Feasibility Analysis of SMartyModeling for Modeling UML-based Software Product Lines

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Abstract: Variability modeling in UML-based Software Product Lines (SPL) has been carried out using basically the UML Profiling mechanism for a diverse of theoretical approaches. However, there is no UML-based SPL life cycle supporting tool, which takes advantages of the UML standard diagrams in a controlled environment exclusively dedicated to it. Users usually adopt general-purpose UML tools to model variability. Its drawback is no control over data regarding SPL models, especially on variability. With such control, one might, for instance, use different visualization techniques to show SPL/variability information, inspecting/testing SPL models and data, apply metrics, and configure specific products. To provide an environment with these characteristics, we developed SMartyModeling. We evaluated its feasibility based on two studies: one qualitative supported by the Technology Acceptance Model (TAM), and one experiment comparing SMartyModeling with Astah. The first study aided to establish assumptions on how to improve the environment. We then, stated hypotheses to be tested in a comparative experiment. Thus, we identified aspects related to the automation of the SPL concepts, the number of errors and the difficulties in modeling SPLs. Hence, we measured effectiveness and efficiency of SMartyModeling over Astah. General results provide preliminary evidence that SMartyModeling is feasible for further developing.

1 INTRODUCTION

The reuse of requirements, architectures and other artifacts in a high level of abstraction is efficient in traditional software development techniques, focused on the source code and opportunistic reuse. In this context, the Software Product Line (SPL) approach has been consolidated as a technique for systematic reuse in many companies around the world (Linden et al., 2007). SPL development comprises a set of essential activities, such as, variability management, which is a key issue for the success of SPLs. Several approaches to variability management have been proposed in the literature (Chen et al., 2009; Galster et al., 2014; Raatikainen et al., 2019).

Secondary studies Chen et al. (2009) Galster et al. (2014) Lisboa et al. (2010), Pereira et al. (2014) and surveys Bashroush et al. (2017) Berger et al. (2013) do not present tools with native support to modeling UML-based SPLs.

Several companies have increasingly required the support of tools for the SPL approach. Hence, they have developed their homemade solutions to support the SPL life cycle. However, the current support tools are mainly restricted to the problem space based on feature modeling (Bashroush et al., 2017).

To provide support to the solution space in SPL, we developed SMartyModeling[1], an environment for SPL modeling, with support to most UML stereotype-based approaches. The main benefit of SMartyModeling is the reuse of structures, including architectural views, requirements, and descriptions, gathered from most existing used SPL tools (Bashroush et al., 2017; Pereira et al., 2014; Berger et al., 2013), even those with no UML support. SMartyModeling provides users control over the data and the integration of new functionalities with existing tools.

To analyze SMartyModeling feasibility and make decisions on its further development, a qualitative

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[1]Available at https://github.com/leandroflores/demo_SMartyModeling_tool

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study was performed through a questionnaire answered by 10 experts in SPL from which identified strengths and limitations of the tool. Then, we conducted an experiment aimed to compare the SMartyModeling environment with the Astah[2] tool.

This paper aims to present the results of the initial qualitative evaluation, which motivated an experiment comparing efficiency and effectiveness of SMartyModeling and the Astah tool by modeling use case diagrams. Results on these studies revealed main points to improve SMartyModeling and lessons learned.

2 THE SMartyModeling ENVIRONMENT

SMartyModeling provides support for the following main functionalities: **Variability Model:** management to variability model and composition rules; **Variability Decision:** providing support to the management of variability resolution; **Variability Validation:** performing consistency checking;**Domain Asset Management:** document the processes, classify assets and manage them through their life cycle; **Guide:** including key steps to use the environment; and **Import/Export:** including a specific module for reading and writing the projects.

Figure 1 presents the SMartyModeling main interface for use case modeling, with five fundamental components: **Operations Panel (Component A):** key system operations: new, open, save and close Project; undo, redo; in and out zoom; print, help and about; **Buttons Panel (Component B):** features to the respective diagram. For the use cases there are: drag and drop diagram elements; new actor; new use case; new variability; new include association; new extend association; and new realization association; **Project Panel (Component C):** organization of the Project as a tree to display: diagrams, variabilities, products, instances, metrics and traceability; **Modeling Panel (Component D):** draws diagrams; **Information Panel (Component E):** tabs with information on selected elements.

