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Students' Perception of Collaborative Project Management Tools in Programming-Based Projects: The Case of GitHub

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Abstract

Project management tools aim to support developers throughout the development phases and help them manage projects successfully. GitHub is the largest and most advanced software development platform developers and companies use to help with version control, collaborative development, task administration, project hosting, etc. GitHub is utilized in classrooms, coursework, and most often in group project assignments; students rely on GitHub in various coding and management activities such as collaborative coding, submitting assignments, sharing tasks, and code review. Applying such tools in education aroused the interest of educators and researchers in studying the implication on students' performance and measuring the adoption of this promising technology. The main goal of this paper is to demonstrate the effectiveness and the acceptance of using the collaborative project management tool (GitHub) for students in programming-based projects using the extended Unified Theory of Acceptance and Use of Technology (UTAUT2) model adopted with collaborative learning and learning value as external variables. Overall, the result shows that students' behavioral intention to use GitHub was significantly influenced by performance expectancy, collaborative learning, and habit. Besides, GitHub use was influenced considerably by facilitating conditions and habit. In addition, collaborative learning has a significant impact on students' performance expectancy.

Keywords: GitHub, Project management tools, Collaborative learning, Programming projects, UTAUT2 model, Technology acceptance.

1. Introduction

GitHub is the largest and most advanced software development platform developers, and companies use to help with version control, project management, project hosting, etc. Based on GitHub statistics, more than 37 million developers, 4+ million organizations, and more than 200 million repositories are hosted. GitHub provides free and paid products for cloud-based storage and joint coding for individuals and enterprise businesses (GitHub's Products, 2022).

One of the main features offered by GitHub is collaborative coding. Developers can contribute to projects efficiently with automated environment setup, get updates about code changes, assign code reviews for team members, post and discuss projects with the team, and build a community around the code. With the project management in GitHub, project managers can effectively manage the team and projects through project scheduling, tasks list, boards, labels, and tracking

milestones features. Moreover, the team administration feature provides the ability to build a group of user accounts, add users to project repositories with their accounts, and define users' access level to the code, data, and settings based on their role. In addition, GitHub offers a mobile version to access the project repositories anywhere, anytime, easily (GitHub Features, 2022).

A considerable amount of literature has been published on using GitHub to support the education process (Milovanović et al., 2021; Tu et al., 2022; Zagalsky et al., 2015; Tushev et al., 2020). The GitHub Education study shows that using GitHub in the classroom can improve students' project management understanding. From an educational perspective, teamwork projects and group assignments were the primary motivation for applying GitHub in the classroom in computing education (Glazunova et al., 2021). A study done by Nelson & Ponciano (2021) reported the importance of employing Project Management Tools (PMTs) to improve students' learning process. Hsing & Gennarelli (2019) showed that students using GitHub in the classroom tended to achieve better learning outcomes, be more prepared for the job market, and report successful experiences.

It has been approved that GitHub achieves different pedagogical benefits based on how it is adopted in education. For example, GitHub can be used for course development by senior students. It can also increase students' engagement through different learning styles. In addition, students can use GitHub to store individual and team projects to permit immediate feedback and group discussions. However, students' unfamiliarity with the tool may negatively impact the learning process (Gunnarsson & Larsson, 2017).

Several studies have investigated the factors influencing the use of PMTs in students' coursework. Recently, researchers have examined the effectiveness of using cloud services such as GitHub on collaborative software development. The most adoption factors were collaborative environment, bug tracking, the code editor, and student peer review. Other features such as organization and planning of teamwork, team communication have also been studied (Glazunova et al., 2021).

Due to the importance of understanding the willingness to continue using technologies, the main purpose of this research is to develop and test a theoretical model that identifies the determinants predicting the students' continuance intention towards using collaborative project management tools exemplified by GitHub using the extended Unified Theory of Acceptance and Use of Technology (UTAUT2). The question of the potential motivational factors that affect students' decisions to continue using GitHub is addressed in this paper.

2. Theoretical Background

Based on an intensive literature review, various technology acceptance models and theories were developed and verified to explain users' intention toward using technologies. The most widely used technology adoption theories are Technology Acceptance Model (TAM) developed by Davis, (1989), Theory of Planned Behavior introduced by Ajzen (1991), Theory of Reasoned Action developed by Ajzen and Fishbein (1977), Unified Theory of Acceptance and Use of Technology

(UTAUT) developed by Venkatesh et al. (2003), and Unified Theory of Acceptance and Use of Technology2 (UTAUT2) by Venkatesh et al. (2012). In reference to Tarhini et al. (2014), UTAUT2 is the most widely used model to explore Information Technologies (IT) areas, including e-learning.

The Unified Theory of Acceptance and Use of Technology (UTAUT) has four constructs influencing behavioral intention to use technology. These factors are performance expectancy, effort expectancy, social influence, and facilitating conditions. UTAUT has extended with three constructs (i.e., hedonic motivation, price value, and habit), making it more user-centered than TAM. Age, gender, and experience are individual differences theorized to moderate the effects of these constructs on behavioral intention and actual use behavior (Venkatesh et al., 2012).

