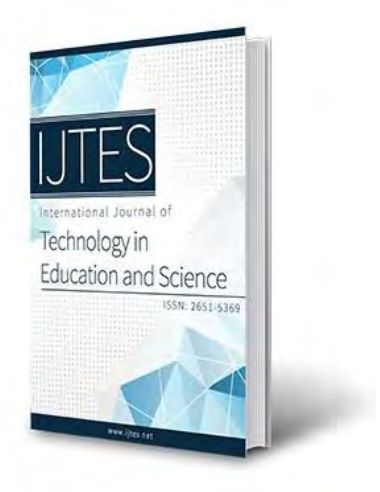

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Revisiting Unified Theory of Technology and Use of Technology Using Meta-analytic Structural Equation Modelling

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Abstract

The Unified Theory of Technology and Use of Technology (UTAUT) has been widely used in information system studies since its introduction in 2003. The current study synthesizes 40 empirical studies based on UTAUT in educational contexts using the one-stage meta-analytic structural equation modelling method. While the study confirmed the initial findings by Ventakesh et al. (2003), the model in this study underperformed in the explained variance of behavioral intention. However, the explained variance of usage behavior performed better than the original UTAUT. After introducing new direct relationships between the UTAUT constructs, it was found that the construct, facilitating conditions, was a new predictor of behavioral intention. At the same time, effort expectancy and social influence were new predictors of usage behavior. There have been studies on the UTAUT model with many diverse findings since its inception in 2003. The method introduced in this study, a One-Stage combined Meta-Analysis and Structural Equation Modelling (OSMASEM), offers an approach for researchers to use past empirical data to examine the UTAUT framework without relying on replicating similar studies. As more empirical data from UTAUT research are added to train the data model using OSMASEM, researchers can now study how educational technology trends change over time.

Introduction

The Unified Theory of Technology and Use of Technology (UTAUT) (Venkatesh et al., 2003) was introduced 20 years ago and has been used extensively in information system studies. Venkatesh et al. (2016) then reviewed the related UTAUT literature between September 2003 and December 2014 to understand the developments in research on technology acceptance and use. Their paper organized the existing UTAUT extensions into four categories: exogenous mechanisms, endogenous mechanisms, moderation mechanisms, and outcome mechanisms. At the same time, the researchers analyzed the amassed literature using Weber's (2012) framework of theory evaluation. Venkatesh et al. (2013) further analyzed the amassed literature based on the cross-context theorizing concept (Whetten, 2009). The results of their theoretical analysis were integrated into a multi-level framework with eight dimensions of the technology acceptance contexts. The researchers synthesized the UTAUT extensions within the framework and highlighted future research directions that involved identifying new context effects and specifying contextual moderation. The eight dimensions are: (1) user class, who are the individuals who use technologies to assist them in performing their tasks (Burton-Jones & Straub, 2006; Goodhue & Thompson, 1995); (2) technology class, the IT artifact that individual users use in carrying out their tasks (Burton-Jones & Straub, 2006; Goodhue & Thompson, 1995); (3) task class, which are the goal-oriented processes and tasks supported by the target technology in turning inputs into outputs (Burton-Jones & Straub, 2006; Goodhue & Thompson, 1995); (4) time or event class, that includes the time relative to the implementation or introduction of the target technology (Jasperson et al., 2005); (5) organization class, which referred to the social context of technology acceptance and use (i.e., team, unit, division, organization, user community and informal social network) (Jasperson et al., 2005); (6) location class, which is the location where the target technology is implemented, introduced, adopted or used; (7) environment class, referred to as the physical environment and conditions in which the target technology is used; and (8) rationale class, the rationale for conducting the research or collecting research data. Ventakesh suggested that researchers could synthesize existing UTAUT research within the eight classes of technology acceptance and use research contexts, which in the case of this study, lies in the user class in the educational contexts.

Unified Theory of Acceptance and Use of Technology Model

Venkatesh et al. (2003) consolidated various previous technology acceptance theories (Davis, 1989, Taylor & Todd, 1995) and models (Ajzen, 1991; Compeau et al., 1999; Fishbein & Ajzen, 1975; Moore & Benbasat, 1991; Thompson et al., 1991) and proposed UTAUT. In the UTAUT, four constructs play a significant role as direct determinants of user acceptance and UB: (1) performance expectancy (PE), (2) effort expectancy (EE), (3) social influence (SI); and (4) facilitating conditions (FC). In the UTAUT, attitude toward using technology, self-efficacy and anxiety are not direct determinants of behavioral intentions (BI). A diagrammatic representation of the UTAUT model is shown in Figure 1.

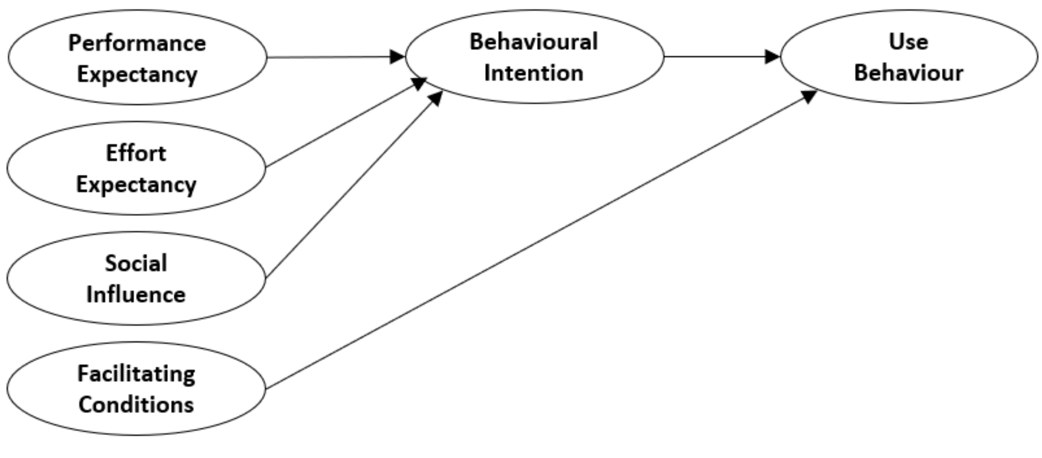

Figure 1. Unified Theory of Acceptance and Use of Technology
Note: Adapted from Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly, 425-478.