A practical example using the SMarty approach is presented below. We consider the use case diagram defined for Arcade Game Maker (AGM)[3], a pedagogical SPL created by the Software Engineering Institute (SEI)[4] to support learning and experimentation of SPL concepts. We used AGM as a reference for the qualitative study (Section 3) and the experiment (Section 4).

[2]http://astah.net

[3]https://www.sei.cmu.edu/productlines/ppl

[4]https://www.sei.cmu.edu

Figure 1 presents an adaptation of the AGM use case diagram modeled, containing the following elements: `Game Installer`: actor responsible for actions of configuration of the games produced by AGM; `Game Player`: actor responsible for playing; `Save Score`: saves the player's current score; `Install Game`: install the chosen game; `Exit Game`: exits the game in progress; `Uninstall Game`: removes the selected game; `Play Selected Game`: an actor selects the game and begins its execution; `Play Bowling`: starts the game Bowling; `Play Brickles`: starts the game Brickles; and `Play Pong`: starts the game Pong.

Considering the `Play Selected Game` use case in Figure 1, we note the variationPoint stereotype, indicating that the use case is a variation point, associated with the play game variability, that has three variants associated: Play Brickles, Play Pong and Play Bowling, the three stereotypes with alternative_OR, indicating that they are inclusive, thus different combinations can be selected. The optional stereotype is associated with one use case: Save Score. The optional stereotype indicates the optional presence. The other elements are mandatory.

3 QUALITATIVE STUDY

We adopted the Technology Acceptance Model (TAM) (Davis, 1989) to understand the causal relationship between external variables of user acceptance and the actual use of the technology under analysis. Furthermore, we wanted to understand the behavior of these users based on their usefulness and ease of use perspectives.

Therefore, 10 SPL experts answered a questionnaire[5] related to ease of use, utility and future use. The questionnaire was composed of open and closed questions. For the closed questions the Likert scale was used. We adopted the SMarty approach (OliveiraJr et al., 2010) for variability representation. All experts have at least 1 year of experience in SPL.

Regarding the **Ease of Use**, experts agreed: the modeling interface was intuitive and easy to handle (5 totally and 5 partially); the environment allows the modeling according to the concepts defined by the UML (7 totally and 3 partially); and the environment allows the modeling according to the concepts of SPL in an intuitive way (6 totally and 4 partially). Figure 2a) presents the responses about Ease of Use.

[5]https://zenodo.org/record/3336227

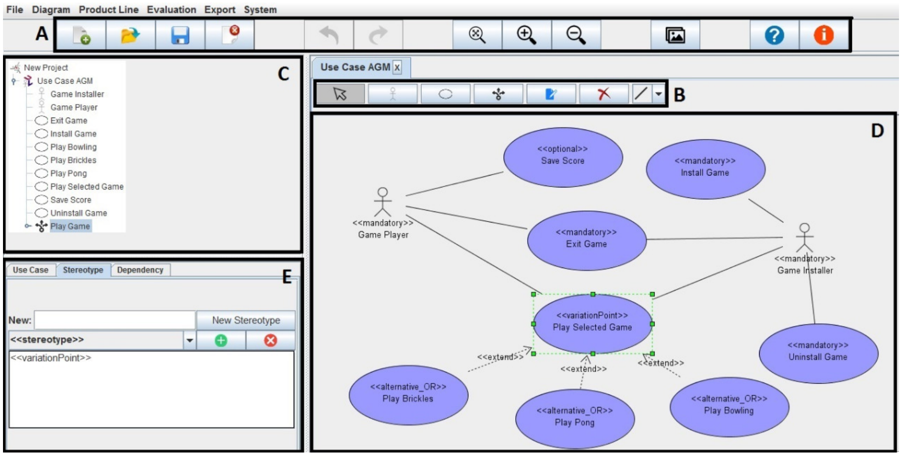


Figure 1: SMartyModeling interface.

Regarding **Utility**, we observed certain divergences. Although the experts were able to perform the modeling using the interface as expected (4 totally and 6 partially), difficulties were encountered in exploring the features of saving and opening diagrams, fully maintaining the information of the diagram, with 7 (4 fully and 3 partially) exploring correctly and 3 (2 partially and 1 fully) reporting difficulties. Figure 2b) presents the responses about Utility.