In an education context, several studies have utilized the UTAUT2 constructs and investigated the influence of performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, habit, price value, and other factors in a different context (LMS, Blackboard, GitHub, Google Apps, and social media). A summary of the latest research literature is available in Table 1.

Concerning using GitHub by students, Čižmešija et al. (2018) analyzed the students' acceptance of adopting GitHub in software engineering courses using the UTAUT model extended with collaborative learning. The results indicated that the most influential predictors of behavioral intention to use GitHub were the independent variables of social influence and performance expectancy. In addition, the perception of the usefulness of collaborative learning among the team members has a significant impact on the inclination toward the future use of such collaboration tools.

To the best of our knowledge, researchers have not investigated students' perceptions of using project management tools in their software projects and programming courses. In response to this gap, this study studies the factors that motivate students to develop positive intentions to continue using project management tools exemplified by GitHub. We adopted UTAUT2 as a theoretical base and extended it by adding additional variables.

3. Proposed Research Model and Hypotheses Development

In this study, UTAUT2 is selected as a theoretical base, and it is extended by adding the collaborative learning factor from Čižmešija et al. (2018) and W. M. Al-Rahmi and Zeki (2017), and the learning value factor according to Ain et al. (2016). The research model is illustrated in Figure 1.

Performance expectancy (PE) is the degree to which students believe using collaborative learning tools will improve their work performance. According to Venkatesh et al. (2012), PE has seen the most significant construct of intention and use of various technological applications.

H1. *Performance expectancy will positively influence students' intention to adopt GitHub.*

Effort expectancy (EE) represents the degree to which students believe the use of PMTs will be ease and require less mental effort.

H2. *Effort expectancy will positively influence students' intention to adopt GitHub.*
H3. *Effort expectancy will positively influence the performance expectancy of GitHub.*

Social influence (SI) is defined by Venkatesh et al. (2012) as the degree to which students are influenced by surrounding people (family, friends, and instructors) and motivate them to use technology.

H4. *Social influence will positively influence students' intention to adopt GitHub.*

Collaborative learning (CL) refers to cloud-based services platforms used to facilitate students' collaboration in file management and sharing, group discussion, video conferencing, task management, and peer feedback. Several researchers, such as Larusson and Altermanh (2009) and Zhu (2012), reported that students adopting social media in their coursework positively impact the level of learning and students' performance, thus affecting their behavioral intention to adopt the collaborative technologies.

H5. *Collaborative learning will positively influence students' intention to adopt GitHub*
H6: *Collaborative learning will positively influence students' performance expectancy of GitHub*

Hedonic motivation (HM) is the pleasure derived or fun experienced when users use technologies.

H7. *Hedonic motivation will positively influence students' adopt GitHub.*

Learning value (LV) is described by Ain et al. (2016) as the value associated with the learning achieved from PMTs, which determines the perceived value of GitHub.

H8. *Learning value influences the behavioral intention to use GitHub.*

Facilitating condition (FC) relates to the availability of adequate resources and support for students to use the technology (Venkatesh et al., 2003).

H9. *Facilitating conditions will positively influence students to adopt GitHub.*
H10. *Facilitating conditions will positively influence students to use GitHub.*

Habit (HB) is described as individuals' habitual or self-directing behaviors to use technology. According to Venkatesh et al. (2012), Habit is ''a perceptual construct that reflects the results of prior experiences''.

H11. *Habit will positively influence students' intention to adopt GitHub.*
H12. *Habit will positively influence students' intention to use GitHub.*

Behavioral intention (BI) is defined as users' intention to use a particular technology for different tasks.

H13. *Behavioral intention will positively influence students' adoption of GitHub.*