In the UTAUT, PE is the extent an individual believes that using a system will benefit him or her in terms of job performance. EE is the ease with which users can adopt the system (Venkatesh et al., 2003). SI is the extent an individual perceives that 'important others' consider that he or she should use the system (Venkatesh et al., 2003). FC is the extent an individual believes that there is an existing organizational and technical infrastructure to support the system's users (Venkatesh et al., 2003). BI is the individual's intention to use the technology.

With respect to the importance of these factors for predicting BI and UB, PE, EE, and SI are all proposed to be predictors of BI, and via BI as a mediator, of UB. Conversely, FC is not theorized to operate via BI but more directly on UB unless other predictors in the model are not present. Specifically, Venkatesh et al. (2003) pointed out that if EE is not included as a predictor of BI, FC will act as a significant predictor of BI. However, in the presence of both PE and EE, FC will not be a significant predictor of BI.

Meta-analysis of UTAUT

While the UTAUT model is used extensively in the information system field, this paper aims to examine the use of UTAUT in educational contexts. Many researchers have attempted to examine UTAUT through meta-analysis (Dwivedi et al., 2011; Dwivedi et al., 2020; Hwang & Lee, 2018; Khechine et al., 2016). For instance, Khechine et al. (2016) conducted a meta-analysis of empirical studies on UTAUT from 2003 to 2013 to determine how parsimonious, accurate, and robust UTAUT was at predicting acceptance and use of technology. In another meta-analysis study, Dwivedi et al. (2011) conducted a detailed examination of UTAUT with 43 research articles. The researchers found that only a small proportion of citations utilized the UTAUT theory or its constructs in their empirical research to examine information system and technology-related issues. In order to examine whether UTAUT was performing consistently well across various studies, the researchers conducted a statistical meta-analysis of findings reported in the 43 published studies that utilized the UTAUT theory or its constructs in their empirical research. It was revealed that the UTAUT underperformed in subsequent studies compared to the original model by Ventakesh et al. (2003). Dwivedi et al. (2020) performed a citation analysis and review of articles that cited UTAUT. The findings showed that the largest category of studies selected constructs similar to UTAUT and cited the theory to support the proposed casual relationships. The second largest category comprised studies that cited UTAUT in their literature review and theoretical background sections. The third largest category involved the studies where UTAUT was cited while discussing the evolution of technology adoption.

Meta-analytic Structural Equation Modelling

Recent research utilized a combined meta-analysis and structural equation modelling method to study UTAUT. For example, Dwivedi et al. (2019) proposed a revised theoretical UTAUT model with an additional construct, attitude. The study empirically examined UTAUT using a combined meta-analysis and structural equation modelling (MASEM) approach based on 1600 observations on 21 relationships from 162 prior studies on information systems and technology acceptance and use. MASEM has been increasingly applied to advance theories by synthesizing past study findings in recent years. The MASEM approach consists of two stages. In Stage 1, a pooled correlation matrix is estimated based on the reported correlation coefficients in the individual studies. In Stage 2, a structural model, such as a path model, is fitted to explain the pooled correlations. Tang and

Cheung (2016) demonstrated that researchers could benefit from MASEM by introducing a two-stage meta-analytic structural equation modelling (TSSEM) and comparing it with a conventional approach: the univariate-r approach. The illustration and comparison of MASEM with the conventional method showed that the TSSEM was a practical approach. However, there was a common challenge: not all the individual studies provided the correlation coefficients between the variables. Jak and Cheung (2018) modified the MASEM method to address the missing correlation coefficients and compare its performance with the current structural equation modelling methods. Their study was the first to examine the performance of fixed-effects MASEM methods under different levels of missing correlation coefficients.

Jak et al. (2021) introduced a one-stage MASEM (OSMASEM) built on foundations from R using its metaSEM and semPlot packages. The OSMASEM is a random-effects technique, meaning that it is assumed that each study has its own specific population correlation matrix. The differences between the population correlation matrices are modelled by estimating a matrix with between-study variances and covariances. As OSMASEM is based on the average correlation matrix across studies, it does not require estimating a pooled correlation matrix as an intermediate step. Rather, it restricts the pooled correlations in the multivariate meta-analysis to the model-implied correlations given by the specified structural equation modelling utilizing regression weights and covariances. In this way, OSMASEM can directly estimate the SEM parameters without having to estimate the pooled correlations first. Although OSMASEM and TSSEM result in highly comparable results (Jak & Cheung, 2022), OSMASEM is comparatively more versatile and can also include study-level moderators for each SEM parameter.

According to Jak et al. (2021), there were studies missing correlations on the variable level; some studies may not report all correlations between the included variables, leading to missing data on the correlation level. For instance, a study may report the correlations between predictor variables and an outcome variable but not between the predictor variables themselves. Both cases, on the variable and correlation levels, are technically not a problem for OSMASEM to be applied. In many UTAUT studies, researchers adapted the original UTAUT by omitting some constructs. UB and FC are the constructs that were often dropped from the researchers' theoretical frameworks (Abu-Al-Aish & Love, 2013; Adel Ali & Rafie Mohd Arshad, 2018; Almutairy, 2022; Alyoussef, 2021; Andrews et al., 2021; Arumugam et al., 2014; Buabeng-Andoh & Baah, 2020; Čižmešija, 2018; Ho et al., 2016; Khechine & Lakhal, 2018; Kissi et al., 2018; Marandu et al., 2022; Mikalef et al., 2016; Padhi, 2018; Park & Lee, 2021; Raman et al., 2014; Sidik & Syafar, 2020; Teo & Noyes, 2014; Thongsri et al., 2018; Thongsri et al., 2019; Wan et al., 2020; Wong et al., 2013). Therefore, OMASEM is suitable for examining meta-analysis of existing UTAUT studies.

