
Analyzing the Students' Perception of UML Diagrams: Results of the TAM (Technology Acceptance Model)

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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. In this technical report, we present the students' answers to the Technology Acceptance Model (TAM) questionnaires for five UML diagrams.

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 questionnaire based on the TAM¹ constructs (PU, PEU and IU) for each UML diagrams, such as: class diagrams, use case diagrams (and specifications), sequence diagrams, state machine diagrams, and activity diagrams. Below we present the TAM statements adapted for each UML diagram

Perceived Ease of Use

PE1. My interaction (modeling and comprehension of the information) with this diagram is clear and understandable.

PE2. Interacting (modeling and comprehension of the information) with this diagram does not require a lot of my mental effort.

PE3. I find this diagram to be easy to use (for modeling and comprehension of the information).

PE4. I find it easy to get this diagram to do what I want it to do (in terms of modeling and comprehension of the information).

Perceived Usefulness

PU1. Using this diagram improves my performance better for understanding aspects of the software.

PU2. Using this diagram in my job has improved my productivity for understanding aspects of the software.

PU3. Using this diagram enhances my effectiveness in understanding aspects of the software.

PU4. I consider this diagram useful for software design.

Intention to Use

¹ These TAM questionnaires used for each UML diagram are available in XXX.

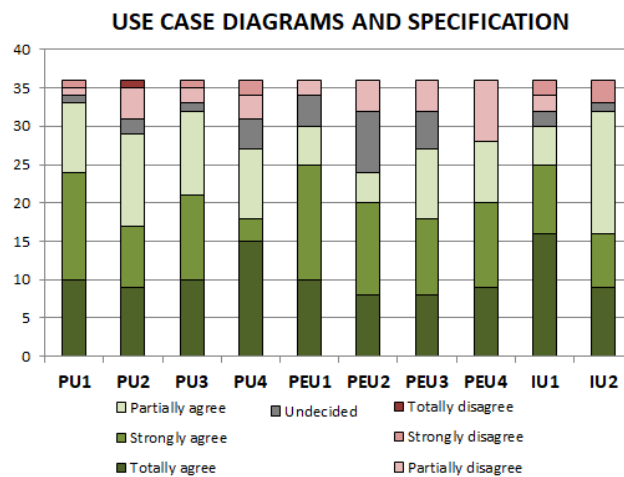
- I1. Assuming I had enough time to design software, I intend to use this diagram.
- I2. Considering that if I could choose any notation for the analysis and design, I predict that I would use this diagram.

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.



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’ reliability². 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 [5]. Thus, these statements in fact evaluated the PU and PEU constructs for each evaluated artifact (see Figure 2). We used the IBM SPSS Statistics 20³ tool for statistical tests.

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

² The Cronbach Alpha test and factor analysis that exceeds a threshold of 0.7 indicates a reliable measure [7].

³ IBM SPSS Software – www.ibm.com/software/br/analytics/spss/

	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 & Biffi [5] and Sánchez & Hueros [6].

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
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

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.

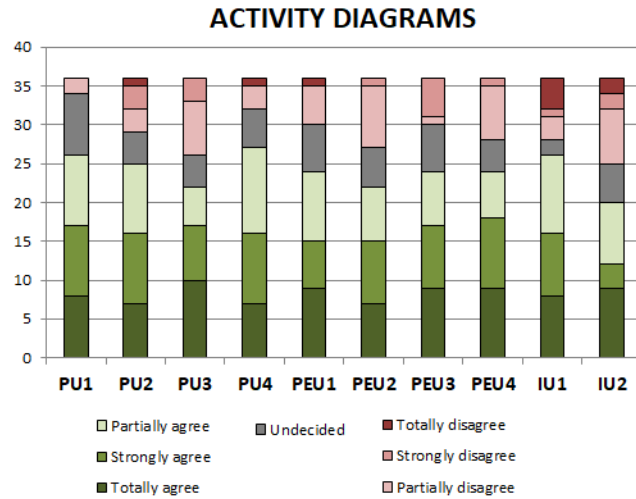


Table 2: Participants' answers to the activity diagrams.