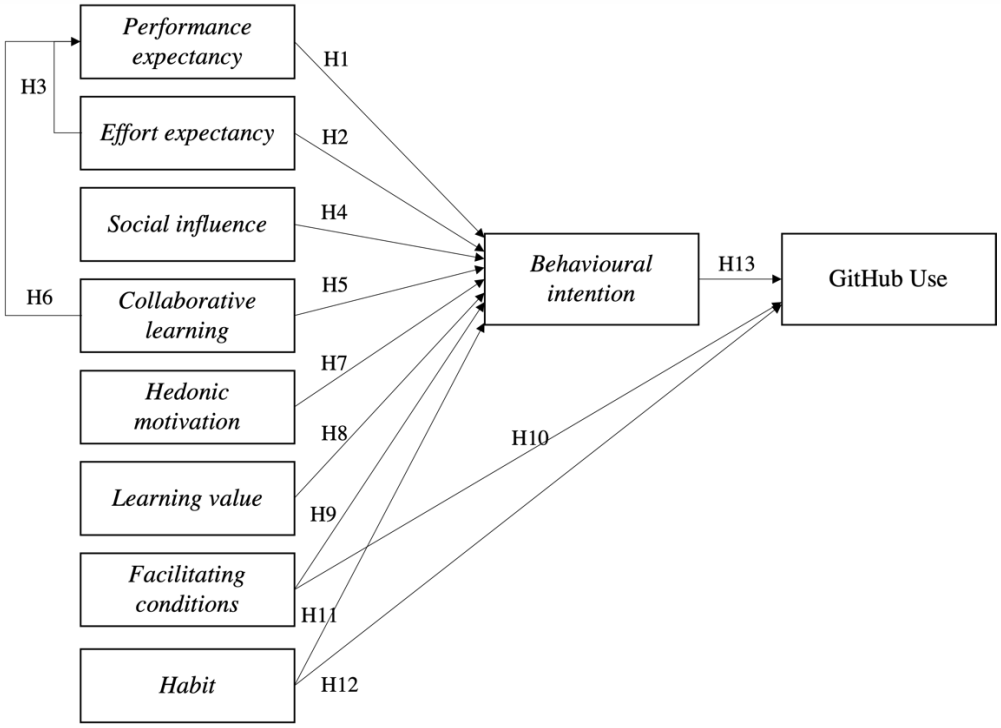

Figure 1: Proposed research model

Table 1: Summary of latest TAM studies on e-learning and collaborative learning

Model	Study cited (Author & Year)	Domain of measure	Item used/Variables	Result (Supported)	Result (Not supported)
UTAUT2	(Mzava & Kalinga, 2017)	Examine determinants of nurses' intention to use eLearning in Tanzania.	PE, EE, SI, HM, H, PV, Self-management, Resources FC, Technology FC.	PE → BI EE → BI SI → BI HM → BI SM → BI	RFC → BI TFC → BI HB → BI PV → BI
UTAUT2	(Ain et al., 2016)	Understanding students' perceived value in the LMS.	PE, EE, SI, HM, H, FC, Learning value,	PE→BI; SI→BI FC→Use LV→BI PI→Use	EE → BI FC → BI HM → BI HB → BI HB → Use
UTAUT	(Čižmešija et al., 2018)	Students' acceptance of adopting GitHub	PE, EE, SI, FC, Collaborative learning	PE → BI SI → BI CL → BI	EE →BI FC → BI
UTAUT2	(Chandradasa & Galhena, 2021)	Students' Intention of Continuous Use of Zoom for e-Learning.	PE, EE, SI, HM, Work-life quality, Intent experience	PE → BI HM → BI IE → BI WLE → BI EE →BI	SI → BI
D&M, TAM, UTAUT2	(Cavus et al., 2021)	The factors that affect LMS success for sustainable education during COVID-19.	Perceived enjoyment, Attitude toward tech., Perceived usefulness, perceived ease of use, System quality, User satisfaction, FC, SI	PE → BI ATT → BI PU → BI PEOU→BI SQ→BI; US→BI FC→BI; SI→BI	-
TAM	(Binaymin et al., 2019)	Understanding Students' use of LMS in Saudi Higher Education	Content quality, Learning support, Visual design, System navigation, Ease of access, System interactivity, Instructional assessment, System learnability, PEOU, PU, BI	CQ →PEOU SN → PEOU EOA → PEOU SI → PEOU IA → PEOU SL → PEOU CQ → PU LS → PU SI → PU IA → PU PEOU → PU PEOU → BI PU → BI BI → AU	LS → PEOU VD → PEOU VD → PU SN → PU EOA → PU SL → PU
TAM, UTAUT	(Sulaymani et al., 2022)	Acceptance of e-Learning Platforms Among Younger Students in Saudi Arabia	Previous experience, Self-efficacy, SI, FC, PEOU. PU,	PEX → SE SI → PEOU PEOU → PU PEOU → BI PU → BI SE → BI	FC → BI
TAM	(Yadegaridehkordi et al., 2019)	Decision to adopt online collaborative learning tools in higher education	Mobility, Collaboration, Personalization, PU, PEOU, Intention to adopt	PU → IA PEOU → PU M → PEOU C → PU C → PEOU P→ PEOU	PEOU → IA M → PU P → PU
TAM	(Cheung & Vogel, 2013)	Predicting user acceptance of collaborative	PU, PEOU, ATT, Compatibility (COMPA), Perceived	COMPA→ PEOU RES → PEOU	SN-Media → BI

		technologies for e-learning	Resources (RES), Sharing (SHA), Self-efficacy (SELF-EF), Subjective Norm-Media (SN-Media), Subjective Norm-Peer (SN-Peer), Subjective Norm-Lecturer (SN-LEC), System Usage (Use)	SHA → PU PEOU → PU COMPA → ATT PEOU → ATT PU → ATT SHA→ ATT SN-P → BI SHA → BI SELF-EF → BI ATT → BI ATT* SN-P → BI SH → Use BI → Use	SN-LEC → BI
Constructivism Theory and (TAM)	(W. M. Al-Rahmi & Zeki, 2017)	Utilizing social media for collaborative learning to enhance learners' performance	Perceived ease of use, Social media use, Perceived enjoyment, Perceived usefulness, Collaborative learning, Learners' performance Student satisfaction	PU→SMU PU→CL PE→SMU PE→CL PEU→SMU PEU→CL SMU→CL SMU→SS CL→LP SS→LP	-

Performance expectancy (PE), Effort expectancy (EE), Social influence (SI), Collaborative learning (CL), Hedonic motivation (HM), Facilitating condition (FC), Habit (HB), Behavioral intention (BI), Price Value (PV), Learning value (LV), Perceived ease of use PEOU, Perceived usefulness (PU), Perceived enjoyment (PE).