The Current UTAUT Study using OSMASEM

The current study synthesizes the existing empirical research on the UTAUT in educational contexts. It capitalized on the potential of synthesizing correlation matrices with the help of correlation-based OSMASEM (Jak et al., 2021). The current meta-analysis will address the following research questions:

1. To what extent do pooled correlation matrix relationships among the constructs show significant variations from the past UTAUT empirical studies using the OSMASEM approach?

2. To what extent does the UTAUT fit the data from a pooled correlation matrix using the OSMASEM?
3. Are there other direct relationships among the UTAUT constructs discovered using the OSMASEM?

Method

Literature Search and Screening Procedures

The Google Scholar database was searched to identify the relevant literature to the current UTAUT study. The following search terms and Boolean operators were used, "UTAUT" AND "education". The other advanced search settings were included "anywhere in the articles" and "return articles dated between 2013 and 2022." After the search, an initial screening of the identified 17,700 studies was performed according to the following criteria: (1) the studies must address school or university's technology acceptance; (2) the studies must describe the relationships between the UTAUT constructs; and (3) the studies must analyze, report and discuss the findings in English. The initial screening resulted in 88 eligible empirical studies. Some studies were then excluded by applying the following criteria: (1) the studies did not target teachers, lecturers, educators or students in K-12, college or university education; (2) the studies were not based on the original UTAUT model but UTAUT2 or UTAUT3 models; and (3) the studies had insufficient statistical reporting of the correlations between UTAUT constructs. Figure 2 summarizes the results of the literature search and screening procedures. Table 1 lists the various research from which the data is used in this OSMASEM study.

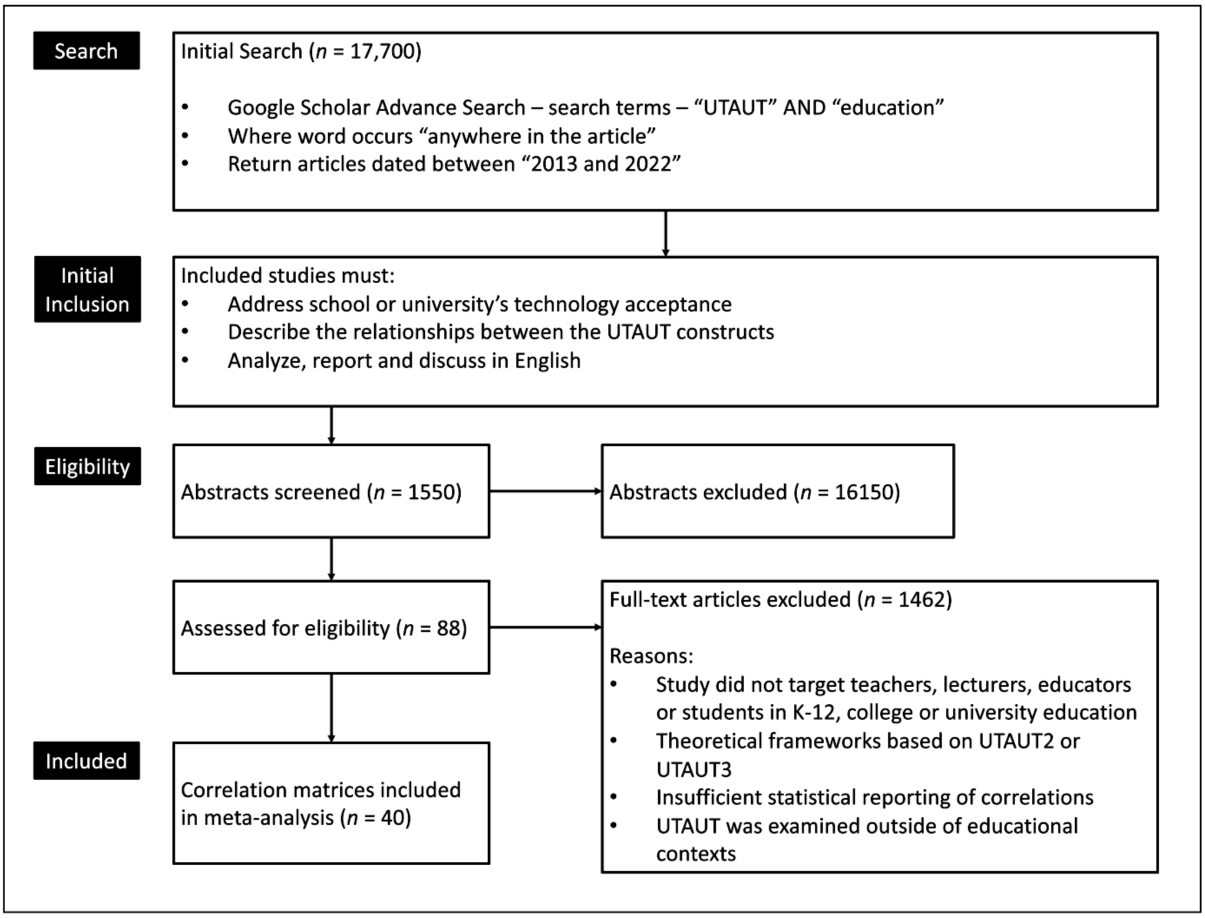

Figure 2. Diagram describing the Literature Search and the Selection of Eligible Studies for Meta-analysis

