Evaluating the usability expressiveness of a USability-oriented INteraction and Navigation model

Anna Beatriz Marques
USES Research Group, Institute of Computing, Federal University of Amazonas
Amazonas, Brazil
anna.beatriz@icomp.ufam.edu.br

Simone Diniz Junqueira Barbosa
Informatics Department, PUC-Rio
Rio de Janeiro, Brazil
simone@inf.puc-rio.br

Tayana Conte
USES Research Group, Institute of Computing, Federal University of Amazonas
Amazonas, Brazil
tayana@icomp.ufam.edu.br

ABSTRACT
The success of an interactive system is strongly related not only to the quality of its user interface, but also to the quality of its interaction and navigation mechanisms. Those mechanisms need to be carefully designed, but there are still no de facto standard design models to represent user-system interaction in a way that privileges decisions regarding the usability of the product being developed. Recently, we proposed USINN (USability-oriented INteraction and Navigation model) to express usability mechanisms in interaction and navigation modeling solutions. In this paper, we present an empirical study conducted in academic environment to investigate the use of USINN to represent usability mechanisms in interaction and navigation design solutions. The results indicated that the participants consider USINN to be easy to use and useful for the interaction and interface design. They also pointed out the need for a better knowledge about usability to apply USINN effectively.

Author Keywords
interaction model, navigation model, interactive systems usability, usability-oriented design.

ACM Classification Keywords
D.2.2 Design Tools and Techniques – user interfaces, object-oriented design methods. H.5.2. User Interfaces - evaluation/methodology, user-centered design.

INTRODUCTION
The software industry has increasingly focused on offering high-quality interactive system to users [16]. However, interactive systems often contain design defects that may cause users problems [9]. Since the system is only perceived by users through what they can see and with what they can interact, the success of an interactive system is inexorably related to the quality of its user interface [21]. In order to improve the quality of user interfaces, we can focus on first designing interaction rather than interfaces [3]. Thus, it is important that the artifacts employed in interaction design allow expressing quality criteria to be met by the interaction.

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Usability is a quality attribute that impacts the user interaction with the system, when the system provides commands to allow users to undo actions, to validate user requests and to provide appropriate feedback [12]. Representing functional usability features [12] in models used in the design phase is a proposed strategy for use cases, classes and sequence diagrams of UML (Unified Modeling Language) models [6], and MDD (Model-Driven Development) approaches [20].

We believe that adopting a similar strategy on models used in interaction design will allow increasing the usability expressiveness of the models and, consequently, the usability of the solutions designed. As usability expressiveness, we consider the model capability of representing usability aspects related to its modeling perspective. When using models with usability expressiveness, the interaction designer can design her/his solutions by more directly reflecting on usability mechanisms to be integrated in the interaction. This strategy can reduce the rework needed to consider usability in later stages of systems engineering [20].

Recently, we proposed USINN (USability-oriented INteraction and Navigation model) to represent usability mechanisms related to the interaction and navigation of interactive systems [17]. Our goal is that designers adopt USINN during the interaction and interface design.

To investigate whether and to what extent the adoption of USINN enables designers to represent usability mechanisms in modeling tasks and to build mockups with usability, we conducted an empirical study in an academic environment with students of three undergraduate classes as participants. We analyzed their perception about USINN and the quality of the artifacts they created with USINN. The participants considered USINN easy to use and useful for the interaction and interface design, indicating some difficulties to properly express usability when using the model.

The following sections describe the background knowledge for our work, the USINN model, and the feasibility study that we conducted. Finally, we present our concluding remarks and future work.

BACKGROUND AND RELATED WORK

A structured representation of user goals and tasks is a key activity in the user-centered design of interactive systems [8]. Although task models are an established approach to this end, representing alternative paths to reach the same goal requires the development of different task models and it is difficult to take advantage of rich control flows and contexts [4]. Such limitations can be addressed by the use of interaction models [2, 4].

We consider as interaction model any model that describes the communication between the user and the system, specifying when the user can perform specific tasks to achieve certain goals, when the user can inform input data, and when the system can process the user information and show appropriate content and feedback [2]. Interaction and navigation are interrelated aspects of design, because the user-system interaction can lead to navigation flows [17].

Navigation models comprise basically navigation nodes (a set of information or features that will be presented to users) and navigation flows among nodes [19]. Models that represent different views of the same solution must be consistent with each other [1]. Modeling the navigational perspective according to the way in which the user wishes to explore the application helps to obtain more usable navigational paths [10]. As discussed in [17], USINN was the first model to explicitly integrate interaction and navigation representations.

Furthermore, representing usability aspects in models used in the design phase is a proposed strategy for use cases, classes and sequence diagrams of UML (Unified Modeling Language) models [6] and MDD (Model-Driven Development) approaches [20], but USINN was the only similar approach for interaction models. We believe that increasing the usability expressiveness of the interaction models will also improve the usability of the solutions designed. Using models with better usability expressiveness could enable the designer to reflect on usability aspects to be considered in the interaction.

