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# How do Students Perceive UML and Mockups?

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USES Technical Report  
RT-USES-2017-0018  
October, 2017

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## **ABSTRACT**

Models taught in Software Engineering disciplines can facilitate the communication and understanding of systems by practitioners. These models can be expressed by Unified Modeling Language (UML). In the literature, existing reports show how professionals perceive the adoption of UML in practice. However, little is known about the students' perception regarding these models. This perception may influence the models' adoption, since the students are the future software engineering professionals. We present an exploratory study that aims to better understand how undergraduate and graduate students perceive different UML diagrams and mockups. In this technical report, we present the participants' answers to the Technology Acceptance Model (TAM) questionnaires for UML diagrams and mockups.

## **TECHNOLOGY ACCEPTANCE MODEL**

The Technology Acceptance Model (TAM) is usually employed to understand the users' acceptance of technologies [1]. It posits that user's behavioral Intention to Use (IU) a technology is determined by two constructs: Perceived Usefulness (PU) and Perceived Ease of Use (PEU). PU is defined as the extent to which a person believes that using a technology will enhance his or her job performance and PEU is defined as the degree to which a person believes that using a technology will be free of effort. In addition, PEU directly influences PU [1]. Other authors have used the original or the extended versions of TAM. They have applied it on different systems to better understand determinants of the technology acceptance [2]. Furthermore, TAM has been applied for the evaluation of several technologies, producing reliable results [3].

## **RESULTS FROM THE TAM QUESTIONNAIRES**

We also prepared an online questionnaire based on the TAM constructs (PU, PEU and IU) for each UML diagrams and for the mockups. Below we present the TAM statements adapted for each UML diagram and mockups.

### **Perceived Ease of Use**

PEU1. My interaction (modeling and comprehension of these models) with this artifact is clear and understandable.

PEU2. Interacting (modeling and comprehension of these models) with this artifact does not require much of my mental effort.

PEU3. I find this artifact easy (both for modeling and comprehension of these models).

PEU4. I find it easy to get this artifact to do what I want (modeling and comprehension of these models).

### **Perceived Usefulness**

PU1. Using this artifact makes my performance better for understanding aspects of the software.

PU2. Using this artifact in my work has improved my productivity for understanding aspects of the software.

PU3. Using this artifact increases my effectiveness in understanding aspects of the software.

PU4. I consider this artifact useful for software design.

### **Intention to Use**

IU1. Assuming I have enough time to design software, I would use this artifact.

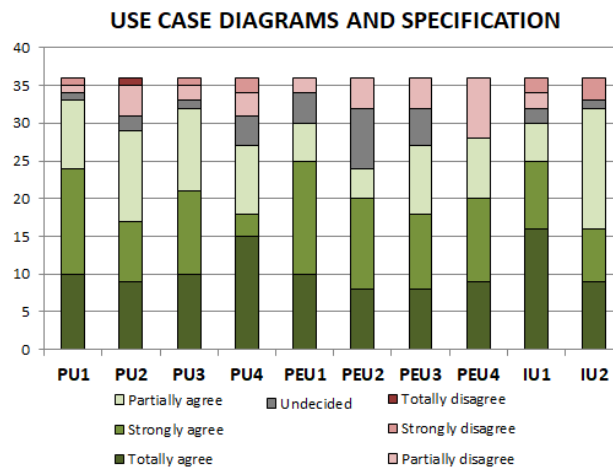
IU2. Taking into account that I have the domain to choose any notation for the analysis and project, I predict that I will use this artifact.

Regarding these statements, we changed the word “artifact” to the name of the UML diagrams and mockups being assessed. Participants provided their answers on a seven-point Likert scale with neutral option. The possible answers were: totally agree (7), strongly agree (6), partially agree (5), neutral (4), partially disagree (3), strongly disagree (3), and totally disagree (1). The next subsections show the results of this analysis for the different UML diagrams and mockups.