4. Research Method

This research adopts the exploratory method approach for collecting the data using the qualitative technique. A self-administered online questionnaire was used to test the proposed theoretical model and hypotheses, provided in Appendix A. The total number of returned questionnaires was 82. Among responses, one respondent was a master's student; therefore, her response was excluded, leaving 81 responses for the final data analysis.

After examining the assumptions of the structural equation modeling (SEM) analysis technique, a two-step approach was applied as recommended by Anderson and Gerbing (1988). These two steps are measurement model analysis and structural model analysis. Warp-PLS 7.0 was utilized for the present study.

4.1 Data Collection

Following most technology acceptance studies, this study utilizes survey for data collection. Eighty-two students participated and submitted their answers online using Google forms. Data was collected in March 2022 opened from 6 to 15th of March. We asked undergraduate students (male and female) studying computer science, information technology, information systems, software engineering, or other related computing departments at Saudi Universities to respond regarding their perception of the aspects related to behavioral intention and adoption of GitHub. We distributed the survey to students and encouraged them to participate in the classroom. The survey was distributed to other instructors teaching in computer science departments in different Saudi universities to reach a higher number of students.

4.2 Measures

The conducted survey comprises two sections. The first section of the survey aimed to collect the demographic information about students, while the second section was designed to collect data related to UTAUT2 factors relevant to research questions regarding the usage and acceptance of GitHub. The second section includes the eight external variables with 32 positive statements. The questionnaire was designed using closed-ended questions and a five-point Likert-type scale for responses starting from 1 (strongly disagree) to 5 (strongly agree). The instrument and its sources are provided in Appendix A.

5. Results

5.1 *Demographic Analysis*

The results show that out of 82 filled questionnaires, most respondents were female students, with 75 respondents (91.9%) and seven male students (8.5%). Most of the respondents are studying software engineering with 69.5%, followed by computer science with 19 respondents (23.2%), information technology and information system with (4.9%, 2.4%) respectively. A significant proportion of respondents, 75.6%, are studying at King Saud University, followed by Taif University (7.3%). Most students reported using GitHub for programming-based projects, with 58 respondents (70.7%), 64.6% for software projects, and 45.1% for coursework. Only 1.2% of respondents use GitHub for education.

In terms of students' academic level, the results indicated that 65.1% are in their final year, 30.5% in the third year, 7.3% in the second year, and only four students reported using GitHub in the first year. Most respondents (48.4%) reported that they have been using GitHub for one academic semester, 32.9% for two semesters, and 18.3% used GitHub for more than one year.

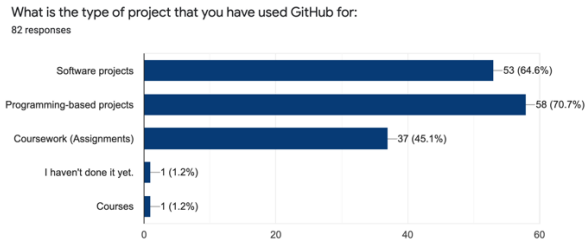

Figure 2: Type of Projects GitHub is used for.

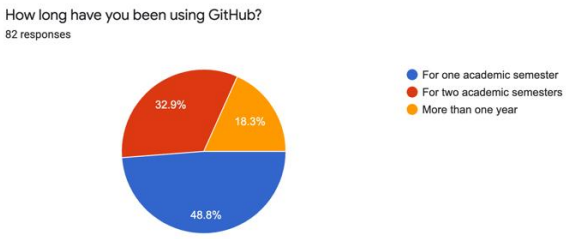

Figure 3: For how long GitHub has been used

5.2 Measurement Model Analysis

Cronbach's alpha (α) and indicator loading were used to check reliability, while Composite Reliability (CR) and Average Variance Extracted (AVE) were used to check the validity of the instrument. Cronbach's alpha scores ranged from 0.653 to 0.939, indicating that the constructs

have (α) scores greater than the minimum acceptable level of 0.6 (Hair et al., 2010). The indicator loading value should be significant and above .70; however, values above 0.5 are also accepted by some researchers (Chen & Tsai, 2007). CR values ranged from 0.814 to 0.961, achieving the recommended level of 0.7. The AVE ranged from 0.602 to 0.891, which was greater than 0.5. As shown in Table 2, all indicators of this study are valid and reliable.