Juristo et al. [12] identified a set of functional usability features (named FUFs) that impact the design of the application, specifically the user interaction. They detailed each FUF in terms of usability mechanisms (which are different ways of designing each FUF) and proposed guidelines to elicit usability requirements related to usability mechanisms [13]. Carvajal et al. [6] proposed guidelines to incorporate usability requirements related to usability mechanisms [13] in use case diagrams, class diagrams, and sequence diagrams in order to support design.

We have identified a proposal to include usability requirements in navigation models [19]. However, the authors do not provide specific guidelines on how to elicit usability requirements related to navigation (i.e. it is not directed to FUFs). We decided to consider the usability mechanisms defined by Juristo et al. [13] because then one can use the available guidelines to elicit usability requirements to be considered in the solution design. Beyond that, there are evidences regarding the positive effect of the usability mechanisms on development time [12] and final product quality [13, 20].

USINN: USABILITY-ORIENTED INTERACTION AND NAVIGATION MODEL

The USability-oriented INteraction and Navigation model (USINN) aims to represent both interaction and navigation aspects of an interactive system. At the same time, USINN allows to expand the interaction and navigation elements related to usability. In order to define the necessary usability elements, USINN elements were also based on the usability mechanisms related to the FUFs [13]. Figure 1 presents the elements of the USINN notation.

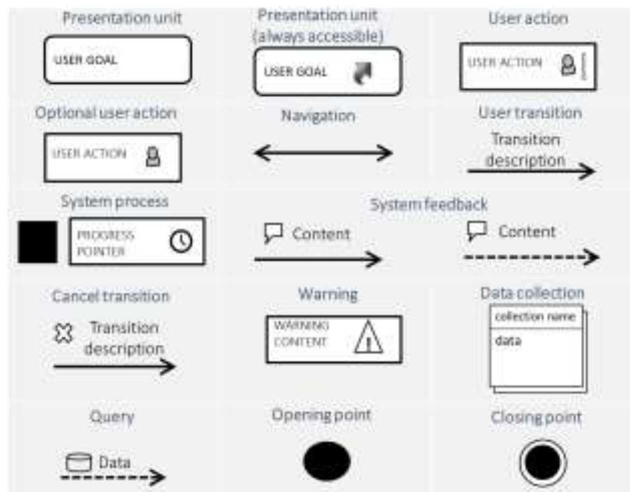

Figure 1. Summary of the USINN elements representation.

In this section, we provide a brief description of how USINN can visually represent the usability mechanisms associated to the FUFs. Note that, in addition to representing those usability mechanisms, USINN can also represent both interaction and navigation aspects, even if usability *requirements* are not explicitly represented.

Step-by-Step execution: it allows tasks with multiple steps to be represented as a series of navigable windows. Certain tasks require a series of inputs from the user that may not feasible to perform in a single window. The *presentation units* and *navigation* elements (Figure 1) can be used to represent step-by-step execution. The *presentation unit* can represent the steps and *navigation* provides next/previous commands to user.

System Status Feedback: it provides the user with information on the different statuses the system might be in at any given time. The *system feedback* elements can be used to inform users about the internal status of the system.

Progress feedback: it aims at providing the user with accurate visual feedback on the progress of the current task. The *system process* with the progress pointer can be used to inform users that the system is processing an action that will take some time to complete. In such cases, the user will need to be able to cancel the task (see abort operation).

Undo: it provides a way for the user to revert the effects of a previously executed action or series of actions within an application. The *cancel transition* can be used to represent the possibility of undoing user actions.

Abort operation: it provides the means to cancel an on-going task or to allow for exiting the application altogether. The *cancel transition* can also be used to represent the possibility of cancelling an ongoing operation. The *navigation* element enables the user to go back to a particular state in a navigation sequence.

Warning: it entails providing different alert types upon execution of sensitive actions. Certain tasks have potentially serious consequences (may not be undoable, for example). The system may need to verify whether the user actually aims to proceed with the task to prevent the user from performing tasks by mistake. The *warning* element can be used to inform users of any action with important consequences. Some warnings may require providing a cancel option to the user.

Multi-level help: it allows the user to access textual help features in different levels of detail throughout the system. The help content can be represented by *data collection*. An *optional user action* can be used to represent that the user can view the help content during the interaction.

Preferences: it provides users with a centralized place where they can alter the application settings. The presentation unit can be used to represent a place where the user can configure his/her preferences. The *user actions*, *system process*, *system feedback* and *user transitions* can detail how the user can configure his/her preferences. The user preferences options can be represented by *data collection*.

Favorites: it allows the user to bookmark and keep a collection of favorite places within an application. The *user action* can be used to represent the possibility of bookmarking places or objects in the system. The user favorites can be represented by *data collection*.

Personal Object Space: it covers the users' needs to arrange and manipulate objects graphically on screen. Similar to the favorites mechanism, user actions and data collection can be used to represent it.