### USE CASE DIAGRAMS AND SPECIFICATION

In Figure 1, we present the participants’ answers to the perceived usefulness (PU1 to PU4), perceived ease of use (PEU1 to PEU4) and intention to use (IU1 and IU2) related to the use case. Table 1 presents the answers from the students regarding the TAM statements.

**Figure 1: Answers to perceived ease of use, perceived usefulness and intention to use the use case diagrams.**



**Table 1: Participants’ answers to the use cases.**

P#	PU1	PU2	PU3	PU4	PEU1	PEU2	PEU3	PEU4	IU1	IU2
P1	6	5	5	5	6	6	6	5	7	6
P2	6	6	5	5	6	6	6	5	7	6
P3	7	5	6	7	7	3	5	3	7	5
P4	7	5	6	7	6	3	5	3	7	5
P5	7	7	7	7	7	7	7	7	7	7
P6	7	7	7	7	7	7	7	7	7	7
P7	5	7	7	7	6	6	3	3	6	5
P8	5	7	7	7	6	6	3	3	6	5
P9	7	7	7	7	7	7	7	7	7	7
P10	7	7	7	7	7	7	6	7	7	7
P11	6	5	5	4	6	4	6	6	7	7
P12	5	4	5	4	6	5	5	6	6	5
P13	6	1	2	4	7	6	6	6	7	7
P14	2	3	5	2	4	3	4	3	3	5
P15	6	3	5	5	6	6	6	6	7	5
P16	6	6	6	6	6	6	6	6	6	6
P17	6	5	6	6	7	7	7	6	7	5
P18	6	5	6	6	6	6	6	7	6	6
P19	5	6	5	5	5	4	6	5	5	6
P20	5	5	5	5	4	5	4	5	5	5
P21	6	5	5	5	4	4	4	3	5	4
P22	5	5	3	3	7	7	7	5	7	5
P23	7	7	7	7	5	5	5	6	6	5
P24	5	3	5	3	5	4	4	5	3	2
P25	7	7	7	7	7	7	7	7	7	7
P26	6	6	6	5	4	4	4	5	5	5
P27	7	7	7	7	6	6	5	6	5	5
P28	7	6	6	7	7	7	7	7	7	7
P29	6	6	6	5	5	4	5	6	6	6
P30	5	3	4	7	6	6	7	6	4	5

P#	PU1	PU2	PU3	PU4	PEU1	PEU2	PEU3	PEU4	IU1	IU2
P31	5	5	3	3	3	3	3	3	2	2
P32	6	5	6	5	6	5	5	6	6	6
P33	6	5	6	7	5	4	5	5	4	5
P34	4	6	6	4	6	6	5	7	6	5
P35	3	4	5	2	3	4	3	3	2	2
P36	6	6	7	7	6	6	6	7	7	7

We analyzed the reliability to guarantee the internal validity and consistency of the questionnaires used for the PEU and PU constructs. We applied the Cronbach Alpha test to assess the questionnaires' reliability<sup>1</sup>. The Cronbach Alpha result shows that the statements for ease of use and usefulness are reliable ( $\alpha = 0.894$  for ease of use and  $\alpha = 0.862$  for usefulness). In addition, we performed the factorial analysis to measure the statements related to PEU and PU. Through this type of analysis, it is possible to understand whether a group of statements is correlated or not with a factor [4]. We applied the test only to the PUE and PU constructs since the UI construct is correlated with both **Erro! Fonte de referência não encontrada.**. Thus, these statements in fact evaluated the PU and PEU constructs for each evaluated artifact (see **Erro! Fonte de referência não encontrada.**). We used the IBM SPSS Statistics 20<sup>2</sup> tool for statistical tests.