Table 2: Convergent validity and internal reliability

Constructs	**Indicators**	**Indicator Loading**	**Cronbach's alpha (α)**	**Composite reliability** (CR)	**Average variance extracted** (AVE)
PE	PE1	0.891	0.895	0.935	0.827
	PE2	0.922			
	PE3	0.915			
EE	EE1	0.914	0.904	0.940	0.838
	EE2	0.922			
	EE3	0.911			
SI	SI1	0.866	0.767	0.867	0.687
	SI2	0.900			
	SI3	0.708			
FC	FC1	0.876	0.653	0.814	0.602
	FC2	0.858			
	FC3	0.551			
GU	GU1	0.818	0.786	0.875	0.701
	GU2	0.803			
	GU3	0.899			
CL	CL1	0.861	0.888	0.931	0.817
	CL2	0.930			
	CL3	0.919			
LV	LV1	0.838	0.853	0.895	0.630
	LV2	0.797			
	LV3	0.805			
	LV4	0.725			
	LV5	0.801			
HM	HM1	0.959	0.939	0.961	0.891
	HM2	0.945			
	HM3	0.928			
HB	HB1	0.896	0.868	0.919	0.792
	HB2	0.921			
	HB3	0.851			
BI	BI1	0.946	0.935	0.959	

	BI2	0.929			0.885
	BI3	0.947			

In addition, the discriminant validity was tested using the Heterotrait-Monotrait ratio of correlations (HTMT) approach (Henseler et al., 2015). HTMT represents the estimate for the construct's correlation with the other constructs, which should be smaller than one. Thus, a value closer to one shows a lack of discriminant validity (Henseler et al., 2016). The results of the HTMT assessment in Table 3 ranged between 0.776 and 0.944, indicating the discriminant validity of the constructs.

Table 3: Correlation matrix and the square root of the average variance extracted (AVE)

Constructs	**PE**	**EE**	**SI**	**FC**	**GU**	**CL**	**LV**	**HM**	**HB**	**BI**
PE	**0.909**									
EE	0.457	**0.916**								
SI	0.550	0.350	**0.829**							
FC	0.592	0.534	0.532	**0.776**						
GU	0.583	0.623	0.339	0.614	**0.837**					
CL	0.738	0.512	0.422	0.510	0.602	**0.904**				
LV	0.723	0.405	0.484	0.593	0.626	0.814	**0.794**			
HM	0.630	0.638	0.406	0.501	0.667	0.670	0.574	**0.944**		
HB	0.596	0.505	0.319	0.508	0.700	0.638	0.697	0.658	**0.890**	
BI	0.740	0.365	0.514	0.485	0.437	0.706	0.672	0.570	0.629	**0.941**

5.3 Structural Equation Modelling (SEM) Analysis

Criteria used to evaluate the structural model in the current study are Coefficient of determination (R^2), Path coefficient (β), Effect size Cohen's f^2, and Predictive relevance (Q2). The coefficient of determination (R^2) refers to the effect of independent variables on the dependent variables (Leguina, 2015). The result showed that CL explained 56.4% (relatively substantial) of the variance in PE. Regarding behavior intention, three independent variables, namely PE, CL, and HB accounted for 89% (relatively substantial) of the variance in BI, where PE contributed the most. Both FC and HB explained 57.6% (relatively substantial) of the variance in GitHub use, as summarized in Table 4. In addition, Table 4 shows the predictive relevance of each of the endogenous variables exceeds the cut-off point, as all the values are higher than zero.

Table 6 illustrates the effect size of the exogenous latent variables on the endogenous latent variables' F^2 value. The value of the effect size range between 0.001 and 0.506. Three variables were shown to have a medium effect size (FC→GU, CL→BI, and HB→BI), five variables were

revealed to have a small effect, three variables were shown to have a too weak effect, and two variables has a large effect (HB → GU and CL→PE).

Evaluating the model fit indices is a practical step before examining the hypothesized correlations. In general, the model fit statistics provide evidence of how well the model fits the observations from the field. Five model fit and quality indices provided by Warp-PLS were used in this study, namely the average path coefficient (APC), the average R^2 (ARS), the average block variance inflation factor (AVIF), the average full collinearity VIF (AFVIF), and the Tenenhaus GoF (GoF). Table 5 summarized the model fit and quality indices values; all the indices showed satisfactory values, demonstrating that the model fits the data well. The model's explanatory power is 0.657, which is deemed large.

The structural model results (path coefficients and p values for the model's paths) are presented in Table 7 and Figure 4. In this study, the null hypothesis is rejected (accepting the alternative hypothesis) if the p-value <0.05. The p values in this study were reported using a one-tailed test supported by Warp-PLS as it is suggested to use this type of test if the path coefficients are hypothesized to have a sign (+ or -). The data supported six hypotheses: H1, H5, H6, H10, H11, and H12 (positive and significant path). The hypotheses H2, H3, H4, H7, H8, H9, and H13 were rejected because the p values associated with these hypotheses were not statistically significant. H13 was not supported due to the negative sign of the estimated path coefficient, which is the opposite of what was assumed.

To sum up, students' behavioral intention to use GitHub was significantly influenced by performance expectancy, collaborative learning, and habit. Besides, GitHub use was influenced considerably by facilitating conditions and habit. In addition, collaborative learning significantly affects students' performance expectancy.

