

Validating the Extended Technology Acceptance Model through Exploratory Factor Analysis (EFA): The Role of Educational Support in Online Homework Systems for Gateway Courses at Community Colleges

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Abstract: Gateway math courses at community colleges increasingly rely on online homework platforms to support practice, feedback, and assessment, yet many students continue to experience challenges adopting these systems effectively. Accordingly, the present study examined an extended version of the Technology Acceptance Model (TAM) that incorporates Educational Support (EdS) alongside Perceived Usefulness (PU) and Perceived Ease of Use (PEU) to better capture contextual and instructional influences on technology acceptance. Moreover, survey data from approximately 200 students enrolled in gateway math courses across multiple modalities were analyzed using exploratory factor analysis (EFA) to examine the underlying factor-structure of the instrument. Results supported a stable three-factor solution corresponding to PU, PEU, and EdS, with strong item loadings and acceptable internal consistency across all constructs. Consequently, findings provide empirical support for extending TAM to include educational support in math coursework and establish a foundation for subsequent confirmatory factor analysis (CFA) and model validation in learning environments at community colleges.

Keywords: Technology Acceptance Model, Computer Attitude Questionnaire, Mathematics Education, Community Colleges, Exploratory Factor Analysis, Online Learning

Introduction

Online technologies are changing how students practice and complete coursework in gateway math classes at community colleges. As a result, online platforms have become key spaces for engagement, feedback, and assessment across different teaching methods (Davis, 1989; Zogheib et al., 2015). Building on this context, the Technology Acceptance Model (TAM) is often used to understand how students view and use educational technologies in higher education, focusing on perceived usefulness and ease of use (Davis, 1989; Noh et al., 2021). Nevertheless, recent research suggests that these TAM constructs may not fully capture the instructional and contextual supports that shape students' experiences in first-year math classes, particularly within the diverse populations of community colleges (Albelbisi et al., 2024; Mailizar et al., 2021). To address these limits, extending the TAM model is often examined using Exploratory Factor Analysis, which enables researchers to identify underlying factor structures in student responses without strict assumptions during early model development (Comrey & Lee, 2013; MacCallum et al., 1999; Türkyılmaz, 2023; Yunus et al., 2022).

Purpose

The purpose of this study is to examine the factor structure of an extended TAM model within gateway math courses at community colleges through the use of the Exploratory Factor Analysis (EFA), an approach that supports early-stage model development by identifying meaningful patterns among observed variables (Comrey & Lee, 2013; MacCallum et al., 1999). Moreover, the study focuses on students' perceptions of perceived usefulness (PU) and perceived ease of use (PEU) alongside instructional and contextual support dimensions (EdS), an extension that responds to prior research calling for broader representations of technology acceptance in educational settings (Davis, 1989; Mailizar et al., 2021; Türkyılmaz, 2023). Consequently, results from this exploratory phase aim to clarify construct reliability and conceptual alignment to inform future confirmatory factor analyses (CFA) involving student technology use in first-year math classes across all modalities at community colleges (Comrey & Lee, 2013; DeVellis, 2016; Noh et al., 2021).

Research Questions

RQ1: How well do the items in the extended Technology Acceptance Model (TAM) align with the three underlying constructs, Perceived Usefulness (PU), Perceived Ease of Use (PEU), and Educational Support (EdS), as identified through exploratory factor analysis?

RQ2: What are the internal consistency reliability levels for PU, PEU, and EdS, as measured by Cronbach's alpha, among students enrolled in gateway mathematics courses at a community college?

RQ3: How do the factors of usefulness, ease of use, and educational support collectively define students' acceptance of online homework systems in community college math courses as revealed through exploratory factor analysis?

Literature Review

Studies on technology in education emphasize how learners' beliefs shape technology adoption and persistence (Davis, 1989; Mailizar et al., 2021). TAM links perceived usefulness (PU) and ease of use (PEU) to engagement with online platforms, especially where practice and feedback are important (Çelik & Yeşilyurt, 2013; Noh et al., 2021; Sallam et al., 2023). In gateway math and other skill-based courses, perceived usefulness and manageability lead to stronger engagement, particularly in online or blended formats (Han & Sa, 2022; Zogheib et al., 2015).

Recent TAM extensions stress the role of contextual and instructional supports, such as resources, instructional clarity, and guidance (Mailizar et al., 2021; Türkyılmaz, 2023). Validation studies using factor analysis show that extended TAMs better reflect learner experiences in demanding settings (Abd-El-Fattah, 2010; Brown, 2015; Kline, 2023). EFA is a widely recommended first step for scale alignment when adapting TAM to new educational populations or contexts (Comrey & Lee, 2013; DeVellis, 2016; Watkins, 2021).