**Figure 2: Factorial validity for the TAM constructs – Use case.**

	Component	
	1	2
U1	,532	,586
U2	,064	,886
U3	,059	,913
U4	,381	,806
E1	,846	,243
E2	,801	,229
E3	,932	,016
E4	,825	,148

We interpreted factor 1 as the ease of use, because of the correlation level of E1, E2, E3 and E4 (highlighted in red). We interpret factor 2 as the usefulness, because the statements U1, U2, U3 and U4 are related to this factor (highlighted in blue). These results are similar to the results reported by Babar, Winkler & Biffel [5] and Sánchez & Hueros [6].

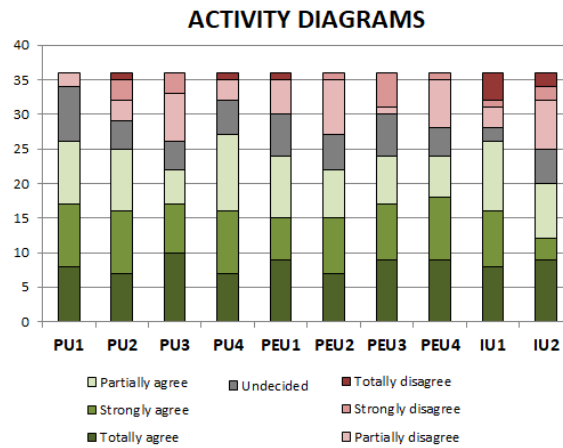
<sup>1</sup> The Cronbach Alpha test and factor analysis that exceeds a threshold of 0.7 indicates a reliable measure [7].

<sup>2</sup> IBM SPSS Software – [www.ibm.com/software/br/analytics/spss/](http://www.ibm.com/software/br/analytics/spss/)

## ACTIVITY DIAGRAMS

In Figure 1, we present the participants' answers to the perceived usefulness, perceived ease of use and intention to use related to the activity diagrams. Table 2 presents the answers from the students regarding the TAM statements.

**Figure 3: Answers to perceived ease of use, perceived usefulness and intention to activity diagrams.**



**Table 2: Participants' answers to the activity diagrams.**

P#	PU1	PU2	PU3	PU4	PEU1	PEU2	PEU3	PEU4	IU1	IU2
P1	4	5	4	5	4	3	4	4	5	4
P2	4	5	4	5	5	3	4	4	5	4
P3	7	7	7	7	7	6	7	7	7	7
P4	7	7	7	7	7	6	7	7	7	7
P5	4	6	6	5	4	3	2	5	6	4
P6	6	6	6	5	4	3	2	5	6	4
P7	7	6	7	6	7	7	7	7	6	7
P8	6	6	7	6	7	7	7	7	6	6
P9	7	7	7	7	7	7	7	7	7	7
P10	6	6	6	7	7	7	7	6	7	7
P11	6	3	2	3	5	5	6	4	6	3
P12	4	4	5	4	4	3	4	3	4	3
P13	5	6	3	5	3	3	2	2	1	1
P14	7	1	7	7	7	7	7	7	7	7
P15	3	2	3	3	3	4	4	5	1	5
P16	6	6	6	6	6	6	6	6	6	6
P17	5	4	4	4	6	6	6	6	3	3
P18	3	2	2	1	1	2	2	3	1	1
P19	4	3	2	4	5	4	4	4	3	5
P20	5	2	3	5	6	6	6	6	6	5
P21	7	7	7	7	7	7	7	7	7	7
P22	5	5	5	5	3	3	5	3	5	3
P23	7	7	7	5	6	6	6	7	5	3
P24	5	5	3	3	5	4	5	3	5	3
P25	7	7	7	7	7	7	7	7	7	7
P26	4	5	5	6	4	4	4	3	3	3
P27	5	5	3	5	3	5	3	5	2	2
P28	6	5	5	6	6	5	6	3	4	4
P29	5	7	5	6	4	4	5	5	5	5
P30	6	6	6	5	5	5	5	6	5	5
P31	6	6	6	6	6	6	6	6	6	6
P32	5	5	3	5	5	5	5	5	5	5
P33	4	3	3	4	5	5	5	6	5	5
P34	6	5	7	6	5	6	6	6	7	7
P35	4	4	6	6	3	3	2	3	1	2
P36	5	4	4	4	5	5	5	6	5	5