Table 1. Research Studies from which Data are used

S/N	Technology / System	Sample Size	UTAUT Constructs	Study
1	Artificial Intelligence	236	PE; EE; SI; BI	Andrews, J. E., Ward, H., & Yoon, J. (2021). UTAUT as a model for understanding intention to adopt AI and related technologies among librarians. *The Journal of Academic Librarianship, 47*(6), 102437.
2	Blend Learning	201	PE; EE; SI; FC; BI; UB	Sarkam, N. A. (2019). Factors Affecting Levels of Acceptance of Academicians in Using Blended Learning (BL) System in Teaching by Using Extended Model of UTAUT. *Management Academic Research Society.*
3	e-learning	307	PE; EE; SI; BI	Thongsri, N., Shen, L., & Bao, Y. (2019). Investigating factors affecting learner's perception toward online learning: evidence from ClassStart application in Thailand. *Behavior & Information Technology, 38*(12), 1243-1258.
4	e-learning	176	PE; EE; SI; FC; BI; UB	Tan, P. J. B. (2013). Applying the UTAUT to understand factors affecting the use of English e-learning websites in Taiwan. *Sage Open, 3*(4), 2158244013503837.
5	e-learning	574	PE; EE; SI; FC; BI; UB	Odegbesan, O. A., Ayo, C., Oni, A. A., Tomilayo, F. A., Gift, O. C., & Nnaemeka, E. U. (2019, August). The prospects of adopting e-learning in the Nigerian education system: a case study of Covenant University. *In Journal of Physics: Conference Series* (Vol. 1299, No. 1, p. 012058). IOP Publishing.
6	e-learning	1627	PE; EE; SI; FC; BI; UB	Samat, M. F., Awang, N. A., Hussin, S. N. A., & Nawi, F. A. M. (2020). Online Distance Learning amidst COVID-19 Pandemic among University Students: A Practicality of Partial Least Squares Structural Equation Modelling Approach. *Asian Journal of University Education, 16*(3), 220-233.
7	e-learning	370	PE; EE; SI; FC; BI; UB	Abbad, M. M. (2021). Using the UTAUT model to understand students' usage of e-learning systems in developing countries. *Education and Information Technologies, 26*(6), 7205-7224.
8	e-learning	300	PE; EE; SI; BI	Park, M.J. & Lee, J.K. (2021). Investigation of college students' intention to accept online education services: An application of the UTAUT model in Korea. *The Journal of Asian Finance, Economics and Business, 8*(6), 327-336.
9	e-learning	509	PE; EE; SI; FC; BI	Marandu, E. E., Mathew, I. R., Svotwa, T. D., Machera, R. P., & Jaiyeoba, O. (2022). Predicting students' intention to continue online learning post-COVID-19 pandemic: extension of the unified theory of acceptance and usage technology. *Journal of Applied Research in Higher Education*, (ahead-of-print).
10	Github Software	78	PE; EE; SI; FC; BI	Čižmešija, A., Stapić, Z., & Bubaš, G. (2018). Using Github in software engineering course: Analysis of student's acceptance

S/N	Technology / System	Sample Size	UTAUT Constructs	Study
				of collaborative coding platform. *In presented at the 11th annual International Conference of Education, Research and Innovation* (pp. 5857-5866).
11	ICT-based instruction	305	PE; EE; SI; FC; BI; UB	Kim, J., & Lee, K. S. S. (2020). Conceptual model to predict Filipino teachers' adoption of ICT-based instruction in class: using the UTAUT model. *Asia Pacific Journal of Education*, 1-15.
12	Interactive Whiteboards	149	PE; EE; SI; FC; BI	Wong, K. T., Teo, T., & Russo, S. (2013). Interactive whiteboard acceptance: Applicability of the UTAUT model to student teachers. *The Asia-Pacific Education Researcher, 22*(1), 1-10.
13	Interactive Whiteboards	438	PE; EE; SI; FC; BI; UB	Šumak, B., & Šorgo, A. (2016). The acceptance and use of interactive whiteboards among teachers: Differences in UTAUT determinants between pre-and post-adopters. *Computers in Human Behavior, 64*, 602-620.
14	Interactive Whiteboards	460	PE; EE; SI; FC; BI; UB	Šumak, B., & Šorgo, A. (2016). The acceptance and use of interactive whiteboards among teachers: Differences in UTAUT determinants between pre-and post-adopters. *Computers in Human Behavior, 64*, 602-620.
15	Learning Management System	65	PE; EE; SI; FC; BI	Raman, A., Don, Y., Khalid, R., & Rizuan, M. (2014). Usage of learning management system (Moodle) among postgraduate students: UTAUT model. *Asian Social Science, 10*(14), 186-192.
16	Learning Management System	267	PE; EE; SI; FC; BI; UB	Bervell, B., & Umar, I. N. (2017). Validation of the UTAUT model: Re-considering non-linear relationships of Exogeneous variables in higher education technology acceptance research. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(10), 6471-6490.
17	Learning Management System	361	PE; EE; SI; FC; BI	Buabeng-Andoh, C., & Baah, C. (2020). Pre-service teachers' intention to use learning management system: an integration of UTAUT and TAM. *Interactive Technology and Smart Education*.
18	Learning Management System	1875	PE; EE; SI; FC; BI; UB	Ahmed, R. R., Štreimikienė, D., & Štreimikis, J. (2022). The extended UTAUT model and learning management system during COVID-19: evidence from PLS-SEM and conditional process modeling. *Journal of Business Economics and Management, 23*(1), 82-104.
19	Learning Management System	277	PE; EE; SI; FC; BI; UB	Al-Mamary, Y. H. S. (2022). Understanding the use of learning management systems by undergraduate university students using the UTAUT model: Credible evidence from Saudi Arabia. *International Journal of Information Management Data Insights, 2*(2), 100092.