Commands Aggregation: it allows the user to aggregate commands into macro-like structures for ease of batch execution. The *data collection* can be used to record the sequences of actions the user may perform repetitively and to save them for future use. The *user action* can represent the possibility for the user to play a previously recorded macro.

We did not consider interaction and structured text entry mechanisms, because interaction and navigation models do not consider the concrete aspects of the user interface that are necessary to represent these mechanisms, such as a mask in a text field or a color change on the edge of a button [6].

Figure 2 illustrates an example of a USINN diagram that combines the elements described in Figure 1 to represent part of the interaction of a user with an internet banking application. The diagram focuses on system status feedback, progress feedback, cancel, and warning.

The user interaction starts with the user providing data in order to perform a transfer. The user selects the recipient account from a collection of registered accounts. The system validates the user data and provides suitable feedback (*system status feedback*). Before completing the transfer, the system verifies whether the user actually aims to confirm the transfer (*warning*) and asks for the user password. While performing the transfer, the system provides an option for the user to cancel the command (*progress feedback* and *cancel*). After the transfer, the system provides the user with information about the current balance (*feedback*).

If different teams are working on user-system interaction and navigation and they prefer to work independently, a USINN model can be created iteratively.

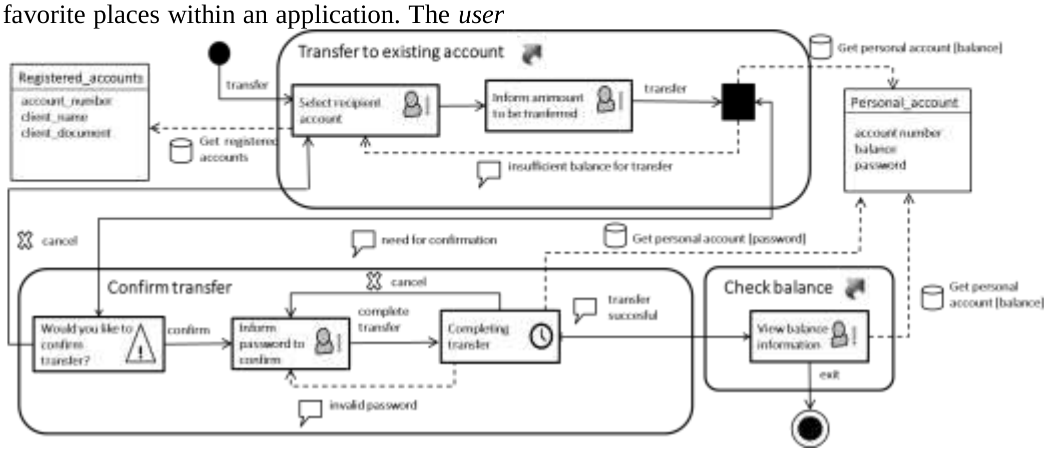

Figure 2. USINN model example.

The system navigation can be represented by presentation units and navigations without representing the user-system interaction. The user-system interaction elements can increment a previously created system navigation model or a single presentation unit. In order to do this, we can add user actions, transitions, warnings, system process, system feedback, data collections, and other USINN elements.

EMPIRICAL STUDY

To investigate whether USINN actually supports interaction and interface design, we conducted an empirical study in two stages. In the first stage of the experiment, participants used USINN to model the interaction and navigation of a system. In the second stage of the experiment, the participants used a USINN model as the basis for building mockups.

Goal

The goal of this study was to characterize the use of USINN as a notation for usability-oriented interaction and navigation modeling and as the basis for mockups building with regards to its ease of use, usefulness, intention to use and the quality of the elaborated artifacts.

Participants

In order to evaluate and refine USINN before adopting it in the industry, we conducted the experiment in an academic environment in a 5th semester class of a Technology in System Analysis and Development course. We then replicated the experiment in two other classes: (i) a 5th semester class of a Computer Science course and (ii) a 3rd semester class of the Technology in System Analysis and Development course. All classes were related to Human-Computer Interface Design. We characterized the participants according to their experience with models employed in the analysis and design phases of the software development process, as well as their experience with interface design, in both academia and industry.

Tasks

In the experiment, we asked participants to perform two tasks: (i) build a model using the USINN notation based on a scenario and a set of usability requirements; and (ii) build interface mockups based on a USINN model.

Scenarios for modeling task

The scenarios and requirements used in modeling tasks were related to a web system to manage to-do lists [18]. We described usability mechanisms [13] as functional requirements in accordance to previous studies conducted by Juristo et al. [13] and Carvajal et al. [6]. We aimed to verify whether the participants would be able to model them with the USINN notation. However, describing all usability mechanisms in a same scenario would make the scenario too complex for the experiment. Thus, we decided to create two scenarios about the same system, describing functional requirements associated with different usability mechanisms, as summarized in Table 1.