We applied the Cronbach Alpha test to assess the questionnaires' reliability. The Cronbach Alpha result shows that the statements for ease of use and usefulness are reliable ( $\alpha = 0.951$  for ease of use and  $\alpha = 0.878$  for usefulness). In addition, we performed the factorial analysis to measure the statements related to PEU and PU. Thus, these statements in fact evaluated the PU and PEU constructs for each evaluated artifact (see **Erro! Fonte de referência não encontrada.**).

**Figure 4: Factorial validity for the TAM constructs – Activity diagrams.**

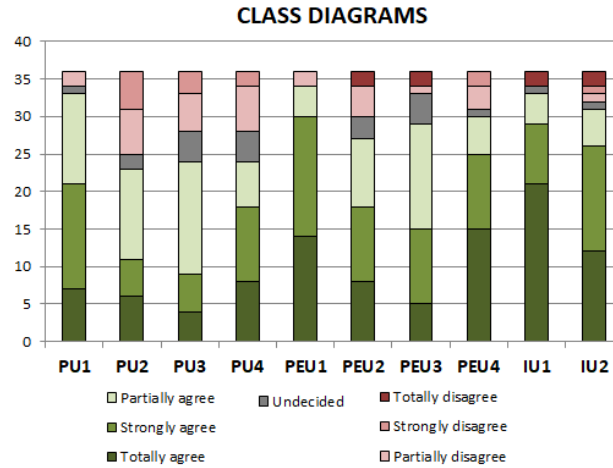
	Component	
	1	2
U1	,711	,564
U2	,053	,899
U3	,414	,803
U4	,448	,769
E1	,886	,332
E2	,944	,226
E3	,921	,181
E4	,829	,276

We interpreted factor 1 as the ease of use, because of the correlation level of E1, E2, E3 and E4 (highlighted in red). We interpret factor 2 as the usefulness, because the statements U1, U2, U3 and U4 are related to this factor (highlighted in blue).

## CLASS DIAGRAMS

In Figure 1, we present the participants' answers to the perceived usefulness (PU1 to PU4), perceived ease of use (PEU1 to PEU4) and intention to use (IU1 and IU2) related to the use class diagrams. Table 3 presents the answers from the students regarding the TAM statements.

**Figure 5: Answers to perceived ease of use, perceived usefulness and intention to class diagrams.**



**Table 3: Participants' answers to the class diagrams.**

P#	PU1	PU2	PU3	PU4	PEU1	PEU2	PEU3	PEU4	IU1	IU2
P1	5	5	5	7	5	3	4	4	7	6
P2	5	5	5	7	5	3	3	3	7	6
P3	4	3	4	6	6	4	5	5	4	3
P4	5	4	5	7	7	5	5	5	7	7
P5	7	7	7	7	7	3	5	3	7	7
P6	7	7	7	7	7	3	5	3	7	7
P7	3	2	2	3	3	1	1	2	1	1
P8	3	2	2	3	3	1	1	2	1	1
P9	7	7	7	7	7	7	6	6	7	7
P10	7	7	7	7	7	7	6	6	7	7
P11	6	2	6	6	6	6	6	6	6	6
P12	6	5	3	4	7	5	6	7	7	7
P13	5	3	4	4	5	5	5	7	7	7
P14	5	6	3	4	6	6	4	5	5	5
P15	7	2	3	2	7	7	6	7	7	5
P16	5	3	5	3	6	6	7	7	6	7
P17	5	5	5	3	7	7	7	7	7	7
P18	6	5	6	3	6	6	5	7	7	6
P19	6	7	5	4	5	4	5	5	6	7
P20	5	3	2	2	6	6	5	7	5	2
P21	7	5	5	6	7	7	7	7	7	6
P22	7	6	6	6	7	7	7	7	7	7
P23	5	7	4	5	7	6	5	7	7	6
P24	5	5	5	6	6	5	5	6	7	6
P25	6	6	6	5	6	5	5	6	6	6
P26	6	4	4	6	7	7	6	7	7	7
P27	6	5	5	6	6	5	4	7	7	6
P28	5	2	3	5	7	6	6	7	5	6
P29	6	6	5	5	7	7	7	7	7	6
P30	6	5	5	6	6	4	5	6	7	4
P31	5	3	3	3	6	6	6	6	6	5
P32	6	6	5	7	6	5	6	7	7	6
P33	6	3	5	5	6	6	6	6	6	6
P34	6	5	5	5	6	5	5	6	6	5
P35	6	5	5	6	6	5	4	5	5	5
P36	6	5	6	6	6	6	5	6	6	6