S/N	Technology / System	Sample Size	UTAUT Constructs	Study
20	Mobile learning	174	PE; EE; BI	Abu-Al-Aish, A., & Love, S. (2013). Factors influencing students' acceptance of m-learning: an investigation in higher education. *The International Review of Research in Open and Distributed Learning, 14*(5).
21	Mobile learning	386	PE; EE; SI; FC; BI	Adel Ali, R., & Rafie Mohd Arshad, M. (2018). Empirical analysis on factors impacting on intention to use m-learning in basic education in Egypt. *International Review of Research in Open and Distributed Learning, 19*(2).
22	Mobile learning	359	PE; EE; SI; BI	Thongsri, N., Shen, L., Bao, Y., & Alharbi, I. M. (2018). Integrating UTAUT and UGT to explain behavioral intention to use M-learning. *Journal of Systems and Information Technology*.
23	Mobile learning	1265	PE; EE; SI; FC; BI; UB	Almaiah, M. A., Alamri, M. M., & Al-Rahmi, W. (2019). Applying the UTAUT model to explain the students' acceptance of mobile learning system in higher education. *IEEE Access, 7*, 174673-174686.
24	Mobile learning	284	PE; EE; BI	Sidik, D., & Syafar, F. (2020). Exploring the factors influencing student's intention to use mobile learning in Indonesia higher education. *Education and Information Technologies, 25*(6), 4781-4796.
25	Mobile learning	200	PE; EE; FC; BI	Alowayr, A. (2021). Determinants of mobile learning adoption: Extending the unified theory of acceptance and use of technology (UTAUT). *The International Journal of Information and Learning Technology*.
26	Mobile learning	362	PE; EE; SI	Alyoussef, I. Y. (2021). Factors Influencing Students' Acceptance of M-Learning in Higher Education: An Application and Extension of the UTAUT Model. *Electronics, 10*(24), 3171.
27	Mobile learning	342	PE; EE; SI; FC; BI; UB	Al Arif, T. Z. Z., Sulistiyo, U., Handayani, R., Junining, E., & Yunus, M. (2022). A Look at Technology Use for English Language Learning from a Structural Equation Modeling Perspective. *Computer-Assisted Language Learning, 23*(2), 18-37.
28	MOOC	464	PE; EE; SI; FC; BI	Wan, L., Xie, S., & Shu, A. (2020). Toward an understanding of university students' continued intention to use MOOCs: When UTAUT model meets TTF model. *Sage Open, 10*(3), 2158244020941858.
29	MOOC	400	PE; EE; SI; FC; BI; UB	Haron, H., Hussin, S., Yusof, A. R. M., Samad, H., & Yusof, H. (2021, February). Implementation of the UTAUT model to understand the technology adoption of MOOC at public universities. *In IOP Conference Series: Materials Science and Engineering* (Vol. 1062, No. 1, p. 012025). IOP Publishing.

S/N	Technology / System	Sample Size	UTAUT Constructs	Study
30	Open Educational Resources	202	PE; EE; SI; FC; BI	Padhi, N. (2018). Acceptance and usability of OER in India: An investigation using UTAUT model. *Open Praxis, 10*(1), 55-65.
31	Podcast	533	PE; EE; SI; FC; BI	Ho, C. T. B., Chou, Y. H. D., & Fang, H. Y. V. (2016). Technology adoption of podcast in language learning: Using Taiwan and China as examples. *International Journal of e-Education, e-Business, e-Management and e-Learning, 6*(1), 1.
32	Smart Board	68	PE; EE; SI; FC; BI	Arumugam, R., Yahya, D., Rozalina, K., Fauzi, H., Sofian, O., & Marina, G. (2014). Technology acceptance on Smart Board among teachers in Terengganu using UTAUT model. *Asian Social Science, 10*(11), 84-91.
33	Social Media	390	PE; EE; SI; BI	Al-Rahmi, A. M., Shamsuddin, A., Wahab, E., Al-Rahmi, W. M., Alturki, U., Aldraiweesh, A., & Almutairy, S. (2022). Integrating the Role of UTAUT and TTF Model to Evaluate Social Media Use for Teaching and Learning in Higher Education. *Frontiers in Public Health, 10*.
34	Tablet Computer	119	PE; EE; SI; FC; BI; UB	Moran, M., Hawkes, M., & Gayar, O. E. (2010). Tablet personal computer integration in higher education: Applying the unified theory of acceptance and use technology model to understand supporting factors. *Journal of educational computing research, 42*(1), 79-101.
35	Technology Usage	264	PE; EE; SI; FC; BI	Teo, T., & Noyes, J. (2014). Explaining the intention to use technology among pre-service teachers: a multi-group analysis of the Unified Theory of Acceptance and Use of Technology. *Interactive Learning Environments, 22*(1), 51-66.
36	Video-based Instruction	420	PE; EE; SI; FC; BI	Kissi, P. S., Nat, M., & Armah, R. B. (2018). The effects of learning–family conflict, perceived control over time and task-fit technology factors on urban-rural high school students' acceptance of video-based instruction in flipped learning approach. *Educational Technology Research and Development, 66*(6), 1547-1569.
37	Video-based Instruction	260	PE; EE; SI; BI	Mikalef, P., Pappas, I. O., & Giannakos, M. N. (2016). Investigating determinants of video-based learning acceptance. *In State-of-the-Art and Future Directions of Smart Learning* (pp. 483-491). Springer, Singapore.
38	Webinar	377	PE; EE; SI; FC; BI	Khechine, H., & Lakhal, S. (2018). Technology as a double-edged sword: From behavior prediction with UTAUT to students' outcomes considering personal characteristics. *Journal of Information Technology Education. Research, 17*, 63.
39	Website Service	422	PE; EE; SI; FC; BI; UB	Jaradat, M. I. R. M., & Banikhaled, M. (2013). Undergraduate Students' Adoption of Website-service Quality by Applying the

S/N	Technology / System	Sample Size	UTAUT Constructs	Study
				Unified Theory of Acceptance and Use of Technology (UTAUT) in Jordan. *Int. J. Interact. Mob. Technol., 7*(3), 22-29.
40	YouTube	399	PE; EE; SI; FC; BI; UB	Bardakcı, S. (2019). Exploring high school students' educational use of YouTube. *International Review of Research in Open and Distributed Learning, 20*(2).

