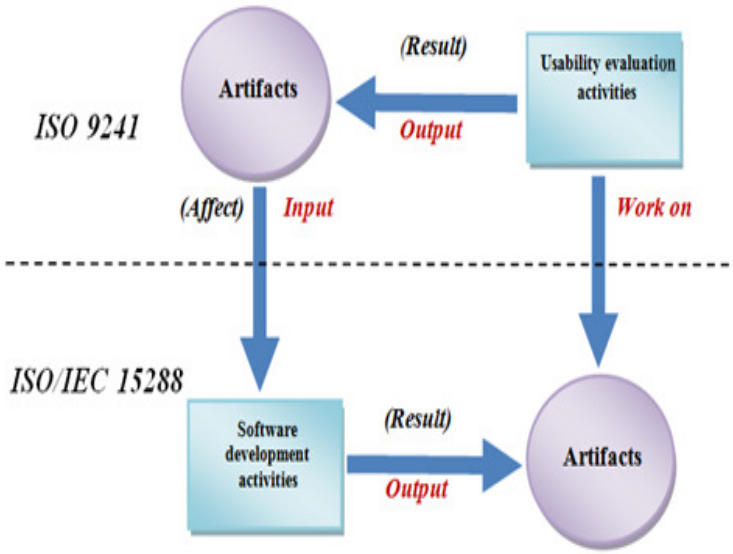

Figure 1: incorporating usability evaluation into development process activities

The tool could benefit development teams as follows: assisting the nomination of appropriate usability evaluation methods; documentation and communication of results; defining fields of competencies for roles in agile development projects; all of which result in quality of use. Furthermore, the tool enables the clear discussion and comparison of processes within organizations through a model, leading to clear identification of incorporation aspects. Existing process models can be both enhanced and evaluated through this tool.

Agile development teams routinely handle complex tasks and extensive methodologies, so the proposed tool, T-GIUESE should be evaluated for effectiveness and efficiency against ISO standards before wider dissemination to professionals. In this paper, we describe a controlled experiment that evaluates the role of T-GIUESE in linking usability evaluation to software development. Software development teams are able to set, prioritize and evaluate usability aspects smoothly through using T-GIUESE, as well as familiarize themselves with standards and methods based usability evaluation. The study includes an experiment to test the performance of T-GIUESE in improving the quality of usability evaluation activities, compared to conventional ISO standards. The measured variable

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is whether T-GIUESE better supports the needs of a software team than conventional ISO standards.

2. USABILITY EVALUATION ACTIVITIES WITHIN AGILE PLAN

Agile methodologies attempt to improve software quality and responsiveness to client requirements, yet usability aspects in agile environments appears to be poorly defined, resulting customers or users feeling overwhelmed with system functionality concerns that result from insufficient attention to product usability issues [14]. Literature reports also indicate that agile teams are concerned with the lack of attention to usability evaluation and usability engineering in general within agile environments [9, 15, 16, 17, 18, 19, 20, 21]. Agile methods are focused on people instead of processes, hence the agile team must address usability in a way that enables successful incorporation into software engineering. Evaluation of an agile development team's performance in setting, prioritizing and evaluating usability aspects during project planning acknowledges the multiple interpretations for the term "performance". In this study, performance is evaluated from the aspects of effectiveness and efficiency. The evaluation of performance will be from the aspects of efficiency and effectiveness[22] [23], which are terms defined by [24] to measure performance abilities such as development of corporate and employee styles, motivation of staff commitment, and development of employee's skills. These terms are selected due to high similarities with our evaluation outcome.

Performance = effectiveness x efficiency;

Effectiveness: The accuracy and completeness with which agile practitioners can produce usability evaluation activities and dependencies within project plans.

Efficiency: The ratio between production of the usability evaluation activities and dependencies to the time consumed by agile practitioners for production.