We applied the Cronbach Alpha test to assess the questionnaires' reliability. The Cronbach Alpha result shows that the statements for ease of use and usefulness are reliable ( $\alpha = 0.894$  for ease of use and  $\alpha = 0.862$  for usefulness). In addition, we performed the factorial analysis to measure the statements related to PEU and PU. Thus, these statements in fact evaluated the PU and PEU constructs for each evaluated artifact (see **Erro! Fonte de referência não encontrada.**).

**Figure 6: Factorial validity for the TAM constructs – Class diagrams.**

	Component	
	1	2
U1	,575	,671
U2	,095	,810
U3	,176	,889
U4	-,113	,839
E1	,803	,419
E2	,949	,023
E3	,917	,201
E4	,916	-,151

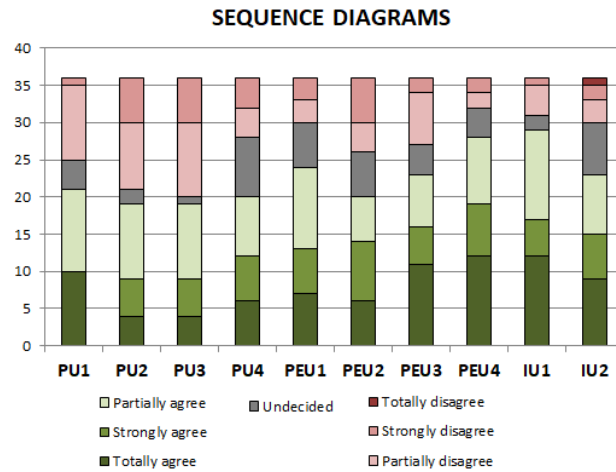
We interpreted factor 1 as the ease of use, because of the correlation level of E1, E2, E3 and E4 (highlighted in red). We interpret factor 2 as the usefulness, because the statements U1, U2, U3 and U4 are related to this factor (highlighted in blue).



## SEQUENCE DIAGRAMS

In Figure 1, we present the results of participants' answers to the perceived usefulness, perceived ease of use and intention to use the sequence diagrams. Table 4 presents the answers from the students regarding the TAM statements.