Table 4: Assessment of coefficient of determination and predictive relevance assessment

	PE	BI	GU
R^2	0.564	0.890	0.576
Q^2	0.572	0.583	0.673

Table 5: Model fit and quality indices

Model Indices	Value	Criterion
APC	0.234, P=0.007	Acceptable if p<0.05
ARS	0.677, P<0.001	Acceptable if p<0.05
AVIF	2.283	Acceptable if <=5, ideally <=3.3
AFVIF	3.051	Acceptable if <=5, ideally <=3.3
GoF	0.720	Small >=0.1, medium >=0.25, large >=0.36

Table 6: Effect size of path coefficients

Path	F^2	Inference*
EE → PE	0.039	EE has a small effect on PE
EE → BI	0.058	EE has a small effect on BI
PE → BI	0.292	PE has a small effect on BI
SI → BI	0.088	SI has a small effect on BI
FC → BI	0.014	FC has a too weak effect on BI
FC → GU	0.214	FC has a medium effect on GU
CL → BI	0.197	CL has a medium effect on BI
CL → PE	0.506	CL has a large effect on PE
LV → BI	0.057	LV has a small effect on BI
HM → BI	0.005	HM has a too weak effect on BI
HB → BI	0.198	HB has a medium effect on BI
HB → GU	0.363	HB has a large effect on GU
BI → GU	0.001	BI has a too weak effect on GU
***Too weak**: below 0.020; **Small**: between 0.020 and 0.150; **Medium**: between 0.150 and 0.350; **Large**: above 0.350		

Table 7: Result of path analysis

Hypothesis	Path coefficient, β	P value	Standard error	Result
H1: PE→BI	0.123	<0.001***	0.099	Supported
H2: EE→BI	0.103	0.127	0.107	Not supported
H3: EE→PE	0.390	0.127	0.108	Not supported
H4: SI→BI	0.168	0.057	0.106	Not supported
H5: CL→BI	0.029	0.004*	0.090	Supported
H6: CL→PE	0.345	<0.001***	0.102	Supported
H7: HM→BI	0.279	0.470	0.111	Not supported
H8: LV→BI	0.681	0.219	0.108	Not supported
H9: FC→BI	0.085	0.395	0.110	Not supported
H10: FC→GU	0.008	<0.001***	0.100	Supported
H11: HB→BI	0.306	0.002 *	0.101	Supported
H12: HB→GU	0.517	<0.001***	0.095	Supported
H13: BI→GU	-0.002	0.493	0.111	Not supported

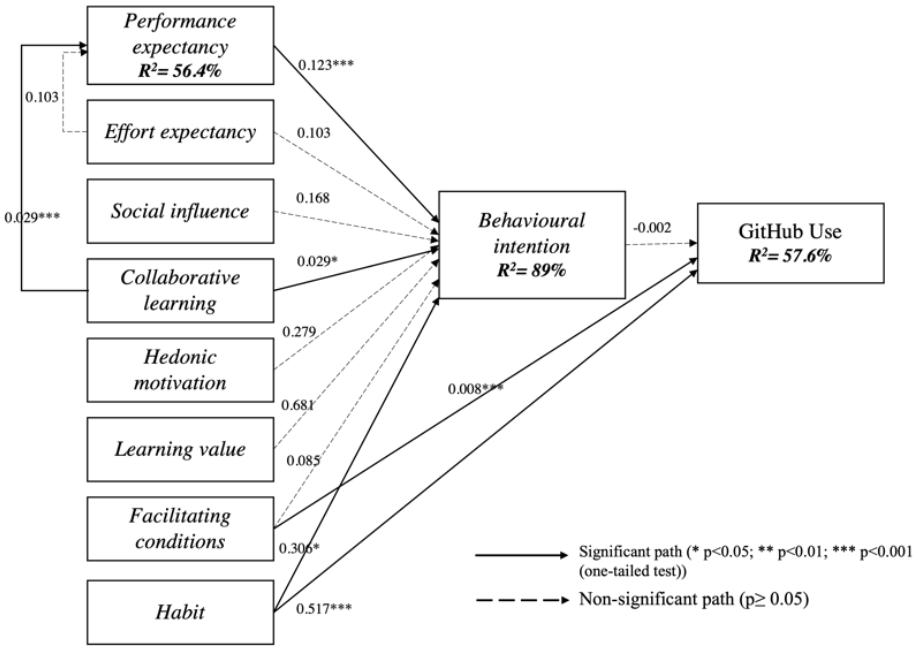

Figure 4: structural model results of the proposed model

6. Discussion

This study examines the factors that motivate students to develop positive intentions to continue using project management tools exemplified by GitHub. This study took place in Saudi Arabia and targeted university students studying in computer science departments. The UTAUT2 was adopted as a theoretical foundation. Two variables were added to the original model represented by learning value and collaborative learning influencing behavior intention of GitHub use.

The analysis of the hypothetical relation between performance expectancy and behavioral intention produced a significant result at β=0.123, p <0.001, which confirms that H1 is supported. This explains students' belief that if they find GitHub useful in performing educational activities, they will tend to use it as part of their programming-based projects. The results were consistent with previous studies, which supported performance expectancy and behavioral intention relationship in the context of LMS (Ain et al., 2016; Mzava & Kalinga, 2017; Cavus et al., 2021; Binaymin et al., 2019), Zoom (Chandradasa & Galhena, 2021), Social media App (W. M. Al-Rahmi & Zeki, 2017), and GitHub (Čižmešija et al., 2018).