	Requirement	Mechanism
Set of functional requirements 1	R01. To create tasks	Progress feedback
	R02. To edit tasks	Warning
	R03. To delete tasks	Undo
	R04. To list tasks with tips about task due to the current date	Multilevel help
	R05. To bookmark tasks as favorites	Favorites
	R06. To create macros	Commands aggregation
	R07. To execute macros	Commands aggregation
Set of functional requirements 2	R01. User authentication	System status feedback
	R02. To create a user	Step-by-step execution
	R03. To define preferences	Preferences
	R04. To organize tasks lists through maps	Personal Object Space
	R05. To move tasks lists among maps	Personal Object Space
	R06. To create lists maps	Personal Object Space
	R07. To exit the system	Abort operation

Table 1. Functional requirements and usability mechanisms described in scenarios for the modeling task.

Models for prototyping tasks

To perform the prototyping task, the participants used a USINN model describing a system to support the knowledge management of a research group. We created two different USINN models that represent functional requirements associated with different usability mechanisms (Table 2).

	Requirement	Mechanism
USINN Model 1	R01. To edit researcher data	Step-by-step execution
	R02. To list knowledge items and bookmark items as favorites	Favorites
	R03. To organize items among maps	Personal Object Space
	R04. To create maps of knowledge items	Personal Object Space
	R05. To obtain information about items through tips	Multilevel help
USINN Model 2	R01. To access the system	System status feedback
	R02. To create knowledge items	Progress feedback
	R03. To exit the system	Abort operation and Warning
	R04. To search knowledge items	Undo
	R05. To create and execute macros	Commands aggregation
	R06. To define preferences	Preferences

Table 2. Functional requirements and usability mechanisms described in the models for prototyping tasks.

The requirements were balanced between the scenarios and models in such a way that they presented comparable complexity. We considered (i) the number of requirements to balance the scenarios and (ii) the number of elements to balance the models (we considered user actions, system process, presentation unit, data collection, warning and system progress) The association among requirements and usability mechanisms was not described in the scenarios.

Metrics

To characterize the USINN model, we used metrics for the quality of the produced artifacts and the perception of the participants. We defined quality metrics based on quality goals drawn from work on conceptual models [11]:

<u>Completeness</u>: it defines how much the artifact presents the necessary information according to its purpose. Omission defects reduce the completeness (See Table 3).

Correctness: it defines how much the artifact employs the elements and relationships according to the notation syntax and describes correctly the application domain according to the available information. Inconsistency, incorrect fact and ambiguity defects reduce the correctness (See Table 3).

Table 3 shows the taxonomy proposed by Lopes et al. [16] for classification of defects in interaction models and mockups.

Defect Types	Art.	Description
Omission	ID	The omission or negligence of any necessary information to solve the problem in the interaction diagram.
	M	The omission or negligence of any information that is needed for the mockup solution.
Ambiguity	ID	A poor definition of certain information in the interaction diagram, which may lead to multiple interpretations.
	M	A poor definition of certain information in a mockup, which may lead to multiple interpretations.
Incorrect Fact	ID	Misuse of the elements from the interaction diagram for the interpretation of those involved.
	M	Misuse of the interface elements during the mockup development, allowing an incorrect interpretation.
Inconsistency	ID	Conflicting information between the elements of the interaction diagram and the information needed to solve the problem.
	M	Conflicting information between the elements of the mockup and the information needed to solve the problem.

Table 3. Defect taxonomy for interaction diagrams (ID) and mockups (M) defined by Lopes et al. [16].

Different defects can have different severity levels. The severity level may indicate a higher or lower completeness and correctness of the artifacts. We defined the following formula to calculate the correctness and completeness from the number of defects identified in an artifact and the severity level (see Table 4) of the defects:

indicator =	1 - defects, where:
defects =	(n_req_low/n_req) + 2*(n_req_medium/n_req) + 3*(n_req_high/ n_req)/6
n_req_low =	number of requirements with low severity defects
n_req_medium =	number of requirements with medium severity defects
n_req_high =	number of requirements with high severity defects
n_req =	number of requirements described in an artifact (model or mockup)

The correctness and completeness of an artifact can range from 0 (worst result) to 1 (best result).

The metrics for perception of the participants were based on the Technology Acceptance Model (TAM) [15], which aims to assess a user's perception about the usefulness and ease of use of a proposed technology. Based on the TAM model, we have the following metrics:

Perceived usefulness: to evaluate the degree to which a person believes that using USINN would enhance his/her job performance.

Severity level	Description
Low	The defect in the model/mockup does not affect the comprehension and understandability of the artifact by the reader.
Medium	The model/mockup is incomplete according to the requirements, is ambiguous in the representation our used elements of the model notation incorrectly.
High	The omission of one or more requirements in the model/mockup or notation errors affects the understanding of the artifact.

Table 4. Defect severity levels.

Perceived ease of use: to evaluate the degree to which a person believes that using USINN would be free of effort.