Results

Internal Structure

The fit of the UTAUT Model 1 using the data from past research was examined using R Studio and its metaSEM package. The analysis was conducted to estimate whether the actual factor structure and factor loadings aligned with the theorized structure by testing the fit between the observed correlations and the proposed measurement model statistically (Albright & Park, 2009; Bollen, 1989; Hair et al., 2006; Kline, 2005). Five indices were used to assess the fit of the model to the data: (a) *χ2*/ Degree of Freedom *χ2/df*), (b) Root Mean Square Error of Approximation (RMSEA; Steiger, 1990), (c) Standardized Root Mean Square Residual (SRMR), (d) Comparative Fit Index (CFI; Bentler, 1990) and (e) Tucker-Lewis fit index (TLI; Bentler & Bonett, 1980) (Table 2). Because χ2 is overly sensitive to the sample size (Hu & Bentler, 1999), the ratio of χ2 to its degrees of freedom *χ2/df*) was used, and a range of not more than 3 was indicative of an acceptable fit (Kline 2005). For the RMSEA, values of less than .05 are deemed to indicate a close model fit; those between .05 and .08 a good fit; those between .08 and .1 a mediocre fit; and those greater than .100 an unacceptable fit (Browne & Cudeck, 1993). The CFI and TLI compare the hypothesized model to a 'null' or worst-fitting model, considering model complexity, and indicate an acceptable model fit when values are greater than .950. In contrast, a good model fit is indicated when values are greater than .95 (Hu & Bentler, 1999). The values for UTAUT model fell within the recommended thresholds for acceptable model fit based on all other indices (*χ2/df* = 2.062; RMSEA = .008; SRMR = .026; CFI = 1.000, TLI = .984) (Table 1). The reliability of the data was examined using IBM SPSS version 28.0.1.1 and was found to be highly reliable (N = 40; α = .959).

Table 2. Goodness-of-fit Indices of Model 1

Measure	Threshold	Value
χ^2	--	8.245
df	--	4.000
χ^2/df	< 3.000	2.062
***p*-value**	> .050	.083
RMSEA	< .050	.008
SRMR	<.080	.026
CFI	> .950	1.000
TLI	> .950	.984

The correlation matrices extracted from the 40 studies were analyzed with the help of the R package metaSEM (version 1.2.5.1) and further used for OSMASEM method. The metaSEM package provides functions for univariate analysis, multivariate analysis, three-level meta-analysis, two-stage SEM, and OSMASEM using the SEM approach through the OpenMx package in the R software. The OSMASEM approach was the most suitable for processing longitudinal relationships between variables at continuous time points (Cheung, 2014). This study extracted empirical studies from the last decade, 2013 to 2022. The metaSEM, with the maximum likelihood estimation for analyses, used the sum rather than the average of sample sizes to compute the standard errors for the path coefficients, which increases the sensitivity of significance tests.

Model 1 in this current meta-analysis underperformed as compared to the original model by Venkatesh et al. (2003). The original UTAUT model performed at an adjusted R^2 of 69% for BI. The model in this study only attained an R^2 of 47.2%. It was not a new finding, though, as Dwivedi et al. (2021) found in their meta-analysis study that UTAUT models in later studies underperformed as compared to the original UTAUT model by Ventakesh et al. (2003). As for the explained variance of UB, the model in this study outperformed the original UTUAT model at R^2 of 57.7% (Table 3). The original UTAUT model attained an explained variance at 47% for UB.

Table 3. Comparison of Variances Explained

	Variance Explained (R^2)	
	Original Model	**Model 1**
BI	.690	.472
UB	.470	.577

As posited by Ventakesh et al. (2003), PE remained the best predictor of BI (β= .370; p<.001) compared to EE and SI in the current model. EE has a significant positive effect on BI (β= .246; p< .001). SI also has a significant positive effect on BI (β= .204; p<.001), while FC has a significant positive effect on UB (β= .358; p<.001). Similar to the original UTAUT findings by Ventakesh et al. (2003), BI had a significant positive effect on UB (β= .525; p< .001). The results for the variables are summarized in Figure 3 and Table 3.

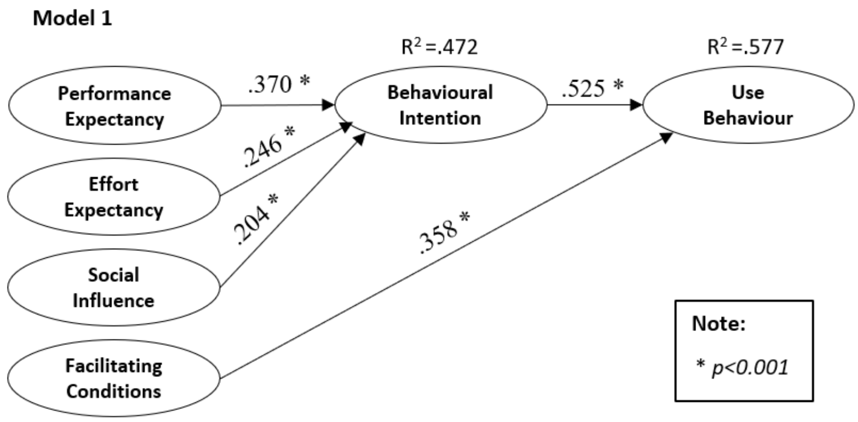

Figure 3. Path Diagram of UTAUT Model

One additional model tested in this MASEM study was to include all possible exogenous variables and stimulate the various possible direct relationships between them (Figure 4). In Model 2, a direct relationship was added between FC and BI. Other direct relationships were also added between EE and UB, as well as SI and UB. However, when a direct relationship was added between PE and UB, all goodness-of-fit indices of Model 2 fell outside all the recommended thresholds.