In relation to **Future Use**, the environment was considered for future use for all experts (8 totally and 2 partially). All of them would recommend our environment to other people (9 totally and 1 partially). Figure 2c) presents the responses about Future Use.

The analysis of the open responses was performed using Grounded Theory procedures, assigning labels to sections of text (open coding), and grouped and categorized (axial coding) according to the expressed answers.

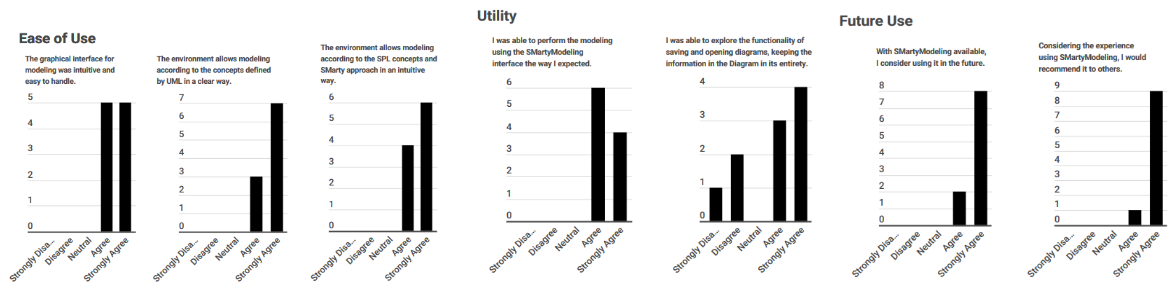
Analyzing the experts quotes on the positive aspects, the following points stand out: **application of SPL concepts:** "Automates and simplifies the process of modeling the stereotypes defined in SMarty" (Expert #1) and "It was very clear the application of the SPL and SMarty concepts in the tool, facilitating the modeling of the diagrams." (Expert #5); **intuitive interface:** "Interface standardization also helps in learning" (Expert #2), "The graphical part of the environment is simple and very well developed, which makes it simple and easy for anyone to use" (Expert #6) and "Intuitive interface and ease of use. You can start using the use case and/or class quickly." (Expert #9); and **ease of use:** "Each element of a model is very well represented." (Expert #5) and "The terms of the options are clear, allowing one to immediately understand what each option does." (Expert #9).

The analysis also identified the points to improve: **graphical interface:** "I believe the visual interface can be improved" (Expert #3 :), "It would be nice to have a bigger space to draw." (Expert #4) and "I had to use the scroll bar because the elements were large on the screen." (Expert #7); **modeling features:** "I had difficulties in creating a Variation Point and in the association of its respective variants" (Expert #1), "when registering a new use case, it was not possible to add it as a variant." (Expert #2) and "The options to remove and edit classes, interfaces on the side menu did not work" (Expert #5); and **Export/Import Diagrams:** "I found some difficulty saving my work" (Expert #2), "I had difficulty saving the templates." (Expert #4) and "I saved the class for the first time, but it did not appear in my files. When I saved again, then it appeared." (Expert #8).

The results of this qualitative study motivated the conduction of an experiment, with the objective of comparing SMartyModeling with another regular UML tool. Hypotheses from the results of this qualitative study were raised to plan the experiment. In general, quantify the difference in modeling using SMartyModeling against other tools.

The answers raised questions for the experiment. First, in relation to the intuitive modeling interface. The goal is to identify how far SMartyModeling is from currently used tools. To evaluate this aspect, the total time required to model an SPL is a factor of analysis. Another goal is to compare SMartyModeling with another tool in relation to the automation of SPL concepts. To analyze this aspect, a factor of analysis is the number of errors made during the modeling.

A previous survey Agner and Lethbridge (2017) indicates Astah as a modeling tool used considerably for teaching and practicing, considering their main benefits: simple to install and learn, besides supporting important notations to teach. As far as we



(a) Ease of Use (b) Utility (c) Future Use

Figure 2: Responses to closed questions.

know, there is no specific UML tool for SPL modeling based on UML, except SMartyModeling. This is the main reason we did not choose feature-based tools as, for instance, FAMA, FeatureIDE, and pure::variants. Therefore, we are interested, at first, in the solution space (modeling), rather than in the problem space (SPL features, for instance) as such other tools are.

4 THE EXPERIMENT

The proposed experiment is classified as a quasi-experiment that relaxes the conditions imposed by probability distributions and statistical inferences for the population. All instrumentation and observed values of this experiment are available at https://zenodo.org/record/3336227.