Self-predicted future usage: to indicate whether users would prefer to use USINN over other technologies.

Table 5 presents the statements of our questionnaire based on TAM. We used a 5-point ordinal scale, using the opposing statement question format in order not to influence the participant response (positive or negative). In other words, each question contains two opposite statements that represent the maximum and minimum possible values (5 and 1), and in which the value 3 is considered to be a neutral opinion. Also, we replaced the term "[task]" with the terms "interaction and navigation modeling" or "building mockups" according to the task the participant was carrying out, generating two different questionnaires that we used in the different stages of the experiment.

Artifacts

To support the experiment execution, we produced: (i) a consent form; (ii) a participant characterization form; (iii) two scenarios for the modeling task; (iv) two USINN models for the prototyping task; (v) an evaluation questionnaire about the modeling task; and (vi) an evaluation questionnaire about the prototyping task.

Execution

The participants received training on interaction and navigation modeling with USINN. The training occurred during three lessons (each lesson lasted for one hour and forty minutes), which included practical modeling and prototyping activities. Figure 3 illustrates the experiment execution. To enable the use of the different scenarios and models, the participants were organized into two groups (Group A and Group B). To balance the groups, we considered the participants' previous experience in the industry.

In the first stage, the participants elaborated an interaction and navigation model using the USINN notation, based on a scenario and a set of functional requirements. After concluding the modeling task, the participants received a questionnaire to indicate their perceived usefulness, perceived ease of use and self-predicted future usage of USINN for interaction and navigation modeling.

Perceived usefulness of USINN	
Using USINN in my job would enable me to accomplish [task] more quickly.	Using USINN in my job would not enable me to accomplish [task] more quickly.
Using USINN would improve my job performance in [task].	Using USINN would not improve my job performance in [task].
Using USINN to [task] would increase my productivity.	Using USINN to [task] would not increase my productivity.
Using USINN would enhance my effectiveness on [task].	Using USINN would not enhance my effectiveness on [task].
Using USINN would make it easier to do [task].	Using USINN would make it more difficult to do [task].
I would find USINN useful in [task].	I would not find USINN useful in [task].
Perceived ease of use of USINN	
Learning to [task] with USINN would be easy for me.	Learning to [task] with USINN would be difficult for me.
I would find it easy to get USINN for [task].	I would find it difficult to get USINN for [task].
USINN elements would be clear and understandable.	USINN elements would be confused and hard to understand.
It was easy to become skillful using USINN for [task].	It was difficult to become skillful using USINN for [task].
It is easy to remember how to perform [task] using USINN.	It is difficult to remember how to perform [task] using USINN.
I would find USINN easy to use in [task].	I would not find USINN easy to use [task].
Self-predicted future usage of USINN	
Assuming USINN would be available on my job, I predict that I will use it on a regular basis in the future.	Assuming USINN would be available on my job, I predict that I will not use it on a regular basis in the future.
I would prefer using USINN to other models (like UML models) for [task].	I would prefer using other models (like UML models) to USINN for [task].

Table 5. Questions of subjective metrics questionnaire.

In the second stage, the participants built mockups based on a USINN interaction and navigation model. After concluding the prototyping task, the participants received a second questionnaire to indicate their perceived usefulness, perceived ease of use and self-predicted future usage of USINN as a basis for building mockups.

RESULTS OF QUALITY METRICS

We defined correctness and completeness metrics as quality indicators of the produced artifacts. To calculate the quality metrics, we analyzed the artifacts that were produced by the participants (models and mockups) to identify defects that could affect their quality.

To define the artifacts *correctness*, we performed an inspection to detect inconsistency, incorrect fact, and ambiguity defects. To define the artifacts *completeness*, the inspection aimed to detect omission defects. The taxonomy proposed by Lopes et al. [16] guided us during the classification of the defects that were identified during the inspection. We classified the severity level of the defects, following the rules described in Table 4. One experimenter identified the defects and classified their severity level in the models/mockups and a second experimenter validated the results.

Models correctness and completeness

Figure 4 illustrates the model correctness and completeness means per class. We observed means greater than 0.8 for correctness, indicating a positive result for this indicator.

We observed means between 0.5 and 0.7 for completeness, indicating a need for improvement related to this indicator. These results may have two causes: either the participants did not know how to represent some requirements through the USINN elements or they did not remember the model notation, causing them to omit certain elements.