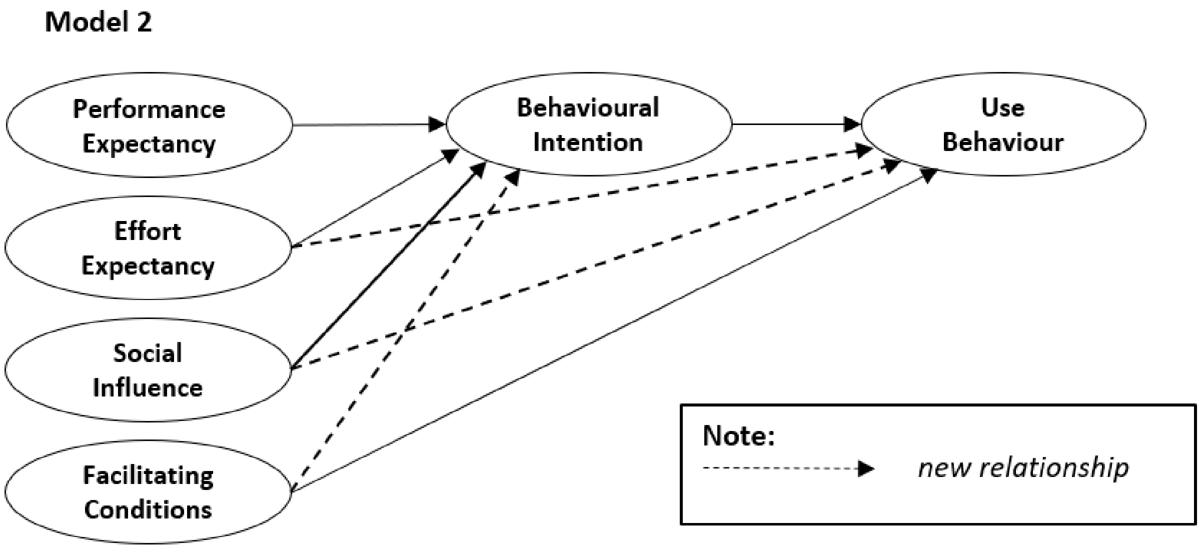

Figure 4. Proposed UTAUT Model 2

Without a direct relationship between PE and UB, however, it was then found in Model 2 that PE, EE, SI, and FC were all predictors of BI and EE, SI, and FC were predictors of UB. The goodness-of-fit indices for the Model 2 fell within the recommended thresholds for acceptable model fit (*χ2/df* = 1.059; RMSEA = .002; SRMR = .014; CFI = 1.000, TLI = 1.000) (see Table 4).

Table 4. Alternative UTAUT Model Goodness-of-fit Indices

Measure	Threshold	Value
		Model 2
χ^2	--	1.059
df	--	1.000
χ^2/df	< 3.000	1.059
***p*-value**	> .050	.303
RMSEA	< .050	.002
SRMR	<.080	.014
CFI	> .950	1.000
TLI	> .950	1.000

While there was a good internal data structure in Model 2, the explained variance for BI (46.8%) underperformed as compared to the initial model introduced by Venkatesh et al. (2003) (69%). However, the explained variance for UB fared better (53.7%) than the initial model (see Table 5). In Model 2, PE remained the strongest predictor of BI (*β*= .360; *p*<.001), with FC as an additional predictor of BI (*β*= .173; p<.001) (see Figure 4). EE has a significant positive effect on BI (*β*= .140; *p*<.001), while SI has a significant positive effect on BI (*β*= .158; *p*<.001). Two other direct relationships were observed in Model 2, where EE and SI both have a significant positive effect on UB (EE→UB; *β*= .132; *p*<.001, SI→UB; *β*= .092; *p*<.001). FC has a significant positive effect on UB (*β*= .210; *p*<.001), and BI has a significant positive effect on UB (*β*= .444; *p*<.001). Overall, Model 2 underperformed in comparison to Model 1 in both explained variances of BI and UB (see Table 5).

Table 5. Comparison of Model Variances Explained

	Variance Explained		
	Original Model	**Model 1**	**Model 2**
BI	.690	.472	.468
UB	.470	.577	.537

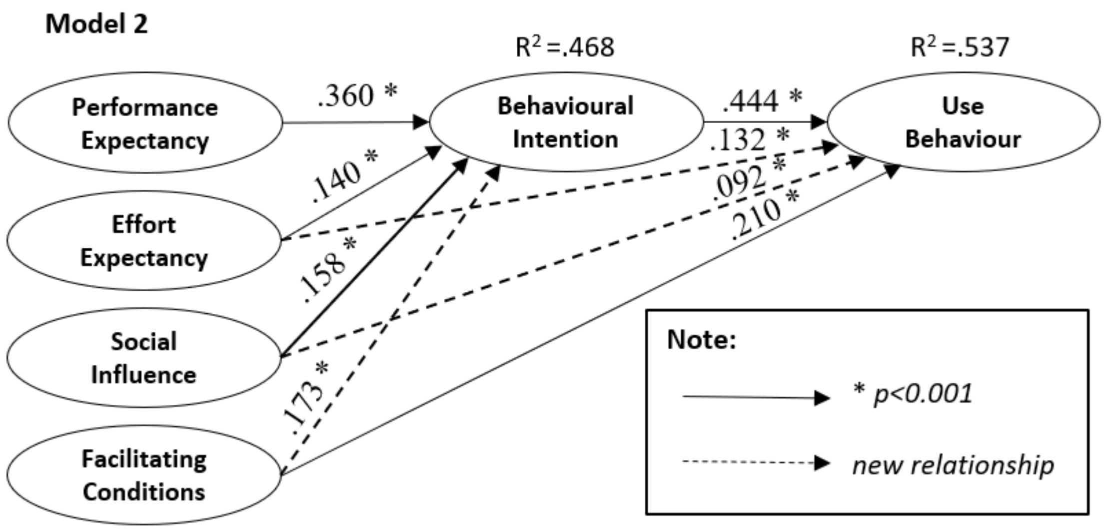

Figure 4. Model 2 (with direct relationships between FC and BI; EE and UB; SI and UB)

In assessing the extent to which each independent variable impacts the dependent variables, the direct effects, indirect effects, total indirect effects and total effects associated with each variable were examined. A coefficient linking one construct to another in the models represents the direct effect of a determinant on a dependent variable. An indirect effect indicates a determinant's impact on a target variable through its effect on other intervening variables in the models. A total indirect effect on a given variable is the product of the indirect effects, while a total effect is the sum of the respective direct and indirect effects.