4.1 Goal and Research Questions

The goal of this experiment is to compare an SPL modeling tool, SMartyModeling, and general UML modeling tool, Astah, with the purpose of characterizing them for the modeling of SPLs and variability with respect to effectiveness and efficiency from the point of view of researchers of SPL, in the context of undergraduate students and masters in Computer Science in the Software Engineering area. We chose Astah as it is one of the most used UML general tool (Agner and Lethbridge, 2017), and to the best of our knowledge there is no specific tool to model UMl-based SPL for the solution space.

According to the Goal-Question-Metric (GQM) model, two main questions were established for our study: "**RQ1: Which tool is more efficient in modeling SPL use case diagrams according to the SMarty approach: SMartyModeling or Astah?**" and "**RQ2: Which tool is more effective in modeling SPL use case diagrams according to the SMarty approach: SMartyModeling or Astah?**".

The term effectiveness has been used to identify the number of correct and incorrect responses of variability modeling activities for the ADO method for domain modeling using UML.

4.2 Planning

This section presents the planning of our experiment. **Context Selection:** we adapted the AGM use case diagram, an SPL proposed for experimental purposes. The participant should model the diagram of Figure 1 on SMartyModeling and on Astah by taking into account the SMarty approach. Several different stereotype-based SPL approaches might be used, however we have lots of experience in SMarty (OliveiraJr et al., 2010).

Hypothesis Formulation: we formulated the following hypotheses in this study, where "var" should be replaced with effectiveness or efficiency:

- **Null Hypothesis** ($H0_{var}$)**:** there is no difference in effectiveness/efficiency between Astah and SMartyModeling for modeling use case diagrams. Therefore, $H0_{var}$: Astah = SMartyModeling;
- **Alternative Hypothesis** ($H1_{var}$)**:** there is a significant difference in effectiveness/efficiency between Astah and SMartyModeling for modeling use case diagrams. Therefore, $H1_{var}$: Astah $\neq$ SMartyModeling.

Variables and Metrics Selection: we selected the following variables for this experiment:

- **Independent Variables:** use case diagram adapted from AGM as prefixed variable and modeling tools as a factor with two treatments: Astah and SMartyModeling.
- **Dependent Variables: Efficiency** and **Effectiveness** are calculated for each tool (Astah, SMartyModeling), defined as follows:
  - **Effectiveness** is the precision of modeling with one of the tools, which is the **ratio** between **H** and **TE**, where:

    * **H** is the discrete value that represents the relevant number of correct modeled elements;
    * **TE** is the discrete value that corresponds to the total modeled elements.
- **Efficiency** is the **ratio** between **Effectiveness** and **TI**, where:
    * **TI** is the discrete value that corresponds to time interval (in minutes) required for modeling the use case diagram with one of the tools.

Selection of Participants: we defined a non-probabilistic sampling of participants, more specifically the sampling for convenience technique. This type of sampling does not jeopardize the objectives of this study. Participants selected for the experiment were graduate and undergraduate students in Computer Science, Information Technology, Software Engineering and Information Systems, with experience in modeling software systems in UML. We considered experienced the participant who has already modeled use case diagrams in classroom or industry. Thirty-one (31) participants attended the experiment.

Choice of Design Type: we chose a 1x2 independent factorial experimental design type as treatment, and control has neither interactions nor relationships.

Instrumentation: the following materials compose our instrumentation: **Informed Consent Term (ICT):** contains main information on the experiment: confidentiality, procedures and benefits. Such document allowed participants to make their decisions about their participation in a fair way; **Characterization Questionnaire:** in which the participant indicated his/her respective academic degree, area of expertise, and level of experience with UML and SPL modeling; **Instructional material:** contains three parts, the first with the main concepts of SPL, the second with the concepts about SMarty approach, and the third with an example modeling using Astah and SMartyModeling; and **Evaluation Instrument:** contains the diagram to be modeled and the open questions to be evaluated qualitatively. The use case diagram is an adaptation of AGM as shown in Figure 1. The adaptation consisted on: two actors, eight use cases, three extensions (counting as a single element), seven realizations (counting as a single element), an optional variability and an inclusive variability, achieving a total of 14 elements. The main concern was not to be a tiresome task and simultaneously cover all the elements of the use case diagram, including the modeling of different types of variabilities.

