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Augmented Reality and Virtual Reality for Learning: An Examination Using an Extended Technology Acceptance Model

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ABSTRACT As the educational possibilities of AR (Augmented Reality) and VR (Virtual Reality) are getting more attention, understanding teachers' readiness to integrate new technologies for instruction would help researchers and practitioners to plan how to support them. In this regard, the present study explores teachers' willingness to integrate AR and VR technologies for teaching and learning practices. Employing an extended Technology Acceptance Model (eTAM), this study investigated whether technological pedagogical and content knowledge (TPACK), social norm (SN), and motivational support (MS) for teachers influence teachers' intention to use the technologies. Analysis from 292 in-service teacher responses supported all of the eight hypotheses formulated in the study. TPACK was found to have a significant influence on perceived usefulness (PU) and perceived ease of use (PEU) while SN influenced PU. In addition, MS was found to have an influence on PEU, which ultimately affects attitudes toward technology use (ATU) and then behavioral intention (BI). The results imply the importance of providing technology professional development (PD) and support for teachers to promote the use of AR and VR in classrooms.

INDEX TERMS Technology integration, technology acceptance model (TAM), TPACK, motivational support, social norm, emerging technology, augmented reality, virtual reality.

I. INTRODUCTION

In recent years, educational researchers and practitioners have started to expect that emerging technologies such as Augmented Reality (AR) and Virtual Reality (VR) can bring new opportunities in educational settings [1], [2]. Unlike expensive and high-end devices in the past, recent devices for AR and VR have become affordable with rapid technological advancement, which gives teachers easy access to VR/AR learning activities. AR supplements reality, rather than completely replacing it [3] by enabling users to see the real world with virtual objects superimposed upon or composited with the real world. With the seamless augmentation between real and virtual worlds, AR is known to enhance presence [4], which, in turn, promotes active, constructivist, and authentic learning [5]. Different from AR, when experienced with head-mounted display (HMD), VR effectively isolates users from their physical spaces so that they can focus their attention on the stimuli provided by VR [6].

With the potential of educational uses, many studies have explored the benefit of using AR and VR in students' learning. In a systematic review of 68 studies on AR published up to 2015, Kavanagh and Akçayır [7] reported a growing number of studies that found students' enhanced learning achievement, positive attitudes, and motivation as outcomes of AR-enabled instruction. More specifically, a collaborative AR simulation system helped undergraduate students acquire knowledge in physics more than those who used traditional 2D simulation system [8].

Also, the use of an AR-based application positively affected not only students' learning achievement but also their attitudes when engaging in an environmental project [9]. More evidence has shown the benefit of AR in affective learning. For example, Erbas and Demirer [1] conducted a comparison study investigating the effect of AR activities on ninth graders' Biology learning, in which they found higher

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motivation in the AR group compared to the control group. Further, at the college level, students performed laboratory activities using AR, which showed an improvement in their lab skills and positive attitudes toward physics laboratories [10].

Literature on the educational use of VR also shows various benefits. A systematic review of several VR studies indicated an increase in students' learning achievement and intrinsic motivation [11]. In addition, learning in a virtual space has been found to have an enhanced learning effect especially when the virtual environment is more closely aligned with that of physical world, such as allowing students to move around the space, and touch and interact with objects through more sophisticated devices such as HTC's VIVE rather than a gamepad like a PlayStation 4 (PS4) [12]. Therefore, educational activities using VR can go beyond mere observation and exploration: they allow students to have experiential learning, in which learning is achieved through direct experiences [12]. VR has been also found to influence student motivation where an immersive VR with head-mounted display (HMD) positively influenced students' motivational beliefs by diminishing test anxiety [13]. Lastly, realistic 360° scenes projected onto HMDs have been found to provide engaging experiences that give a sense of presence for elementary students by participating in immersive virtual field trips without having to leave their classroom [14].

While many studies have focused on VR's effects on students' learning, little has been explored from teachers' perspectives on using AR and VR in education [15]–[18]. A few studies have investigated educational uses of VR with teachers. For example, one study examined teacher perception on the instructional use of virtual technologies [19] and the other investigated teacher's process of designing and implementing a VR-based instruction [20]. However, those studies focus on teachers' perceptions and instructional decisions when using VR technologies in classrooms without providing an insight on what factors influence teachers' decision of accepting and using emerging technologies in the first place. Given the advantages that AR and VR can bring into classrooms, it is important to encourage teachers to use emerging technologies in their classrooms. Since teachers are gatekeepers for the use of technology in the classroom [21], studies on teachers' acceptance and intention to use technologies can provide practical implications in education. A few recent studies found that teachers were generally positive about integrating AR and VR in the classroom [15], [16], [22], [23]. However, how much they are ready and willing to adopt them are less explored.

Regarding teachers' readiness for and willingness to the use of technologies in the classroom, previous research revealed that teacher knowledge [24], [25], social norm [26], and motivational support [24], [27] are among the major influencers for teachers' technology integration. In this regard, the present study aims to identify factors that have an impact on teachers' intention to use AR and VR technology by employing an extended Technology Acceptance Model (TAM). The TAM has been widely adopted with proven empirical supports in explaining teacher perception on technology acceptance [28] and predicting their adoption of technology [29]. We expect that the current study will shed light on teachers' integration of AR and VR for teaching and learning, analyzing their perception and the influencing factors for their intention to use the technologies in classrooms.