Despite these advances, notable gaps remain in literature. Specifically, existing TAM and extended TAM studies have predominantly focused on university populations or modalities of choice, with limited attention given to math classes at community colleges, particularly gateway courses offered across face-to-face, hybrid, and online formats (Davis, 1989; Mailizar et al., 2021; Noh et al., 2021; Zogheib et al., 2015). Additionally, few studies have examined whether extended TAM constructs demonstrate stable factor structures within these settings, where students often rely heavily on instructional platforms as the primary means of engagement and practice (Davis, 1989; Kline, 2023; Mailizar et al., 2021). Accordingly, the present study addresses this gap by using EFA to examine the structure of an extended TAM framework within first-year math classes at community colleges across all instructional modalities, thereby contributing empirical evidence to an underexplored yet necessary educational setting.

Methods

The study received IRB approval from a local community college and followed ethical guidelines to make sure participation was voluntary, and data stayed anonymous (DeVellis, 2016). Moreover, data were collected from students in first-year math courses across all modalities to better represent different student experiences at community colleges (Comrey & Lee, 2013; Zogheib et al., 2015). Furthermore, a sample of 200 students was used to run an EFA with SPSS, looking at how survey items matched up with the main ideas of PU, PEU, and EdS in the extended TAM Model (Davis, 1989; Watkins, 2021).

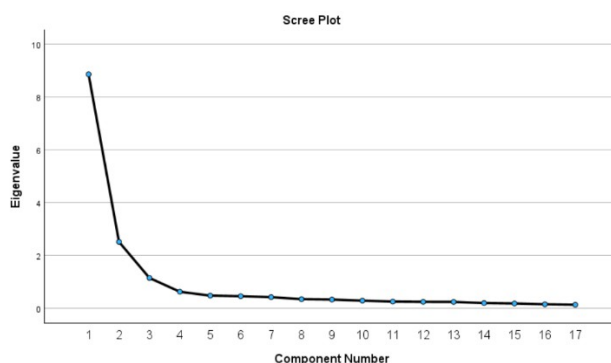
Students who participated in the survey reflected a typical group found in first-year math classes at community colleges. Most participants were between the ages of 25 and 34 years ($n = 160$, 80.0%). Other age groups included 35–44 years ($n = 31$, 15.5%), 45–54 years ($n = 7$, 3.5%), 55–64 years ($n = 1$, 0.5%), and 65 years or older ($n = 1$, 0.5%). In terms of gender, 118 participants identified as male (59.0%) and 77 identified as female (38.5%). Students in the study were also enrolled in different course formats, including face-to-face classes ($n = 101$, 50.5%), online classes ($n = 86$, 43.0%), and hybrid classes that combined face-to-face and online instruction ($n = 13$, 6.5%). Hence, the demographic information provides context for interpreting the reliability checks and factor analysis used to evaluate the survey instrument.

Additionally, internal consistency was checked using Cronbach's alpha to confirm the reliability of the scales before interpreting the factors, as recommended for early validation (DeVellis, 2016). Hence, factor retention and interpretation followed established research criteria, including factor loadings, theoretical fit, and previous TAM validation studies, to make sure the results reflected students' real experiences with instructional platforms in gateway math courses (Brown, 2015; Kline, 2023). For completeness, a full list of the surveys used is provided in Appendix A.

Results

Sampling adequacy and factorability were examined to determine the suitability of the dataset for EFA, and the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was .935, indicating excellent overall suitability for factor extraction, and Bartlett's Test of Sphericity was statistically significant, $\chi^2(136) = 2702.12$, $p < .001$, confirming that item correlations were sufficiently large for factor analysis (DeVellis, 2016; Nchindo, 2019). Next, an EFA using principal component extraction with varimax rotation was conducted to examine the underlying structure of the extended TAM instrument. Moreover, eigenvalues greater than 1 and inspection of the scree plot supported a three-factor solution, with the first three components accounting for 73.79% of the total variance. Specifically, the first component explained 52.16% of the variance, the second component explained 14.83%, and the third component explained 6.80%, indicating a strong and interpretable structure consistent with extended TAM measurement models (Davis, 1989; DeVellis, 2016), as shown in Figure 1.

Figure 1. Scree Plot for Exploratory Factor Analysis of Extended TAM Instrument



Note. Eigenvalues are plotted across extracted components using principal component analysis. The inflection point supports retention of a three-factor solution (DeVellis, 2016).

Finally, the rotated component matrix revealed a clear and theoretically coherent pattern of item loadings, where PU items loaded strongly on the first factor, PEU items loaded on the second factor, and items associated with Facilitating Conditions (FC) and Behavioral Intention (BI) clustered together on the third factor, forming an

Educational Support (EdS) construct. Cross-loadings were minimal, and all retained items exceeded recommended loading thresholds, while communalities ranged from .603 to .845, indicating adequate shared variance among observed variables. Collectively, these results support the structural validity of the extended TAM framework and provide empirical justification for retaining three distinct but related constructs within the proposed measurement model, as illustrated in Figure 2.

