Exploring the Acceptance of the Web-based Coding Tool in an Introductory Programming Course: A Pilot Study

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Abstract. Web-based coding tools are a popular alternative to desktop applications widely employed in education. Understanding the factors that affect the acceptance of web-based coding tools is a prerequisite for their successful application. With an aim to determine to what extent students' attitude towards programming and their previous programming knowledge affect students' acceptance of the web-based programming tool, an empirical study was carried out in which the technology acceptance model (TAM) was employed as a theoretical backbone. Participants in the study were students enrolled to the introductory programming course who used Repl.it as a representative sample of the web-based coding tool. The psychometric features of the introduced research framework were examined by means of the partial least square structural equation modelling technique. The study findings revealed that attitude towards programming does not play an important role in the adoption of a web-based coding tool.

Keywords: Web-based Coding Tool · Technology Acceptance Model · Introductory Programming Course · Empirical Study · Post-use Questionnaire

1 Introduction

Problems related to successful teaching of programming are widely represented in Computer Science (CS) education research [1]. Programming is a core competence of CS and every student should successfully adopt it. However, the practice has shown that acquiring this skill remains a difficult task [2]. Therefore, researchers are constantly trying to introduce new pedagogical interventions and new tools that will ease a learning process. The development and application of novel tools are a significant part of research in CS education [3]. The web-based coding tools represent a widespread alternative to their desktop counterparts used in programming education. Availability on various platforms at any time and from any place, needlessness for installation and maintenance, suitability for face-to-face and online teaching, and support for collaborative learning are just some of advantages of them. These tools are commonly employed in educational ecosystem, we initiated an empirical study on their acceptance by students enrolled in introductory programming course.

2 Research model and hypotheses

Technology Acceptance Model (TAM) [4] is one of the most influential models in research on software adoption. Its psychometric features of validity and reliability have been confirmed in a number of studies where TAM was enhanced with variety of constructs. In this paper, TAM has been used as a background for identifying the antecedents of students' acceptance of the web-based coding tool. According to the main postulates of TAM, the behavioral intention to use the system (BIU) predicts actual use, the user's attitude toward using the system (ATU) is determined by the BIU while ATU is affected by perceived usefulness (PU) and perceived ease of use (PEOU). In that respect, we are proposing following five hypotheses:

H1: Perceived usefulness has a significant positive effect on attitude towards using.
H2: Perceived usefulness has a significant positive effect on behavioral intention
H3: Perceived ease of use has a significant positive effect on attitude towards using.
H4: Perceived ease of use has a significant positive effect on perceived useful-ness.
H5: Attitude towards using has a significant positive effect on behavioral intention.

For the purpose of our study, TAM has been extended with two additional constructs: attitude towards programming (ATP) and previous programming knowledge (PPK). Davis envisaged this type of extension in the model through the concept of external variables. The reason why we have chosen these two constructs is the impact they have on student learning performance. The most frequently mentioned factor related to programming performance is prior programming experience. Numerous studies (e.g. [5][6][7][8]) provide evidence that previous programming knowledge positively influences success in programming courses. The second construct, entitled attitude towards programming, was added to the research model for similar reasons. Students' attitudes toward a course affect their achievements and programming is not an exception in that respect. Some studies (e.g. [9][10]) have found a positive correlation between attitude toward programming and achievement in a programming course. Therefore, we are proposing following four hypotheses:

H6: Attitude towards programming has a significant positive effect on Perceived usefulness.
H7: Attitude towards programming has a significant positive effect on Perceived ease of use.
H8: Previous programming knowledge has a significant positive effect on Perceived usefulness.
H9: Previous programming knowledge has a significant positive effect on Perceived ease of use.

The proposed research framework is presented in Figure 1.