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 Figure 4).

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.

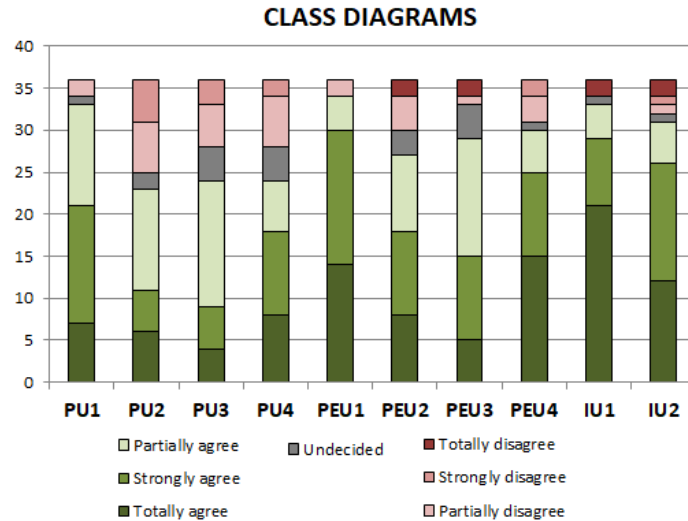


Table 3: Participants' answers to the class diagrams.

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 Figure 6).

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.

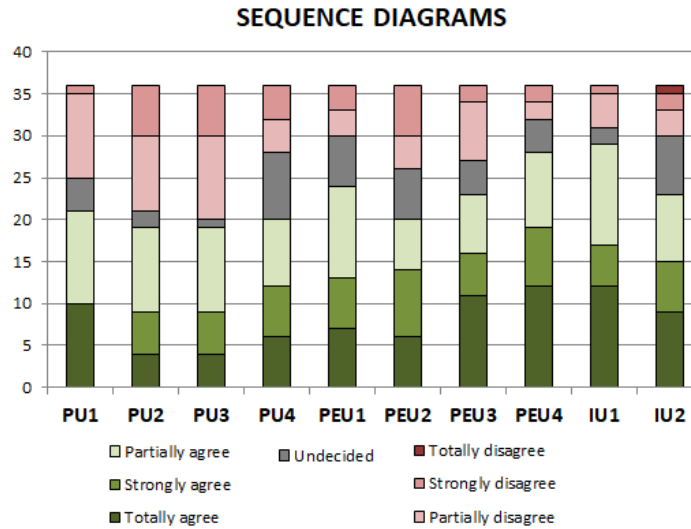


Table 4: Participants' answers to the sequence diagrams.

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 Figure 8).

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.

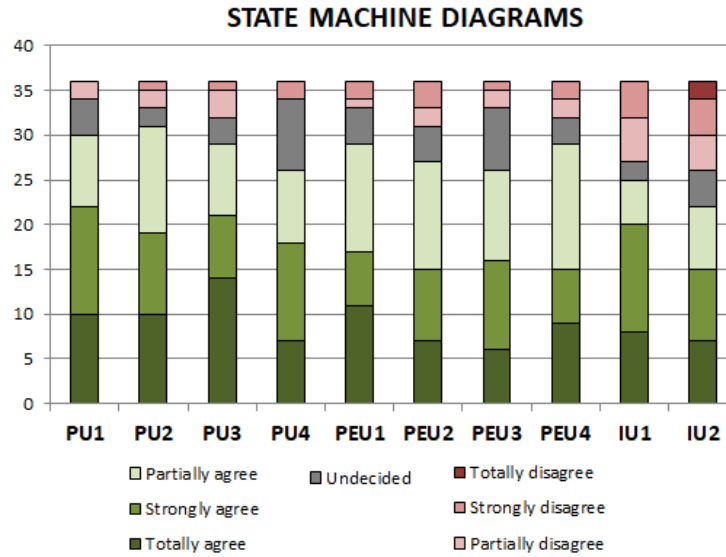


Table 5: Participants' answers to the state machine diagrams.

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 Figure 10).

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).

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