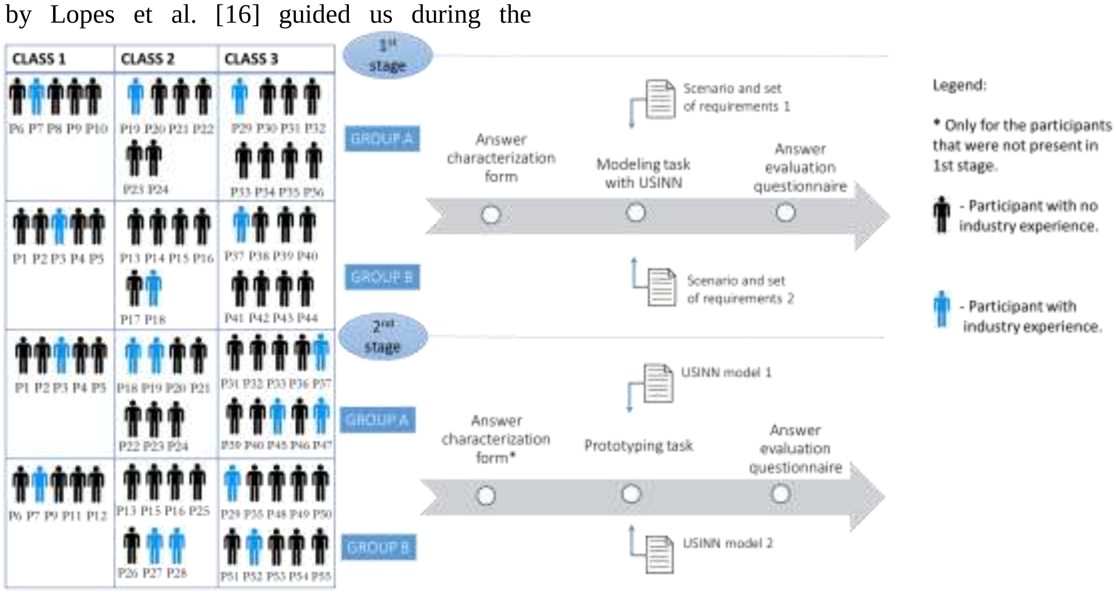

Figure 3. Execution process of the feasibility study.

Figure 4. Models correctness and completeness.

We observed means between 0.5 and 0.7 for completeness, indicating a need for improvement related to this indicator. These results may have two causes: either the participants did not know how to represent some requirements through the USINN elements or they did not remember the model notation, causing them to omit certain elements.

To better understand the quantitative results, we analyzed the comments provided by the participants in our questionnaire. To present the quotes, we have identified the participants by PX-CY, which indicates Participant X from Class Y. Regarding the results of the models correctness and completeness, we highlight the following quotes:

"It is necessary to have domain and knowledge about the elements used to build (the model), because we can understand the requirement, but we can't use the model correctly"– P6-C1

"I need to use USINN more in order to apply it properly. I had difficulties in modeling some requirements" – P3-C2

Mockups correctness and completeness

Figure 5 illustrates the mockups correctness and completeness means per class. We obtained means greater than 0.8 for correctness. On the other hand, we obtained means less than 0.8 for completeness in classes 2 and 3.

Some citations suggest difficulties in understanding the model for building the mockups: "The aspects that represent data left me confused. I did know if it was a data view or a table for the user to fill" – P1-C2.

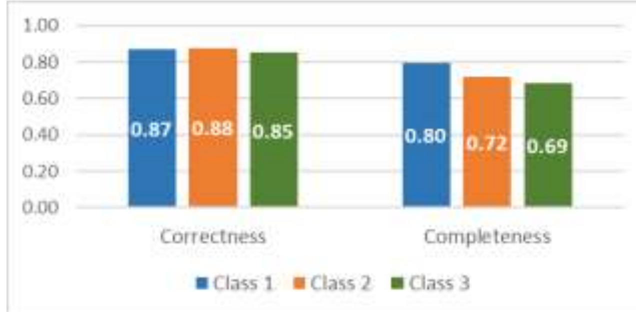

Figure 5. Mockups correctness and completeness.

"I believe I have understood what was being proposed, but I still have questions about the interface elements" – P11-C3

RESULTS OF PARTICIPANTS PERCEPTION METRICS

As our questionnaires were adaptations of the original statements of TAM model, it is important to evaluate the reliability of our data collection instrument. To assess the reliability of the questionnaire, we conducted a Cronbach's alpha statistical test on the study sample. To consider a collection instrument reliable, the test should indicate a reliability level higher than 0.8 [5].

Regarding the questionnaire that we used to evaluate the modeling stage, we have obtained a reliability value equal to 0.940. When we evaluate the questionnaire that we used in the prototyping stage, we have obtained a reliability value equal to 0.948. Thus, the results demonstrate that our questionnaire is a reliable instrument based on the results of several empirical studies using the TAM model [14].

In order to analyze the subjective metrics, we created diverging stacked bar charts illustrating the responses for each statement. Figure 6 illustrates the perceived usefulness results of the USINN for interaction and navigation modeling. The results reveal mostly positive perceptions about USINN and we did not observe a strong agreement to the negative statements. A majority of participants perceived USINN as a useful notation for modeling interaction and navigation (84.2% agreed to the positive statement Q6).