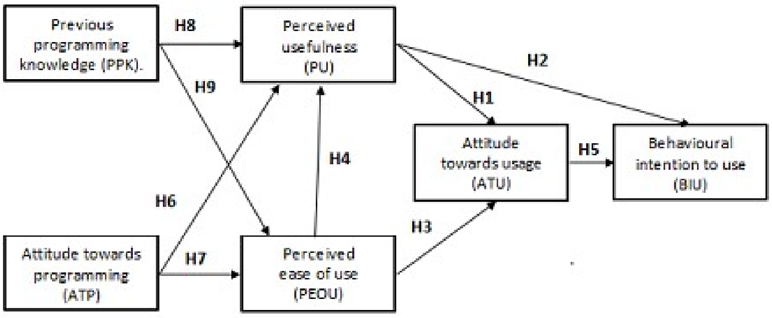

Fig. 1. The research framework

3 Methodology

This study is a part of a larger project exploring the adoption of teaching tools in computer science education. The aim of this research was to determine suitability of TAM in the context of student acceptance of the web-based coding tool. Sample of students was composed of students enrolled to Faculty of Informatics and Department of Computer Science of the Juraj Dobrila University of Pula in Croatia. Data was collected by means of the post-use questionnaire consisted of two items related to respondents' demography and 27 items designed for examining the constructs that constitute the research model. Apart from gender and age, answers to the questionnaire items were modulated on a five-point Likert scale (1 – strongly disagree to 5 – strongly agree). During the semester, students used the desktop version of the integrated development environment (Dev-C ++) for the purpose of lab-based exercises while during the research session they used Repl.it web-based coding tool for the first time. At the beginning of the study, the lecturer briefly presented features of Repl.it tool to students. As a follow up, by working as a group in the multiplayer mode, the students and the lecturer completed together a source code analysis and a problem solving session. The aforementioned mode of the Repl.it tool enables students to work simultaneously on the same code, observe the work of others, comment, correct errors, and run programs. At the end of the study, the lecturer asked all participants to complete the questionnaire that was created and administrated by means of the Google Forms, Validity and reliability of the introduced research framework was explored with the partial least squares structural equation modeling (PLS-SEM) technique in SmartPLS 2.0 M3 [11].

4 Findings

A total of 56 students participated in the study. Majority of them (73.2%) were male. At the time study took place, the half of respondents were 19 years old, 19.6% were 20 years of age, 14.3% were 21 years old while remaining 16.07% had between 22 and 25 years of age. The analysis of the measurement model included testing the reliability of manifest and latent variables and convergent validity. First, we performed confirmatory factor analysis to test the construct validity of manifest variables (items) in the instrument. As shown in Table 1, standardized loadings of all items were greater than 0.707 threshold [12] so we retained all manifest variables in the model.

Table 1. Standardized factor loadings and cross loadings of manifest variables

	ATU	ATP	BIU	PEOU	PU	PPK
ATU1	**0.8665**	0.4771	0.7400	0.5928	0.6729	0.1184
ATU2	**0.7990**	0.4508	0.7454	0.5958	0.6411	0.2726
ATU3	**0.7803**	0.4074	0.6148	0.5551	0.5553	0.2167
ATU4	**0.8570**	0.1525	0.8399	0.4177	0.8082	-0.0593
ATU5	**0.8669**	0.3524	0.7412	0.6612	0.7179	0.1042
ATP1	0.3617	**0.9158**	0.2166	0.4102	0.2436	0.4304
ATP2	0.3768	**0.9155**	0.2736	0.4603	0.3031	0.5154
ATP3	0.4518	**0.9066**	0.3522	0.4463	0.3237	0.4486
ATP4	0.3811	**0.9070**	0.2007	0.4117	0.2204	0.5743
BIU1	0.7829	0.2146	**0.8485**	0.5559	0.7538	-0.0106
BIU2	0.8062	0.2987	**0.9423**	0.4629	0.7786	0.0302
BIU3	0.8127	0.2726	**0.8887**	0.4999	0.6941	0.0499
BIU4	0.7312	0.2289	**0.8944**	0.3670	0.8331	0.0718
BIU5	0.8448	0.2865	**0.9102**	0.5333	0.8190	0.1606
PEOU1	0.4671	0.3719	0.4602	**0.7677**	0.4430	0.3584
PEOU2	0.4589	0.3675	0.2925	**0.6899**	0.3080	0.1998
PEOU3	0.4923	0.3263	0.4347	**0.7156**	0.4529	0.1299
PEOU4	0.5637	0.3501	0.4020	**0.7835**	0.5623	0,1749
PU1	0.7552	0.3386	0.7897	0.5975	**0.8657**	0.0807
PU2	0.6448	0.2061	0.6809	0.3580	**0.8037**	-0.0421
PU3	0.5377	0.2200	0.5193	0.5480	**0.7412**	0.1008
PU4	0.7221	0.1680	0.7881	0.5426	**0.7923**	0.1593
PU5	0.6391	0.2897	0.6955	0.3979	**0.8551**	0.1076
PPK1	0.1544	0.5439	0.0861	0.2852	0.1667	**0.9143**
PPK2	0.1814	0.4356	0.1134	0.2703	0.0958	**0.8715**
PPK3	-0.0198	0.4260	-0.0523	0.1058	-0.1125	**0.7081**
PPK4	-0.1235	0.2382	-0.2260	0.1194	-0.1589	**0.7424**