Based on the result of this study, the link between effort expectancy and behavioral intention (the second hypothesis) was not supported at p=0.127. It seems possible that this result is due to the fact that students in Computer Science (CS) college do not find the ease of use is an obstacle as they are experts in using technologies, especially with the availability of resources on how to use GitHub. Therefore, students' intention to use GitHub is not affected by effort expectance. The results from Ain et al. (2016) and Čižmešija et al. (2018) were also consistent with this finding.

They reported an insignificant relationship between effort expectancy and behavioral intention while investigating e-learning and GitHub adoption.

Similarly, the analysis of the hypothetical relation between effort expectancy and performance expectancy produced an insignificant result at p=0.127, which confirms that H3 is not supported. The results were inconsistent with other TAM studies, which supported the ease of use and usefulness relationship in the context of software development tools and collaborative google Apps (Riemenschneider & Hardgrave, 2000; Cheung & Vogel, 2013). It is expected that students focus more on the usefulness and social coding feature of using GitHub. Therefore, whether using GitHub is easy PMT or not, it does not influence students' perspectives on the usefulness of GitHub in their projects.

Most of the studies (Čižmešija et al., 2018; Ain et al., 2016; Mzava & Kalinga, 2017) indicate that social influence significantly impacts the intention to use technology. On the contrary, this study did not find empirical support for this hypothesis. The possible reason for insignificant results would be that students' usage of GitHub is driven by internal rewards rather than the external pressure, like social influence, practically for using GitHub in their programming-based projects. In addition, this result can be attributed to the fact that some instructors, such as supervisors of graduation projects, may considerably force students to use GitHub for version control and continues integration, which is a mandatory approach to ensure the quality of the code (Vasilescu et al., 2015; Griffin & Seals, 2013).

Previous studies indicate that collaborative learning significantly impacts the performance expectancy of using technology in collaborative learning tools (Čižmešija et al., 2018; W. Al-Rahmi et al., 2015; Yadegaridehkordi et al., 2019). These studies reported a high degree between collaboration and perceived ease of use and usefulness. In the current study, collaborative learning significantly affected students' performance expectancy and students' behavior intention to use GitHub in future projects at $\beta=0.029$, $p<0.004$ and $\beta=0.345$, $p<0.001$, respectively. This is also relevant to a finding proffered by Zhu (2012), who stated that collaboration learning influences individual performance, enhances team performance, and increases the quality of team projects. Thus, students' perceived performance in a collaborative learning tool determines whether a collaborative PMT can be applied sustainably.

The hypothesized relationship between hedonic motivation and behavioral intention towards GitHub, H7, was insignificant at p=0.279. This result is consistent with Ain et al. (2016). Indicating that students do not perceive enjoyment when using GitHub. This insignificant relationship is because GitHub is a more task-oriented project management tool. Students usually use it for projects or coursework-related activities, e.g., reviewing code, sharing files, managing tasks, and group discussions. Obviously, these kinds of tasks are not considered enjoyable for students.

Similarly, the path analysis for hypothesis H8 revealed an insignificant relationship between learning value and behavioral intention towards GitHub at p=0.681. This result is inconsistent with the (Ain et al., 2016) study. One reason is that students mainly use GitHub for project management

and social coding rather than learning platform such as LMS. According to the demographic data, only one student uses GitHub as a learning platform.

The analysis of the hypothetical relation between a facilitating condition and GitHub use (H10) produced a significant result at $\beta=0.008$, $p<0.001$, which confirms that H10 is supported. This path is supported because several online resources and supports were available to students, influencing their use of GitHub. However, H9, which links the facilitating condition and behavior intention, is not supported. These results were consistent with Ain et al., (2016), Sulaymani et al., (2022), and Čižmešija et al., (2018). This means that the availability of facilities had no effect on students' intention to use GitHub in their future projects.

The path analysis for hypotheses H11 and H12 revealed a significant relationship between habit and behavioral intention towards GitHub, and GitHub use, at $\beta=0.306$, $p<0.002$ and $\beta=0.517$, $p<0.001$, respectively. These results were inconsistent with other studies (Ain et al., 2016; Mzava & Kalinga, 2017). This implies that students' readiness towards using GitHub is driven by their tendency or addiction. Accordingly, GitHub use and students' behavioral intention to use GitHub are strongly affected by students' self-directing behaviors to use technology. Students' self-directing perception usually builds upon previous and often successful experiences of using GitHub in their individual or team projects.

The hypothesized relationship between behavioral intention and actual use towards GitHub, H13, was not supported at $p=0.493$. It indicates that students' behavioral intention did not affect the actual use of GitHub. This means that performance expectancy, collaborative learning, and habit subsequently do not influence GitHub use. Several studies reported different results (Cheung & Vogel, 2013). One reason is that most students feel that using GitHub in programming-based projects is relatively mandatory, and they are willing to use it as required. For example, students usually use GitHub in teamwork or individual assignments to support code version control and tasks administration. Therefore, students' actual use of GitHub is not significantly affected by their behavioral intention.