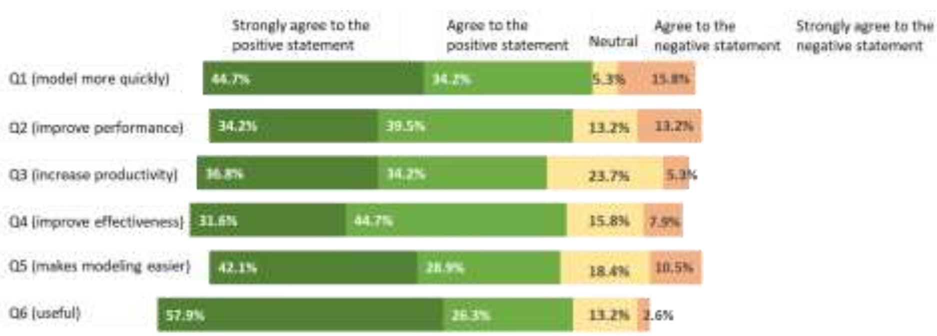

Figure 6. Perceived usefulness of USINN for interaction and navigation modeling.

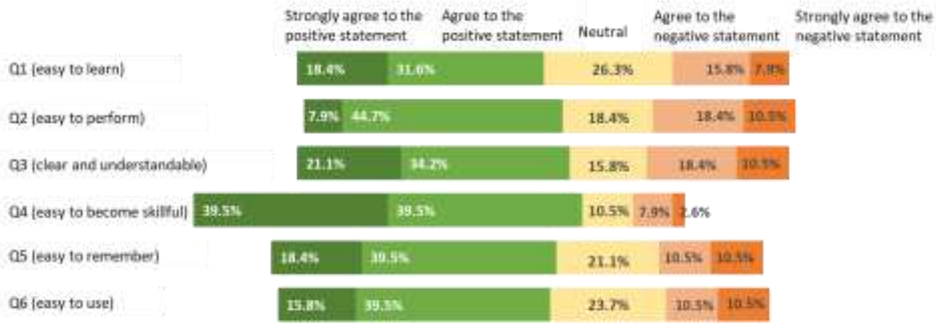

Figure 7. Perceived ease of use of USINN for interaction and navigation modeling.

Some quotes can justify this result: "It is interesting to model interaction and navigation with this model" – P1-C1.

"(The model) allows us to get a better view of the interaction between the user and the system and to view the user and system, alternative flows, possible interfaces..." – P1-C3

Regarding the perceived ease of use of USINN for modeling (Figure 7), we observed fewer positive perceptions. We also noted a tendency to neutral responses to questions Q1 (easy to learn), Q5 (easy to remember), and Q6 (easy to use). Some quotes from participants indicated features that may have influenced this result:

"It is easy to learn USINN elements, but it is difficult to model because USINN is complex" – P9-C2

"The USINN model is easy, because it has few elements in the notation and the elements are clear" – P6-C2

"USINN has elements similar to those of UML models. USINN gives us a better view about user interaction" – P14-C3

Figure 8 illustrates the results of perceived usefulness of the USINN model as the basis for building mockups. We observed a more positive perception. At the same time, we noted an increase in the tendency to be neutral regarding the statements. The following quotes indicate variations in the participants' perceptions:

"Messages, data collections and flows are the most positive aspects of the USINN model. I had problems to understand specific aspects of the application domain" – P7-C1

"Through the USINN model it is easy to understand the usability requirements, thus leaving the mockup more straightforward and clear" – P15-C2

"Within the USINN model as basis for mockup building, it is easy to understand the system behavior, thus facilitating the mockup building" – P7-C3

With regards to the perceived ease of use of the USINN model as basis for mockup building, we also noticed a greater tendency towards neutrality (Figure 9), mainly regarding Q6 (easy to use).

"As a positive aspect of USINN I can point the ease of understanding the navigation between presentation units and the visual elements to be used in the interface" – P5-C3

"The way in which the model is organized makes me feel lost when following or going back in the interaction" – P10-C2

The self-predicted future usage of USINN for modeling and prototyping is illustrated in Figure 10. We obtained mostly positive perceptions regarding self-predicted future usage (Q1), indicating that the participants pointed out the intention of future use of the USINN model.

"I think the USINN model will be essential for future work in my job" – P10-C2.

"I like the USINN model, because I can see how the application can react by certain user actions" – P7-C1

"USINN is a good solution for those who are working in the area and have already the required knowledge" – P3-C2

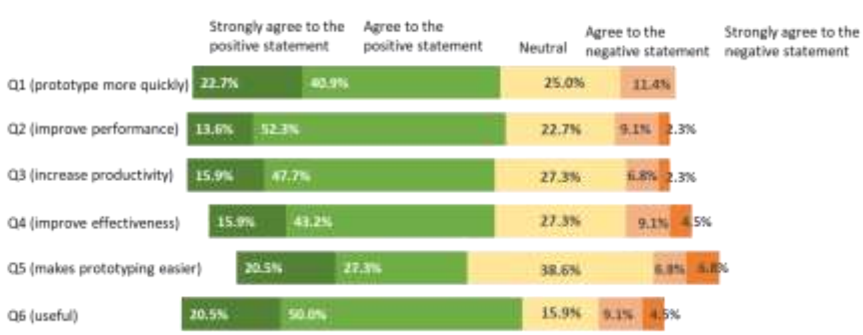

Figure 8. Perceived usefulness of USINN as basis for building mockups.