4.3 Operation

Pilot Project: two pilot projects were applied to evaluate the instrumentation. The first one was performed with an expert in SPL, and we identified adjustments in the instrumentation according to the results. The second was carried out with a graduate student from a different study area, and we defined an estimated time required for modeling in both tools and to verify whether the training was satisfactory.
Training: we trained all participants in essential concepts on SPL, variability modeling and the SMarty approach. All participants are undergraduate students, with at least 3 years of disciplines focused on teaching software engineering. In addition, examples of SPL were presented in both environments to prepare the participants for the execution of the experiment. The training also explained the main functionalities of both tools. The training lasted for 30 to 40 minutes.

During training, participants received three documents: the ICT, the characterization questionnaire, and the instructional material. Training was performed based on Mobile Media SPL use case diagrams. Participants were allowed to ask questions at any time during the training sessions.
Operation Procedures: the following steps were taken in this experiment: participant arrived at the laboratory, and was allocated to a random desktop machine; applicant gave the participant all documents of instrumentation mentioned in Section 4.2; participant read each given document; applicant explained the given documents; all participants read the instructions and the applicant answered their questions; participants modeled the AGM use case diagram, shown in Figure 1, in the two environments; participants returned the instruments to the applicant and finished their tasks in the experiment. It was up to the participant to define the order of the environment for the activity.

4.4 Analysis and Interpretation

Normality Testing: with the support of the R language[6], the *Shapiro-Wilk* test was applied to data collected on effectiveness and efficiency for Astah and SMartyModeling, corresponding to the following results:
Astah (N = 31):
Efficiency: mean value (μ) 1.33397, standard deviation value of (δ) 0.50837, the efficiency for the Astah was *p-value* = 0.6313 for the *Shapiro-Wilk* normality test. In the *Shapiro-Wilk* test for a sample size (N) 31

[6]https://www.r-project.org

with 95% of significance level ($\alpha = 0.05$), p = 0.6313 ($0.6313 > 0.05$) and calculated value of W = 0.97389 > W = 0.929, the sample is considered normal.

Effectiveness: mean value (μ) 0.79262, standard deviation value of (δ) 0.16325, the effectiveness for the Astah was *p-value* = 0.005625 for the *Shapiro-Wilk* normality test. In the *Shapiro-Wilk* test for a sample size (N) 31 with 95% of significance level ($\alpha = 0.05$), p = 0.005625 ($0.005625 < 0.05$) and calculated value of W = 0.89565 < W = 0.929, the sample is considered non-normal.

SMartyModeling (N = 31):

Efficiency: mean value (μ) 0.9162659, standard deviation value of (δ) 0.3381597, the efficiency for the SMartyModeling was *p-value* = 0.0005274 for the *Shapiro-Wilk* normality test. In the *Shapiro-Wilk* test for a sample size (N) 31 with 95% of significance level ($\alpha = 0.05$), p = 0.0005274 ($0.0005274 < 0.05$) and calculated value of W = 0.85082 < W = 0.929, the sample is considered non-normal.

Effectiveness: mean value (μ) 0.8571429, standard deviation value of (δ) 0.07604152, the effectiveness for the SMartyModeling was *p-value* = 0.01851 for the *Shapiro-Wilk* normality test. In the *Shapiro-Wilk* test for a sample size (N) 31 with 95% of significance level ($\alpha = 0.05$), p = 0.01851 ($0.01851 < 0.05$) and calculated value of W = 0.916 < W = 0.929, the sample is considered non-normal.

Hypothesis Testing: for the statistical analysis of efficiency and effectiveness, the comparison between the tools contains at least one non-normal sample, therefore, a non-parametric test is necessary. We used *Wilcoxon-Mann-Whitney* test for samples independently.

Thus, applying the *Wilcoxon-Mann-Whitney* test to analyze the efficiency, we obtained the value of W = 736 and p-value = 0.0003284, characterizing the **rejection** of the **null hypothesis** ($H0_{efficiency}$).

Applying the *Wilcoxon-Mann-Whitney* test to analyze the effectiveness, the value of W = 371.5 and p-value = 0.1117 was obtained, and we **could not reject** the **null hypothesis** ($H0_{effectiveness}$).