According to Cohen (1988), effect sizes of .2 are small, those with .5 are medium, and values of .8 and above are large. These effects are summarized in Table 6. In Model 1, the effects were generally small to medium, ranging from .107 to .525. BI acted as a significant mediator for PE, EE and SI. In Model 2, the effects were also generally small, ranging from .062 to .444, with the largest total effect from FC to UB. With the new relationships added among the variables, BI served as a significant mediator for all exogenous variables in Model 2.

Table 6. Direct, Indirect and Total Effects Implied in Model 1 & Model 2

		Model 1	Model 2
Direct Effects	**PE → BI**	0.370*	0.360*
	EE → BI	0.246*	0.140*
	SI → BI	0.204*	0.158*
	FC → UB	0.358*	0.210*
	BI → UB	0.525*	0.444*
	FC → BI	-	0.173*
	EE → UB	-	0.132*
	SI → UB	-	0.092*
Indirect Effects	**PE → UB**	0.194*	0.160*
	EE → UB	0.129*	0.062*
	SI → UB	0.107*	0.070*
	FC → UB	-	0.077*
Total Effects	**PE → UB**	0.194*	0.160*
	EE → UB	0.129*	0.195*
	SI → UB	0.107*	0.202*
	FC → UB	0.358*	0.287*

Discussion

The MASEM approach was employed to revisit the UTAUT model first introduced by Ventakesh et al. (2003). In Model 1, the results showed that PE remained the strongest predictor of BI, with both EE and SI having a significant positive effect on BI. FC and BI both served as predictors of UB. These results are all in line with the findings from the original UTAUT model. In Model 2, after adding new direct relationships into the alternative model, the findings showed that while EE and SI had significant positive effects on UB, PE did not. It was also found that FC has a significant positive effect on BI, though this was not a new finding, as Venkatesh et al. (2012) revised this relationship in the UTAUT2 model. This finding is also similar to the study by Bervell and Umar (2017) that examined non-linear relationships of UTAUT exogenous variables. The UTAUT study with 267 Malaysian higher education students showed that FC had a significant positive effect on BI.

EE is the ease with which users can adopt the system (Venkatesh et al., 2003). In the initial UTAUT model, EE only has a direct relationship with BI. However, when a direct relationship was also introduced between EE and UB in Model 2, the finding showed that EE has a significant positive effect on UB. Such a finding is not without precedence. In the study by Yueh et al. (2015) with 103 Taiwanese university students exploring factors affecting continued Wiki use, it was found that EE had a significant positive effect on the actual use of wiki.

While there was an attempt to examine other direct relationships between the variables in Model 2, the explained variance of BI did not perform better in comparison to the original UTAUT model proposed by Venkatesh et al. (2003). The possible argument would be whether the behavioral intentions had shifted as technologies changed over the two decades. The UTAUT model was first introduced in 2003 and was revised in 2012 as UTAUT2 for the consumer contexts (Venkatesh et al., 2012). Based on the findings of this MASEM study, it was also observed that explained variance in UB had improved even in Model 1, which had the same constructs as the 2003 model. One might argue that technology usage patterns have shifted compared to two decades ago, along with the changes in behavioral intentions measured in UTAUT models. More so, user behavioral intentions and usage patterns might differ significantly as this MASEM study was conducted in educational contexts compared to studies conducted in information systems or commercial contexts.

Limitations

This MASEM study was based on a recent OSMASEM method introduced by Jak et al. (2021). Only a few studies employed the OSMASEM approach (Bednall et al., 2022; Tehrani & Yamini, 2020; Sur et al., 2022; Wu et al., 2021), and no study has yet to use the OSMASEM approach to examine the UTAUT model at the time of this writing. While the software, R and its packages (i.e. metaSEM; metaplot) are easily accessible, Jak et al. (2021) stated that one of the limitations is that OSMASEM does not quantify the heterogeneity of the structural equation modelling (SEM) parameters. It brings us to the other limitation of this study, the examination of publication bias. Currently, there is no method to address publication bias within the OSMASEM framework (Sur et al., 2022). Also, there will be a steep learning curve for researchers who attempt to use the OSMASEM method in R for the first time, especially in how the dataset is organized and read. For instance, fitting the SEM model may sometimes lead to an error, or there may be problems with the lavaan syntax used to formulate the SEM model.

One of the main reasons that OSMASEM was chosen for this study is that the method allows researchers to examine the moderator effects in MASEM. The identified articles in the literature showed that many researchers omitted moderator variables in their studies. As there was limited UTAUT research in the educational contexts that included moderators, this MASEM study only focused on the main constructs, PE, EE, SI, FC, BI and UB. Future MASEM UTAUT studies should focus on how moderators like age, gender and experience would affect users' behavioral intentions and usage patterns in the educational contexts.

Conclusions

The current study examined the existing empirical research on UTAUT in the educational context using the correlation-based OSMASEM approach (Jak et al., 2021). The meta-analytic findings supported the applicability of the UTAUT in the educational context. They discovered some new relationships of variables within the model, including the direct effect of FC on BI, which is a departure from the original findings by Ventakesh et al. (2003). Also, OSMASEM synthesizes correlation matrices rather than single correlations, showcasing how the approach can be applied to test theory-driven models. However, it has never been used in meta-analyzing the UTAUT model in educational contexts.

There have been studies on the UTAUT model with many diverse findings since its inception in 2003. The method introduced in this study, OSMASEM, offers an approach for researchers to use past empirical data to examine the

UTAUT framework without relying on replicating similar studies. As more empirical data from UTAUT research are added to train the data model using OSMASEM, researchers can now study how educational technology trends change over time. Such an approach will enable researchers to focus on the more important relationships within the UTAUT model and advise their colleagues and executive accordingly when implementing technologies in higher educational institutions.

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