**Figure 7: Answers to perceived ease of use, perceived usefulness and intention to sequence diagrams.**



**Table 4: Participants' answers to the sequence diagrams.**

P#	PU1	PU2	PU3	PU4	PEU1	PEU2	PEU3	PEU4	IU1	IU2
P1	3	3	3	4	2	2	2	2	3	3
P2	3	3	3	4	2	2	2	2	3	3
P3	7	6	6	7	5	6	7	7	7	6
P4	7	6	6	7	6	6	7	7	7	6
P5	4	6	6	6	4	2	3	5	6	5
P6	7	6	6	6	4	2	3	5	6	5
P7	4	5	5	5	3	2	3	5	4	4
P8	5	4	5	5	5	3	3	4	5	4
P9	7	7	7	7	7	7	7	7	7	7
P10	7	7	7	7	7	6	7	6	7	7
P11	5	5	3	6	4	4	5	4	5	5
P12	3	2	2	4	3	4	3	6	5	4
P13	2	2	2	2	4	2	5	7	5	6
P14	7	7	7	7	7	7	7	7	7	7
P15	3	3	2	3	5	5	5	5	5	5
P16	5	3	5	5	6	6	6	6	6	5
P17	5	3	3	4	5	6	7	7	7	7
P18	5	5	5	3	5	5	7	7	7	7
P19	3	2	2	2	2	4	4	4	3	4
P20	7	7	7	7	7	7	7	7	7	7
P21	3	2	3	5	5	5	5	5	5	4
P22	3	3	2	2	3	3	3	3	5	1
P23	5	4	5	5	5	5	5	6	6	6
P24	5	5	5	6	6	4	6	6	5	5
P25	3	2	2	2	4	5	5	5	2	2
P26	7	5	5	5	7	7	7	7	7	7
P27	7	6	6	6	7	7	7	7	7	7
P28	4	3	3	3	6	6	6	6	5	5
P29	5	3	4	4	6	6	6	7	7	7
P30	3	3	3	5	5	3	4	5	3	2
P31	7	5	5	4	7	7	7	7	7	6
P32	5	5	3	3	5	5	4	3	5	3
P33	5	5	3	4	5	4	3	5	5	4
P34	5	5	5	5	6	6	6	6	6	6
P35	3	2	3	6	5	3	5	5	4	5
P36	4	5	5	4	4	4	4	4	5	4

We applied the Cronbach Alpha test to assess the questionnaires' reliability. The Cronbach Alpha result shows that the statements for ease of use and usefulness are reliable ( $\alpha = 0,937$  for ease of use and  $\alpha = 0,942$  for usefulness). In addition, we performed the factorial analysis to measure the statements related to PEU and PU. Thus, these statements in fact evaluated the PU and PEU constructs for each evaluated artifact (see **Erro! Fonte de referência não encontrada.**).

**Figure 8: Factorial validity for the TAM constructs – Sequence diagrams.**

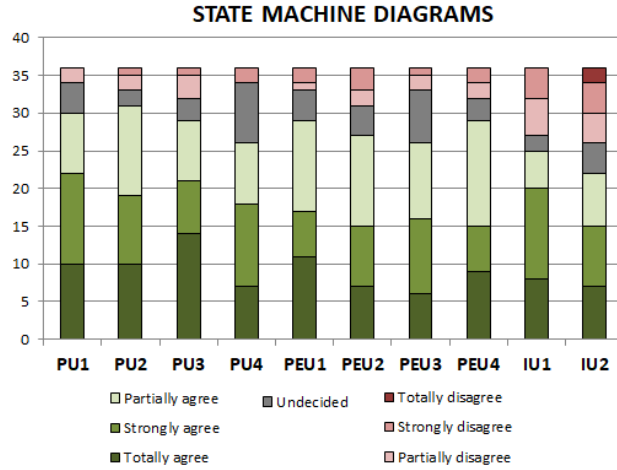
	Component	
	1	2
U1	,515	,783
U2	,204	,918
U3	,301	,910
U4	,162	,868
E1	,823	,424
E2	,904	,197
E3	,934	,229
E4	,852	,217

We interpreted factor 1 as the ease of use, because of the correlation level of E1, E2, E3 and E4 (highlighted in red). We interpret factor 2 as the usefulness, because the statements U1, U2, U3 and U4 are related to this factor (highlighted in blue).

## STATE MACHINE DIAGRAMS

In Figure 1, we present the participants' answers to the perceived usefulness, perceived ease of use and intention to use related to the state machine diagrams. Table 5 presents the answers from the students regarding the TAM statements.