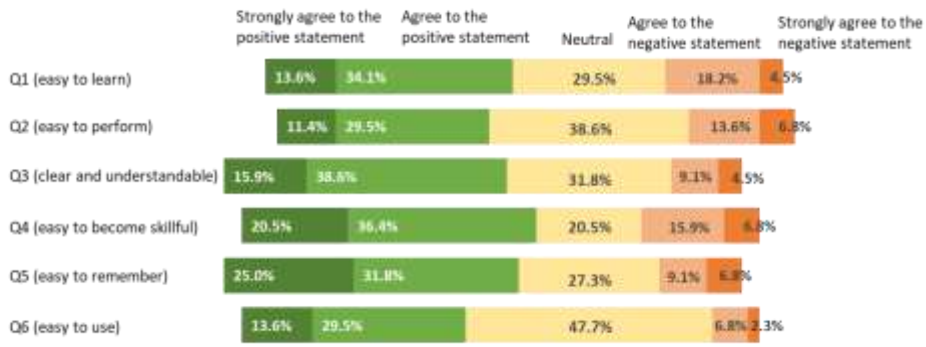

Figure 9. Perceived ease of use of USINN as basis for building mockups.

"Unless the practitioner is someone who has practical experience in interaction design and user experience, it is not easy to use USINN in industry" – P3-C1

Concerning the preference to use USINN for modeling and prototyping we noted a tendency towards neutrality, with a slightly larger number of positive than negative responses.

DISCUSSION

We previously proposed USINN to increase the usability expressiveness in interactive systems design solutions [17]. USINN enables us to represent the usability mechanisms that existing models partially represent. Our empirical study aimed to investigate whether USINN can support novice designers in interaction and interface design.

With our study, we obtained measurements of the quality of the artifacts produced by the participants and the perception of the participants regarding USINN. We obtained correctness values higher than 0.8 for both USINN models and mockups elaborated by the participants. These results indicated that we identified few inconsistency, incorrect fact and ambiguity defects in artifacts. On the other hand, we obtained completeness values under 0.7 in USINN models elaborated by the participants. It indicated that some requirements were not represented in the models. The participants pointed out doubts about the use of the USINN notation and the need for a better knowledge about the USINN notation to effectively apply it.

We collected metrics to evaluate the perceived ease of use, perceived usefulness and self-predicted future usage regarding USINN from the participants' point of view. We obtained positive results, which indicated that the majority of the participants considered USINN as a useful notation. However, the participants tended to neutrality when evaluating the perceived ease of use of USINN. Again, the quotes from some participants indicated they have doubts about the use of the model and the application domain description, which involved usability mechanisms.

CONCLUDING REMARKS AND FUTURE WORK

In this paper, we presented an empirical study of USINN, a model we proposed to support usability-oriented interaction and navigation modeling. USINN allows representing usability mechanisms underlying the interaction and navigation of interactive systems. Our intention was to evaluate whether USINN can be used in interaction and interface design to create more usable solutions.

To analyze whether the model supports those goals, we conducted an experiment with three undergraduate classes. The results demonstrate the feasibility of using USINN and opportunities for improving the ease of use of USINN. In future analysis, we aim to explore the perspective of the experienced subjects, as some quotes indicated the experience as a factor that influences the perception about USINN. To deeply investigate the difficulties the participants pointed out, we will conduct an observational study and evaluate USINN based on the Cognitive Dimensions Notation (CDN) as discussed in [7]. Additionally, we aim to conduct an empirical study with design professionals who are involved in systems development and interaction design in industry.

Also, we intend to propose (i) guidelines to support the inclusion of usability mechanisms when novice designers or non-usability specialists adopt USINN; (ii) design patterns for interaction and navigation modeling with USINN focusing on usability mechanisms.

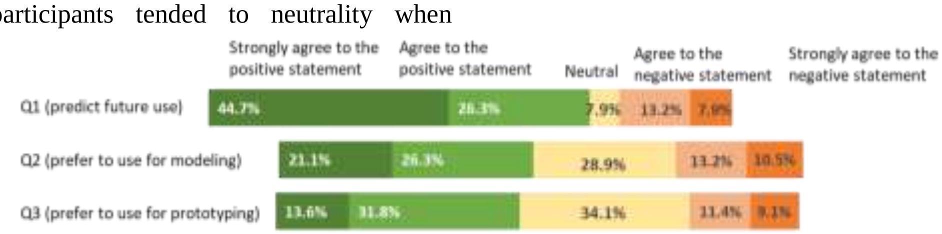

Figure 10. Self-predicted future usage of USINN.

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