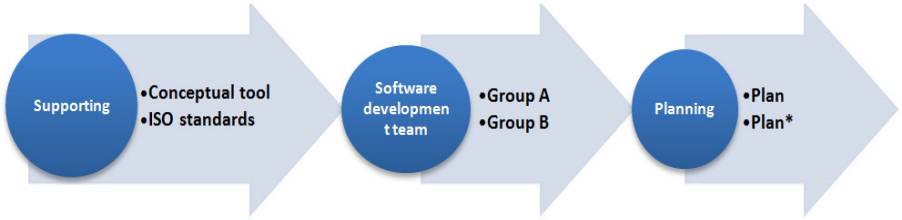

Figure 2: Measuring the effectiveness and efficiency of the compared tools

Figure 2 above is an abstract representation of the evaluation setup of two different tasks, where one is supported by T-GIUESE and another by ISO for both effectiveness and efficiency according to one set of inputs (Task Instructions). Two different sets of outputs (plan and plan*) are produced with the objective of producing the most appropriate plan for the project.

This general setup, which transforms inputs into useful outputs is adopted from [25] as well as [26]. It is assumed that there exists a function for Effectiveness with parameters consisting of a set of inputs and a set of outputs to return a measurement of efficiency and effectiveness for an appropriate plan goal. In the situation where Effectiveness (plan)* > Effectiveness (plan), then (ISO) is defined as being more effective than (T-GIUESE). Additionally, if efficiency (plan) > efficiency (plan)*, then (T-GIUESE) is defined as being more efficient than (ISO) and vice versa.

3. DESCRIPTION OF THE EXPERIMENT

We conducted an experiment with the conceptual tool (T-GIUESE) for purpose to examine the usefulness of the tool for inexperienced agile practitioners.

Setting: The experiment was conducted in relation to a final coursework project for participants (registered students) where they were requested to involve usability evaluation activities in the first and last sprints of their project plan, see Figure 3.

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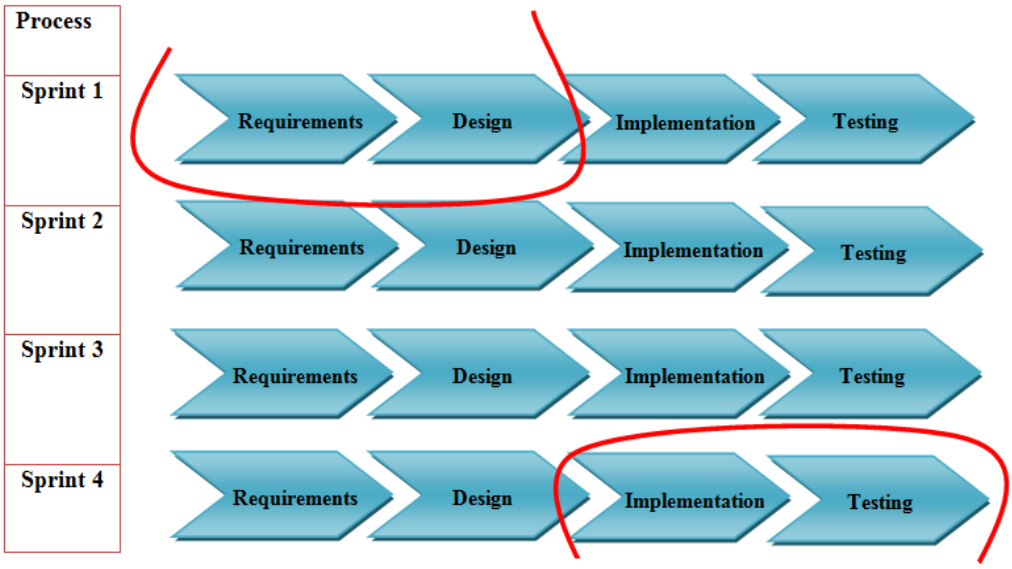

Figure 3: Specific phases for experimental in iterative planning

Participants took a short course in usability evaluation from the author of the paper consisting of the following modules:

A. Introduction to usability evaluation.
B. Usability evaluation activities and artifacts.
C. ISO standards related usability evaluation.

Each module contains a one-hour lecture and a one-hour discussion. The experiment was conducted after completion of the final module, C. The module consists of a presentation on the activities in a usability evaluation and the relevant techniques for each activity. The main literature was the standards document (ISO 9241) supplemented with selected articles. The lectures of the modules had the following contents:

1. The purpose of a usability evaluation, the concept of usability and overview of the activities and artifacts involved in a usability evaluation.

2. Basic decisions, field versus lab, the test monitor role and the test report.

3. Creation of test context, tasks assignments, conducting the test and the think-aloud technique.

4. Interpretation of data, the ISO definition, task load, identification of usability problems, exercises in identification and categorization of usability problems.