**Figure 9: Answers to perceived ease of use, perceived usefulness and intention to state machine diagrams.**



**Table 5: Participants' answers to the state machine diagrams.**

P#	PU1	PU2	PU3	PU4	PEU1	PEU2	PEU3	PEU4	IU1	IU2
P1	5	5	5	4	5	5	5	5	4	3
P2	5	5	5	4	5	5	5	5	4	3
P3	3	4	4	4	7	7	7	3	2	1
P4	4	4	4	4	7	7	7	3	3	1
P5	3	5	5	4	4	2	3	2	3	2
P6	5	5	5	4	4	2	3	5	3	2
P7	6	7	7	6	7	5	6	7	7	6
P8	6	7	7	6	7	5	6	7	7	6
P9	7	7	7	7	7	7	7	7	7	7
P10	6	7	7	6	7	7	7	7	7	7
P11	6	5	3	5	5	5	4	4	5	6
P12	6	6	6	6	5	5	4	5	6	5
P13	4	5	4	4	5	3	4	4	2	2
P14	7	2	7	6	2	4	4	2	2	2
P15	5	5	3	5	5	5	5	5	6	6
P16	6	6	6	6	6	6	6	6	6	6
P17	5	6	6	6	4	5	4	5	3	4
P18	7	6	7	6	6	5	5	5	5	4
P19	4	3	2	2	2	2	2	4	2	4
P20	7	7	7	7	5	6	6	7	7	7
P21	7	5	5	5	6	6	6	6	6	6
P22	4	5	5	4	5	4	4	5	6	4
P23	7	7	7	7	7	7	5	7	7	7
P24	6	6	7	5	6	4	5	6	6	5
P25	5	5	6	5	7	6	6	5	6	5
P26	7	7	7	7	7	7	7	7	7	7
P27	7	6	6	6	7	6	6	7	7	7
P28	7	6	7	7	5	4	5	5	6	5
P29	6	7	6	5	4	5	4	5	3	3
P30	7	7	7	7	5	5	5	5	5	5
P31	5	5	5	6	6	6	6	6	5	5
P32	6	6	7	7	7	7	7	7	6	6
P33	6	5	6	6	6	6	6	6	6	6
P34	6	6	5	5	5	6	5	6	6	5
P35	6	7	7	5	5	5	6	5	6	7
P36	5	3	3	2	3	3	5	5	5	3

We applied the Cronbach Alpha test to assess the questionnaires' reliability. The Cronbach Alpha result shows that the statements for ease of use and usefulness are reliable ( $\alpha = 0.891$  for ease of use and  $\alpha = 0.889$  for usefulness). In addition, we performed the factorial analysis to measure the statements related to PEU and PU. Thus, these statements in fact evaluated the PU and PEU constructs for each evaluated artifact (see **Erro! Fonte de referência não encontrada.**).

**Figure 10: Factorial validity for the TAM constructs – State machine diagrams.**

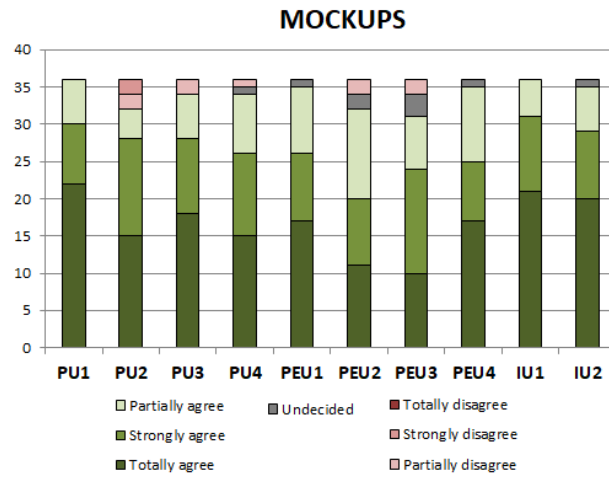
	Component	
	1	2
U1	,868	,075
U2	,763	,323
U3	,861	,196
U4	,848	,331
E1	,244	,898
E2	,274	,878
E3	,201	,920
E4	,645	,463

We interpreted factor 2 as the ease of use, because of the correlation level of E1, E2, E3 and E4 (highlighted in red). We interpret factor 1 as the usefulness, because the statements U1, U2, U3 and U4 are related to this factor (highlighted in blue).