4.5 Discussion of Results and Improvements

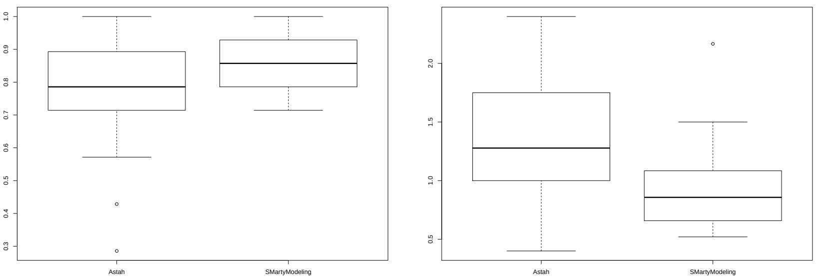
Discussion on Normality and Hypothesis Testing: Figure 3a) presents the boxplot comparing the distribution of effectiveness values for Astah and SMartyModeling. The difference factor for the effectiveness calculation was closely related to the number of correct elements, and although it was not discrepant enough to allow rejection of the null hypothesis, boxplot evidences better values for SMartyModeling, thus suggesting a better support of SMartyModeling with regard to SPL modeling.

Thus, by analyzing the collected data, we verify that, in relation to the number of hits, SMartyModeling presents better results, emphasizing the objective of SMartyModeling to be destined to SPL modeling. However, the time interval for modeling SMartyModeling was higher, being a more significant difference in the number of hits, which resulted in a greater efficiency for Astah. This fact evidences the need for SMartyModeling to have a more intuitive and functional interface, as presented in the open answers discussed in Section 4.5.

Discussion on Qualitative Analysis: Grounded Theory procedures were used to analyze the open answers. Coding allows assigning labels to text parts (open coding), and grouping and categorizing (axial encoding) them according to an expressed idea (Corbin and Strauss, 2008).

The first task for the participants was to: **"Describe the differences in modeling using SMartyModeling and Astah considering the concepts of SPL"**. Analyzing participant responses, we identify the following characteristics: **Automation of SPL concepts:** automation for SPL modeling was evident using SMartyModeling in relation to Astah. In 18 responses, it was mentioned the easiness in defining variability using SMartyModeling, highlighting the following comments: Participant #1: "in Astah it is necessary to manually create variability and stereotypes, which takes a certain time to create and is more susceptible to errors, SMartyModeling avoids this, reducing the occurrence of errors and time to create." Participant #3: "In Astah it was necessary to set each type of stereotype, while SMartyModeling automates this process." Participant #10: "Insertion of variability in Astah is done manually, whereas in SMartyModeling it is set automatically." and Participant #25: "In Astah, stereotypes are defined manually, while SMartyModeling automates this process."; **Intuitive interface:** it was noticeable the difference between interface for modeling using Astah in relation to SMartyModeling. In 10 answers it was mentioned that it was easier to model the diagram using Astah, highlighting the following comments: Participant #4: "However, Astah is more user-friendly and intuitive." Participant #9: "When selecting and inserting, for example dependencies, Astah becomes faster in this case." Participant #16: "Astah is more robust, easier to design a diagram regardless of project size." Participant #17: "The difference is that Astah is more intuitive in creation, allowing the relationship between elements without naming."

The second task for the participants was: **"De-**



(a) Effectiveness (b) Efficiency

Figure 3: Astah and SMartyModeling: Effectiveness and Efficiency.

scribe the general positive and negative points identified by you during modeling using SMarty-Modeling". Analyzing the answers, we identify the following positive points: **Ease of Use:** in 9 responses the ease of use of SMartyModeling was described, with the following comments: Participant #2: "it is easy to learn how to use this tool, even with little experience in modeling, it was not difficult to use SMartyModeling." Participant #5: "ease to create use cases." Participant #12: "easy to understand and to create objects." and Participant #24: "ease of use to create a variation point."; **Interface Simplicity:** in 7 responses it was mentioned the simplicity of using SMartyModeling, with the following comments: Participant #1: "friendly and lightweight interface." Participant #3: "productivity and speed in developing diagrams." Participant #9: "after learning the software feature, it becomes practical." Participant #12: "simple and clear interface." and Participant #23: "lower complexity of understanding, simple and fast generation of variability."