5. Presentation of experiences from our evaluation, heuristic evaluation, comparison with think-aloud method, and training of novices in usability evaluation.

Subjects: The participants in the experiment were 32 second-year Computer Science undergraduate students of university Malaysia Terengganu (UMT). The 13 male and 19 female participants are aged between 20 to 21. They were offered participation as a voluntary exercise, but were promised feedback on their projects.

Conceptual tool: The experiment involved an incorporation tool that the authors had developed based on a model [27]. This tool was customized for use as a supporting tool for Group A during the experiment, whereas the control group, Group B used conventional ISO standards. An excerpt of the conceptual tool is shown in Figures 4, 5.below.

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No.	Software Development Artifacts
1	Record of user needs and requirements
2	Record of system requirements.
3	Feed back the analyzed user requirements (validation).
4	Feed back the analyzed system requirements (validation).
5	Provide key information items as baselines (user requirement).
6	Provide key information items as baselines (system requirement).
7	Collect data and inputs needed for analysis.
8	Review the analysis results for quality and validity.
9	Establish conclusions and recommendations.

No.	Requirements Activities
1	Preparing for stakeholder needs and requirements definitions.
2	Defining stakeholder needs.
3	Developing the operational concept and other life cycle concepts.
4	Transforming stakeholder needs into stakeholder requirements.
5	Analysis stakeholders' requirements.
6	Managing the stakeholder needs and requirement definition.
7	Preparing for system requirements definition.
8	Defining system requirements.
9	Analyzing system

Figure 4: Exchange of information between artifacts and activities

No.	Usability evaluation Activities
1	Collecting new information on the requirements (Needs) the user.
2	Assessing whether the user requirements have been met (Compliance audit).
3	Providing feedback on strengths and Weaknesses of the design solution from the perspective of users (Formative Evaluation).
4	Establishing baselines or comparisons between designs.
5	Performing a user-oriented evaluation.
6	Performing a comprehensive audit to results to get on the system as a whole.
7	Results and necessary adjustments to the develop solutions.

No.	Requirements Activities
1	Preparing for stakeholder needs and requirements definitions.
2	Defining stakeholder needs.
3	Developing the operational concept and other life cycle concepts.
4	Transforming stakeholder needs into stakeholder requirements.
5	Analysis stakeholders' requirements.
6	Managing the stakeholder needs and requirement definition.
7	Preparing for system requirements definition.
8	Defining system requirements.
9	Analyzing system requirements.
10	Managing system requirements.

Figure 5: Incorporating usability evaluation into requirements activities

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Test procedure: The students were told during the introduction to the experiment that there would be an exercise on usability evaluation planning but without further details. They were then divided into two groups of equal size and allowed to complete the experiment without time constraints, resulting in sessions lasting between 1 to 1.5 hours.

They were informed about a required reading handout that describes the sprints relevant to the software development process. Then, they were guided through a description of usability evaluation requiring the information described in the handout and finally, they were asked for making usability evaluation plan to apply within these sprints.

Participants were given the appropriate supporting documents for the comparison experiment between the T-GIUESE and ISO standards a day before for their perusal and comprehension. To minimize variations in comprehension level and time during this portion, the experimenter read the Task Instructions aloud to the participants while taking questions from the audience. Participants were given an Answer Packet while reading the final page of the Task Instructions. Both groups were allowed unlimited time to complete the planning task. After completing said task, the groups were asked to explain their solution in detail to the experimenter to disambiguate any hand-writing or diagrammatic confusion.

Data collection: The main result was the activities and artifacts list produced by each group. In additional information are the working diaries maintained by students, which detailed their observations and problems. We shall discuss only the activities and artifacts lists in this paper.

4. RESULTS

The key results from our experiment are outlined in the following sections. First, we present suggestions for usability evaluation activities and artifacts from the comparison between the two participating groups of students. Secondly, we outline the total number of activities and relevant independence suggested by the groups for each plan, and finally we present the time consumed for task planning by each participant group.

4.1 The Conceptual Tool and ISO Standards

4.1.1 Plans of individuals

Table 1 summarizes key results on the plans suggested by the Group A (T-GIUESE) and Group B (ISO) participants. The table shows that T-GIUESE participants generally suggested a higher number of activities and artifacts on all phases. However, the high standard deviation indicates major variability between subjects in the ISO group as measured from the total number of suggested activities and artifacts. One participant suggested only 2 activities compared to 12 from another participant (SD=3.19). The same variances were not present in the T-GIUESE group, whereby the activities suggested had a narrower range of 9 to 14 (SD=1.59).