7. Conclusion and Recommendation

This study examines the factors that motivate students to develop positive intentions to continue using GitHub as a project management tool in their programming-based projects. This study took place in Saudi Arabia and targeted male and female students studying in the computer science departments. The UTAUT2 was the ground of the proposed research model and extended by learning value and collaborative learning as external features influencing behavior intention of GitHub use. Previous studies have extended UTAUT and other TAM with additional constructs for e-learning. However, few researchers have attempted to understand the determinants of collaborative learning adoption by developing the model for collaborative learning environments. Researchers have not investigated students' acceptance of using project management tools in their software projects and other programming courses in much detail. Thus, this study fills the gaps in

the literature by incorporating students' perceptions regarding GitHub collaborative technologies into the empirical research model involving collaborative features.

This paper shows that the UTAUT2 can be applied to collaborative technologies for programming-based projects. This research reveals that students' behavioral intention to use GitHub was significantly influenced by performance expectancy, collaborative learning, and habit. In addition, GitHub use was influenced considerably by facilitating conditions and habit. Furthermore, collaborative learning has a significant impact on performance expectancy. This result supports several studies that reported collaborative learning significantly impacts students' performance. On the other hand, in the current study, behavioral intention to use GitHub was insignificantly influenced by learning value.

Utilizing GitHub in education is still relatively new, but it has excellent potential for future applications to support the e-learning process. University instructors are recommended to enhance students' understanding of the cloud-based project management tools, such as incorporating GitHub with LMS, conducting tutorial sessions, and encouraging students and instructors to adopt those tools effectively. For future studies, introducing additional constructs may enhance understanding the adoption process of these technologies. In addition, Machine Learning classification algorithms, such as decision tree, Neural Network, and Bayesian networks, will be applied to predict the relationships among the theoretical model's constructs. Moreover, to better understand students' intention to use GitHub, an explanatory research method can be applied to explore students' experience, benefits of using such tool in education and programming projects, challenges of using GitHub, and what type of GitHub features are primarily used by students.

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Appendix A

Table 8: Scale adaptation

Performance Expectancy, (Venkatesh et al., 2012) and (Ain et al., 2016)		
1	PE (1)	I find GitHub useful for my projects.
2	PE (2)	GitHub enhances the quality of my work.
3	PE (3)	GitHub increases my learning productivity.
Effort Expectancy, (Venkatesh et al., 2012)		
4	EE (1)	Learning how to use GitHub tool is easy for me.
5	EE (2)	My interaction with GitHub is clear and understandable.
6	EE (3)	GitHub is easy to use.
Social Influence, (Venkatesh et al., 2012)		
7	SI (1)	My peers who influence my behavior think that I should use GitHub.
8	SI (2)	My friends who are important to me think that I should use GitHub.
9	SI (3)	My instructors, whose opinions that I value, prefer that I should use GitHub.
Facilitating Conditions, (Ain et al., 2016)		
10	FC (1)	I have resources to use GitHub.
11	FC (2)	I have knowledge to use GitHub
12	FC (3)	A specific person (or group) is available to assist when difficulties arise with GitHub
Behavioral Intention, (Venkatesh et al., 2012) and (Paola Torres Maldonado et al., 2011)		
13	BI (1)	I intend to continue using GitHub.
14	BI (2)	For my study, I would use GitHub.
15	BI (3)	I will continue to use GitHub on a regular basis.
GitHub Use, (Ain et al., 2016)		
16	GU (1)	I use GitHub frequently during my academic studying period.
17	GU (2)	I use many functions of GitHub (e.g., bug track, collaborative coding, and project management)
18	GU (3)	I depend on GitHub.
Collaborative Learning, (Yadegaridehkordi et al., 2019)		
19	CL (1)	GitHub helps me to communicate effectively with my team members.
20	CL (2)	GitHub enables me to share knowledge and understanding with my team effectively.
21	CL (3)	In GitHub, I am satisfied with active collaboration in my project.
Learning Value, adopted from (Ain et al., 2016)		
22	LV (1)	GitHub gives me the opportunity to increase my knowledge and control my success.
23	LV (2)	In less time, GitHub allows me to share my knowledge quickly and easily with others (e.g., feedback, wikis, etc.)
24	LV (3)	Managing projects in GitHub is a valuable experience.
25	LV (4)	Learning through GitHub is worth more than the time and effort were given to it.
26	LV (5)	GitHub gives me the opportunity to decide about the pace of my own learning.
Hedonic Motivation, (Venkatesh et al., 2012)		
27	HM (1)	I feel fun using GitHub.
28	HM (2)	I enjoy using GitHub.
29	HM (3)	Using GitHub is very entertaining
Habit, (Venkatesh et al., 2012)		
30	HB (1)	The use of GitHub has become a habit for me
31	HB (2)	I am addicted to using GitHub to accomplish my project tasks
32	HB (3)	I must use GitHub for my projects