Figure 2. Rotated Component Matrix for Extended TAM Constructs

Rotated Component Matrix ^a			
	Component		
	1	2	3
TAM13_PU	.875		
TAM11_PU	.858		
TAM12_PU	.841		
TAM14_PU	.820		
TAM15_PU	.802		
TAM10_PU	.787		
TAM21_PEU		.807	
TAM20_PEU		.806	
TAM18_PEU		.778	
TAM16_PEU		.778	
TAM19_PEU		.748	
TAM17_PEU		.710	
TAM27_FC			.812
TAM24_FC			.786
TAM25_FC			.765
TAM26_FC			.660
TAM29_BI			.636

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization. ^a

a. Rotation converged in 5 iterations.

Note. Values represent rotated factor loadings obtained using principal component analysis with varimax rotation. Loadings below .40 are suppressed for interpretive clarity (DeVellis, 2016; Nchindo, 2019).

Discussion

The results from the EFA analysis support a stable three-factor structure aligned with the extended TAM Model, highlighting PU, PEU, and EdS as distinct yet related dimensions shaping students' acceptance of online homework systems in gateway math courses across all modalities at community colleges (Davis, 1989; Çelik & Yeşilyurt, 2013; Zogheib et al., 2015). Additionally, strong item loadings within the PU and PEU factors reinforce prior findings that students' cognitive evaluations of value and usability remain central to technology acceptance in learning environments in math coursework in higher education (Davis, 1989; O'Dell & Sulastris, 2019). Consequently, the formation of the EdS construct, composed of FC and BI items, emphasizes the importance of instructional and environmental supports in sustaining engagement and consistent system use, particularly in math courses where structured practice and feedback are essential (Noh et al., 2021; Türkyılmaz, 2023). Hence, these findings extend prior TAM-based research by demonstrating that acceptance in gateway math courses at community colleges reflects not only perceptions of usefulness and ease of use, but also the availability of support structures that help students persist across all modalities (Çelik & Yeşilyurt, 2013; Zogheib et al., 2015).

Limitations

Several limitations should be considered when interpreting these findings. The study relied on an instrument survey where data collection took place from a local community college, which may limit generalizability to other institutional settings or student populations at other community colleges (DeVellis, 2016; Watkins, 2021).

Conclusion

Finally, the present study provides empirical support for an extended Technology Acceptance Model that captures students' perceptions of usefulness, ease of use, and educational support when engaging with online homework systems in gateway math courses at community colleges (Davis, 1989; Zogheib et al., 2015). Moreover, the validated factor structure underscores that technology acceptance in mathematics learning environments depends on both cognitive evaluations and contextual supports that help students navigate instructional platforms across different modalities (O'Dell & Sulastri, 2019; Noh et al., 2021). Consequently, these findings offer a foundation for future confirmatory factor analyses and for designing instructional practices that strengthen support structures alongside usability and perceived value in gateway math classes at community colleges (Çelik & Yeşilyurt, 2013; Türkylmaz, 2023).

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Appendix A

Technology Acceptance Model (TAM) Survey Items

Participants responded to the following items using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Additionally, the term “*educational math tools*” refer to online homework systems such as MyLabMath, WebAssign, ALEKS, Connect, and MyOpenMath.

Perceived Usefulness (PU)

1. Using educational math tools in my math class would enable me to complete assignments more quickly.
2. Using educational math tools would improve my performance in this course.
3. Using educational math tools in my math class would increase my productivity.
4. Using educational math tools would enhance my effectiveness in this course.
5. Using educational math tools would make it easier to succeed in my math class.
6. I would find educational math tools useful for my studies.

Perceived Ease of Use (PEU)

7. Learning to operate educational math tools would be easy for me.
8. I would find it easy to get educational math tools to do what I need in my math class.
9. My interaction with educational math tools would be clear and understandable.
10. I would find educational math tools clear and understandable.
11. It would be easy for me to become skillful at using educational math tools.
12. I would find educational math tools easy to use.

Social Influence (SI)

13. In my math class, my instructor encourages the use of educational math tools.
14. Using educational math tools helps me stay engaged and motivated in my coursework.

Facilitating Conditions / Educational Support (EdS)

15. I have the resources necessary to use educational math tools.
16. I have access to the technical support I need to use educational math tools.
17. Educational math tools are compatible with other resources I use for my studies.
18. The use of educational math tools is supported by my instructor or school.

Behavioral Intention to Use (BI)

19. I intend to continue using educational math tools in the future.
20. I will use educational math tools regularly for my assignments.
21. I will recommend the use of educational math tools to others.