The T-GIUESE participants suggested more activity-relevant artifacts than the ISO participants. On average, the T-GIUESE participants suggested 3.88, 10.55 (input/output) artifacts compared to the 3.22, 6.11 artifacts suggested by the ISO participants. However, we found only minor differences for the software development process artifacts.

Table 1:Descriptive Statistics for activities and relevant independence for the two approaches

Plan of individuals		Mini	Max	Mean	Std. Deviation
T-GUISE	Activities	9	14	11.56	1.59
	Artifact (input)	3	5	3.88	.781
	Artifact (output)	8	12	10.55	1.33
	Artifact (work on)	10	12	11.11	1.05
ISO standards	Activities	2	12	6.78	3.19
	Artifact (input)	1	6	3.22	1.98
	Artifact (output)	1	10	6.11	3.14
	Artifact (work on)	6	9	6.88	1.16

Furthermore, some suggestions from the reported activities lists of the 32 participants were classified as non-activities when no meaningful

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activity could be extracted from the goal description. We found that the ISO participants suggested a higher number of these non-activities (M=1.33) compared the T-GIUESE subjects (M=0.44). Similarly, the ISO participants suggested more artifacts which were considered inaccurate, irrelevant or incomprehensible (M=2.44) compared to the T-GIUESE participants (M=0.88).

4.1.2 Plans of groups

Having outlined and discussed the average numbers of added activities and artifacts of usability evaluation within each plan (group A and B), we continue by showing total numbers of activities for the two setups, see Table 2.

Table 2: Total number of activities and relevant independence for the two groups

Phase / Plan of groups		Requiremen	Design	Implementation	Testing	Total	Mean
T-GUISE	Activities	3	2	4	3	12	3.00
	Artifact (input)	2	1	2	0	5	1.25
	Artifact (output)	3	2	3	3	11	2.75
	Artifact (work on)	3	2	3	3	11	2.75
ISO standards	Activities	1	2	3	2	8	2.00
	Artifact (input)	1	1	2	0	4	1.00
	Artifact (output)	1	2	3	2	8	2.00
	Artifact (work on)	1	2	2	2	7	1.75

From Table 2. above, the distribution of identified activities and artifacts among different phases in both groups were rather different. The number of activities in plan A was higher than for plan B, caused by the suggestion of four activities by Group A. Accordingly, plan A contained more artifacts (27) than plan B (19). However, the implementation phase has the most activities (4, 3) as well as the most artifacts (3, 3). There was no phase with the least activities or artifacts since all results were almost at a similar level.

Some of the activities suggested by the participants in both plans A and B were considered non-activities when meaningful activities cannot be extracted from the goal description, and when they were considered inappropriate or relevant to the concerned phase or sprint. We found more non-activities suggested in plan B (M=0.37) than in plan A (M=0.16). Similarly, we classified some artifacts as inaccurate, irrelevant or incomprehensible in relation to the suggested activities. Plan B contained more of these irrelevant artifacts (M=0.35) compared to plan A (M=0.22).

4.1.3 Time planning of the two groups

Completion time needed was measured as a final metric of participant performance. Table 3 outlines the time distribution for task planning. We measured the time from 3 scenarios: time consumed individually to suggest activities and artifacts before group discussion, time taken for group discussion before releasing the plan, and total time consumed for the entire planning process.

The table shows that individual group A participants took less time to perform the planning task, averaging 34 minutes from a range of 29 to 38 minutes. Group B participants averaged 43 minutes from a range of 20 to 56 minutes. As indicated by the high standard deviation, group A and group B spent significantly different times on the suggested activities and artifacts in their plan, which is 9.46 for group B and 3.15 for group A. Only minor differences were observed in the measured discussion time for participants in each group before plan release. Furthermore, group B took a longer time (84 minutes) to complete the entire planning process compared to 67 minutes for group A.