## MOCKUPS

In Figure 1, we present the participants' answers to the perceived usefulness, perceived ease of use and intention to use related to the mockups. Table 6 presents the answers from the students regarding the TAM statements.

**Figure 11: Answers to perceived ease of use, perceived usefulness and intention to mockups.**



**Table 6: Participants' answers to the mockups.**

P#	PU1	PU2	PU3	PU4	PEU1	PEU2	PEU3	PEU4	IU1	IU2
P1	7	7	7	5	6	5	5	4	5	5
P2	6	6	6	5	6	6	6	7	7	7
P3	6	6	6	5	6	5	4	5	6	6
P4	7	7	7	7	7	7	7	7	7	7
P5	7	7	7	7	7	7	7	7	7	7
P6	5	3	5	5	6	6	6	5	5	6
P7	5	2	6	5	7	6	6	6	7	7
P8	6	6	5	4	4	5	4	5	5	6
P9	7	7	7	7	7	7	7	7	7	7
P10	6	6	6	6	6	6	6	6	6	6
P11	7	7	7	3	5	5	5	6	5	4
P12	6	6	7	6	6	6	7	7	6	7
P13	5	3	3	5	5	6	5	7	7	7
P14	7	6	7	6	7	7	7	7	7	7
P15	7	7	7	7	7	7	6	5	7	6
P16	7	7	7	7	7	7	7	7	7	7
P17	7	2	6	5	5	4	4	5	5	5
P18	7	6	6	6	6	6	6	6	7	7
P19	7	6	7	7	6	6	7	7	7	7
P20	7	7	7	6	7	5	6	7	7	7
P21	7	7	7	7	7	7	7	6	6	6
P22	5	5	3	6	5	5	5	6	6	6
P23	5	5	5	5	5	4	5	6	6	6
P24	6	6	6	6	6	6	6	6	6	6
P25	7	7	7	5	6	5	5	4	5	5
P26	7	6	6	6	5	5	6	5	6	5
P27	5	6	5	6	5	5	6	7	7	5
P28	7	7	7	7	7	7	7	7	7	7
P29	6	6	6	5	6	5	4	5	6	6
P30	6	6	6	5	6	6	6	7	7	7
P31	7	7	7	7	7	7	7	7	7	7
P32	5	2	6	5	7	6	6	6	7	7
P33	5	3	5	5	6	6	6	5	5	6
P34	6	6	5	4	4	5	4	5	5	6
P35	7	7	7	7	7	7	7	7	7	7
P36	6	6	6	6	6	6	6	6	6	6

We applied the Cronbach Alpha test to assess the questionnaires' reliability. The Cronbach Alpha result shows that the statements for ease of use and usefulness are reliable ( $\alpha = 0.786$  for ease of use, and  $\alpha = 0.815$  for usefulness). In addition, we performed the factorial analysis to measure the statements related to PEU and PU. Thus, these statements in fact evaluated the PU and PEU constructs for each evaluated artifact (see **Erro! Fonte de referência não encontrada.**).

**Figure 12: Factorial validity for the TAM constructs – Mockups.**

	Component	
	1	2
U1	,064	,896
U2	,131	,801
U3	,286	,868
U4	,637	,495
E1	,816	,326
E2	,863	,235
E3	,883	,205
E4	,794	-,101

We interpreted factor 1 as the ease of use, because of the correlation level of E1, E2, E3 and E4 (highlighted in red). We interpret factor 2 as the usefulness, because the statements U1, U2, U3 and U4 are related to this factor (highlighted in blue).

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