Reliability of latent variables was examined using the composite reliability and Cronbach's alpha. Values of both Cronbach's alpha and composite reliability were above 0.707 [13] which provides support for the internal consistency at the level of every construct in the measurement model. An average variance extracted (AVE) value of all constructs was above 0.50, which indicates that the shared variance between a latent variable and its items is larger than variance of the measurement error [14]. The aforementioned results are summarized in Table 2. In order to test significance of path coefficients in the structural model, we performed the bootstrapping procedure with 5000 samples and 56 cases. The results of hypotheses testing are presented in Table 3. All paths between the four constructs from the original TAM appeared to be significant in the context of our study. More specifically, it has been confirmed that perceived usefulness affects attitude toward using (H1) and behavioral intention (H2), perceived ease of use was found to have influence on attitude toward using (H3) and perceived usefulness (H4), while attitude toward using is a significant predictor of behavioral intention when the use of the web-based coding tool is considered (H5). The reported findings are in line with those revealed is prior studies (e.g. [15]). The path analysis uncovered that previous programming knowledge does not contribute significantly to perceived usefulness nor perceived ease of use which is the reason why hypotheses H8 and H9 were rejected.

Table 2. Convergent validity and internal consistency of latent variables

Construct	AVE	Composite Reliability	Cronbach's Alpha
Attitude Towards Using	0.6968	0.9198	0.8909
Attitude Towards Programming	0.8304	0.9514	0.9320
Intention to Use	0.8053	0.9538	0.9392
Perceived Ease of Use	0.5479	0.8286	0.7248
Perceived Usefulness	0.6608	0.9066	0.8711
Previous Programming Knowledge	0.6620	0.8857	0.8469

Table 3. Hypotheses testing results

Hypotheses	β	T Statistics	p-value	Supported
H1. PU -> ATU	0.6522	6.0438	***	Yes
H2. PU -> BIU	0.4207	4.9677	***	Yes
H3. PEOU -> ATU	0.2768	2.2222	*	Yes
H4. PEOU -> PU	0.6027	5.1363	***	Yes
H5. ATU -> BIU	0,5423	5.9379	***	Yes
H6. ATP -> PU	0.0770	0.4563	ns	No
H7. ATP -> PEOU	0.4510	3.4471	***	Yes
H8. PPK -> PU	-0.1134	0.5112	ns	No
H9. PPK -> PEUO	0.0464	0.2572	ns	No

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Concerning attitude towards programming, it was found that it has significant impact on perceived ease of use but does not affect the perceived usefulness to the significant extent. Therefore, hypothesis H7 was confirmed while hypothesis H6 was rejected. The determination coefficient indicates the proportion of endogenous latent variables' variance explained by the set of predictors. Study findings revealed that 37.7% of variance in perceived usefulness is explained by perceived ease of use, 22.8% of variance in perceived ease of use was accounted for by previous programming knowledge, 72.1% of variance in attitude towards using was explained by perceived usefulness and perceived ease of use while 84.5% of variance in behavioral intention was accounted by attitude towards using and perceived usefulness. According to Orehovački [16], values of 0.15, 0.34, and 0.46 for determination coefficient can be, as a rule of thumb in empirical studies related to the adoption of various software, interpreted as weak, moderate, and substantial, respectively. Taking the set forth into consideration, predictors of behavioral intention and attitude towards use have substantial explanatory power, predictor of perceived usefulness has moderate explanatory power while predictor of perceived ease of use has weak explanatory power.

5 Conclusion

The objective of the work presented in this paper was to examine psychometric features of the research framework composed of TAM model enhanced with two additional constructs: attitude toward programming and previous programming knowledge. Study findings revealed that neither attitude towards programming nor prior programming knowledge significantly affects perceived usefulness while only previous programming knowledge affects perceived ease of use. As all other empirical studies, this one also has its limitations which should be acknowledged. Although students in our study served as a representative sample of users, they were from only one university. Given that a more heterogeneous sample of study participants could provide entirely different answers to post-use questionnaire items, the reported findings should be interpreted carefully. In addition, only one web-based coding tool was used in this study which means that reported findings cannot be generalized to other similar tools. Taking into account that work presented in this paper is a part of an ongoing research, in our future work we will extend the proposed framework with additional constructs adopted from other models and theories dealing with the technology adoption and examine an interplay among them.

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