Table 3: Time planning of the two groups

Time	T-GUISE	ISO standards
Individual participant (Std deviation)	3.15	9.46
Individual participant (Mean)	34	43
Group participants	31	34
All planning process	67	84

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5. DISCUSSION

The experiment showed major improvements caused by provision of T-GIUESE on the number of activities and artifacts considered by the participants while preparing a plan for usability aspects. The results indicated that the conceptual tool had helped the participants to suggest and recommend usability evaluation activities and artifacts for their work. In fact, the T-GIUESE participants on average suggested a higher number of convenient activities and artifacts compared to the ISO participants. We can infer that the T-GIUESE significantly helps users remember the activities that need to be considered when proposing a plan or project. In contrast, ISO standards alone seem applicable for incorporation of usability evaluation, but are challenging to grasp in their entirety due to looseness of composition in the absence of process or organizational specific details. Thus, the ISO participants are confused whether their proposed activities are sufficient.

Overall, the average T-GIUESE participant suggested 4 more activities and 7 more artifacts than the average ISO participant. This indicates that the visual potential incorporation points are easy to follow and simplifies the process of incorporating usability work in plans. Furthermore, it creates more realistic expectations of the number of required artifacts (ie: input and output) in the development process.

There is opposition to using practical guidelines related to usability such as T-GIUESE by agile practitioners, as they are uncommon in agile environments and inessential to the agile process despite the clear advantages of a risk of usability approach. However, usability integration is not something that can be ignored while applying a method in agile software projects. Though many development organizations describe great success in using agile development processes, none of them explicitly describe the inclusion of usability activities [28].Therefore, the acceptance of tool among agile practitioners in companies needs to be evaluated to glean their actual perspectives on the concept of usability integration.

Secondly, the participants using the T-GIUESE suggested fewer non-activities. The bulk of the non-entries recorded (12 out of 16) were reported by the ISO participants. Thus, our tool seemed to support the meaningful and comprehensible presentation of activities by participants. It is acknowledged that neither T-GIUESE nor ISO standards can uncover all activities and artifacts involved, as there are variations in software companies from size, market sector, time in business, management style, location, to the type of provided services and products [29]. Nonetheless, standards are universally agreed guidelines and form a reasonable basis for improving the transferability of incorporation processes.

Software development teams often under-suggest activities and artifact related usability issues in agile environments due to constraints of time and high levels of required effort [5]. Our results confirmed this issue as our participants unsurprisingly only proposed common activities. Despite seeing the big picture from the conceptual tool and having the clarity to select appropriate usability activities, participants still hesitated to imply usability activities. Therefore, we think there is a need for another tool besides T-GIUESE, that supports the timely and relevant selection and application of usability evaluation methods and techniques for agile development iteration planning.

However, Group A identified more activities and artifacts for all four phases except the design phase which showed an equal number of activities. From this, it seems our conceptual tool helps reduce the considerations for constraints as the T-GIUESE participants planned more effectively, which resulted in a more accurate and complete list of activities and artifacts than the ISO participants.

From the perspective of efficiency, the experiment showed that T-GIUESE significantly reduced the time consumption of the participants for planning. Participants who used T-GIUESE spent 67 minutes for all planning tasks, in contrast with 84 minutes by the ISO participants. Evidently T-GIUESE helped the participants significantly in making suggestions for the activities, as well as consider the relevant independence when preparing a plan for usability aspects. The experiment also showed major variability in time consumption between individual ISO. The same variability was not found among individual T-GIUESE participants. Our conceptual tool seemed to reduce personal error as seen through a more uniform performance by the participants and less variability in their usability evaluation activities and artifacts

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lists compared to the ISO participants. The conceptual tool has been developed entirely from ISO international standards, yet facilitates its application in a simplified and clear way. Other researchers have worked with the business perspective of marketing activities. It may be possible to combine these two approaches into an enhanced conceptual tool.

6. CONCLUSION

This paper presents a conceptual tool, T-GIUESE which was designed based on the ISO international standards 9241 and 15288. It aims to improve the quality of usability implementation by agile software teams through conveying the "big picture" of potential incorporation points in both fields. The conceptual tool was evaluated in an empirical study on incorporating usability evaluation activities within an agile development plan.

Through this study, the performance of two groups of novice participants using the T-GIUESE tool and ISO standards respectively were compared. The results showed that the T-GIUESE group performed better on identification of appropriate activities and artifacts by average per participant and group. These results indicate a clear potential usefulness of the conceptual tool as it improves the planning performance of novice participants.

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