In relation to improvement points on SMartyModeling, we identified: **Association between Elements:** in 13 responses the difficulty in defining, editing or removing an association using SMartyModeling, with the following comments: Participant #3: "I cannot remove only the relationship." Participant #6: "difficulty of removing associations." Participant #8: "no delete or edit relationships." Participant #13: "some actions need more steps to be taken, such as creating associations or extensions." and Participant #17: "does not allow the association dragging the objects."; **Resizing Modeling Panel:** in 10 responses it was evidenced the need to resize the modeling panel of SMartyModeling, with the following comments: Participant #10: "improvements are needed such as window resizing." Participant #14: "improvements like screen resizing and screen positioning." and Participant #16: "does not allow screen resizing."; **Usability:** in 15 responses some difficulties were noted to use during the modeling in SMartyModeling, with the following comments: Participant #10: "not very intuitive to use, requiring interface improvements and shortcuts." Participant #18: "does not allow copying and pasting." Participant #21: "back button has undone all the job done." Participant #24: "does not allow undoing actions and similar tasks." and Participant #31: "difficulty to drag elements and to undo actions."

According to the points raised in the qualitative analysis in this experiment, we identify assumptions on the efficiency and effectiveness of tools. Astah interface is considered more intuitive in relation to SMartyModeling based on the idea that the time required for modeling with SMartyModeling was longer. The points to improve also explain the longer time required for modeling in SMartyModeling, especially the identified functionality related to usability, including shortcuts and element copying.

In relation to the effectiveness of SMartyModeling, the automation of SPL concepts evidenced to be a factor that reinforces the decrease of modeling errors in relation to Astah. The fact that in Astah the manual definition of stereotypes and variabilities is necessary, makes it more susceptible to errors during modeling, compared to the SMartyModeling interface that specifies the fields for the definition of variabilities and automatically includes stereotypes.

A second version of SMartyModeling has been developed, taking into account the identified points, mainly redefining its interface, with the aim of improving ease of use and usability. The main change was in the modeling panels, which were rewritten using the JGraph[7] library. Such improvements are discussed next.

SMartyModeling used to use UML notes to represent a variability and tagged-values. For the AGM use case diagram (Figure 1) we have no usability issues as it is a small diagram. However, for a large SPL make the diagram illegible. An identified alternative is to allow users to hide/show the variability

[7]https://github.com/jgraph/jgraphx

notes. Therefore, for the second version, we chose to hide the UML notes from the modeling panel, however, maintaining stereotypes related to SPL concepts. The variability attributes will be presented in the Information Panel (Component E) in Figure 1. This will not compromise the readability of the entire diagram.

To improve usability of SMartyModeling, we included a zoom+ button and a zoom- button in Component A. Furthermore, we identified the need to define a single window for modeling, already including the information, buttons and the file panels. For the second version, we chose to avoid, if possible, the use of modal windows during modeling. Therefore, the use of the JGraph library allows the creation of new elements and associations directly in the modeling panel. For edits, we have chosen to allow editing of attributes in an Information Panel.

As SMartyModeling required longer time for modeling diagrams, we improved it by making selecting and dragging/dropping elements more intuitive. For the second version, we expand the mouse events for the Modeling Panel. The new events allow the creation, alteration, removal of the elements directly in the modeling. They also include resizing, movement and definition of points for associations.

For importing and exporting project information, the classes in the second version were rewritten using the org.w3c.dom[8] Package. Project information continues to be organized in a hierarchical tag file. However, the export classes have been rewritten using their own classes to handle tag documents.

5 CONCLUSION

We analyzed the feasibility of SMartyModeling in two studies: one qualitative and one experiment.

The qualitative study allowed identifying the points to be improved, in particular, the limitation of the interface in manipulating the elements and defining the associations of SMartyModeling elements.

Then, we performed an experiment to identify efficiency and effectiveness of SMartyModeling and Astah, and to provide initial evidence on the feasibility of SMartyModeling and its further development.

Generally analyzing, SMartyModeling helps the variability modeling for SPL, but some further research and development will help to improve it. New experiments and replications should be planned and conducted to reduce threats to analyze the efficiency and effectiveness of SMartyModeling in relation to other well-evaluated tools as those in the Agner and Lethbridge (2017) survey and to generalize the results. Extending this experiment to more complex SPLs and support to other UML diagrams should be performed.

[8] https://docs.oracle.com/javase/8/docs/api/org/w3c/dom

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