II. THEORETICAL FRAMEWORK

To explain how teachers embrace new technologies, this study employed an extended TAM (eTAM) framework. Several theoretical models have been proposed to explain technology acceptance and such examples include Theory of Reasoned Action (TRA; [30]), Technology Acceptance Model (TAM; [31]), and Unified Theory of Acceptance and Use of Technology (UTAUT; [32]). Among them, TAM is the most widely adopted model that explains technology acceptance [28] with findings from numerous studies. The initial TAM had two exogenous variables of perceived usefulness and perceived ease of use that have a direct effect on attitudes toward using technology, and ultimately, influence the intention to use technology. It later encompasses other external variables affecting perceived usefulness or perceived ease of use after being criticized for not considering the external variables [33], [34]. The external variables added to eTAM includes a wide variety depending on disciplines and technologies introduced. Some of the examples include: user habit for accepting mobile library application in Information Science [35] and perceived affective quality for a smartwatch from individuals in three different countries [36].

Such addition of factors to eTAM reflects Legris, Ingham, & Collerette's [37] assertion that other variables besides perceived usefulness and perceived ease of use should be considered in order to provide a broader understanding of multidimensional factors affecting technology adoption.

With regard to teachers' technology acceptance, previous studies revealed that external factors such as teacher knowledge, specifically technological pedagogical and content knowledge (TPACK), and social norm (SN) fairly explains teachers' inclination to use new technology [38], [39]. Teachers' TPACK had a considerable impact on teachers' perceived usefulness and perceived ease of use [40], [41] while SN was found to be a direct influencer to perceived usefulness [28], [42], perceived ease of use [42], and computer attitudes [33].

Literature also reports motivational support (MS) as a crucial factor for teachers' decision-making of adopting and utilizing technology for instruction [27], [43], but it has not been tested on TAM yet. As this study intends to elucidate teachers' intention to use AR and VR in classrooms and demonstrate factors that influence teachers' acceptance of the emerging technologies for instruction, we propose a version of the eTAM comprising of three exogenous variables of TPACK, SN, and MS. Since the three exogenous variables represent individual, social, and environmental aspects, respectively, we expect to understand how each aspect affects teachers' intention for AR and VR-integrated instruction. The variables are discussed in further detail below (See the "Research Hypotheses" section for definitions of these factors).

Another theoretical framework considered in this study is teachers' technology integration. Why and how teachers use (or not) technology in classrooms has been a long-standing research theme [44], and, consequently, several models and variables have been adopted and tested [39]. Ertmer and Ottenberit-Leftwich [19] are among the scholars who proposed an inclusive theoretical model of teachers' technology integration. Summarizing diverse teacher-related factors, they suggested the following four variables that impact teachers' use of technology: teacher knowledge for technology integration, self-efficacy, supportive culture, and pedagogical belief [24], [27]. Teacher knowledge (e.g., TPACK) has been widely used in recent years to explain teacher knowledge that is required for teachers for the meaningful integration of technology. In addition, self-efficacy has proven to influence teachers' technology integration [45], [46], which is often interchangeably used with attitudes toward technology. Literature also tells us that supportive culture affects teachers' pedagogical beliefs and their technology integration [24], [47]. Supportive culture can be translated into motivational support since motivational support was proved as an essential element that constitutes supportive culture [27]. Although belief is reported as one of the influencing factors for teachers' technology integration [24], [48], previous studies also assert that teachers are more likely to be influenced by external factors such as social norm, organizational control especially at the beginning of technology introduction [46], [49]. Thus, for the current study, we employed Ertmer and Ottenberit-Leftwich's [24] framework to guide our study by including TPACK, self-efficacy, motivational support to investigate influencing factors for teachers' intention to use AR and VR in instruction. Considering that AR and VR-based instruction in its early stage in classroom use, we added social norm (SN) as a replacement for belief.

III. RESEARCH HYPOTHESES

A. TECHNOLOGY ACCEPTANCE MODEL (TAM)

TAM was developed to predict the organization's acceptance of new technology with four main factors: perceived ease of use (PEU), perceived usefulness (PU), attitudes toward technology use (ATU), and behavioral intention (BI) [50]. It then became widely applied as a theoretical framework that explains group behaviors on the acceptance of new technology [39], [44]. Since the 1990s, TAM has been used to predict technology acceptance of users as new technologies continue to emerge [51] and the extended model (i.e., eTAM) has been used frequently for a better understanding of technology acceptance by integrating other factors in the model [52].

The model assumes that the adoption of a new technology or system is determined by PEU and PU, which will affect BI after mediated by ATU [31]. PU is defined as the degree to which a person believes using a particular technology will help improve performance [31]. PEU is defined as the degree to which a person believes using a particular technology will be free of effort [31]. ATU refers to the degree to which a user likes or dislikes using a certain technological tool [53]. BI is an indicator describing how much effort an individual is willing to put in order to perform desired behavior (e.g., use of computers) [54]. With all factors together, the model explains that when a user perceives a new technology easy to use and/or useful, s/he is more likely to have a positive attitude, which in turn, affects a higher level of intention to use the technology. As to the teachers' technology acceptance, previous studies showed that PU and PEU had a positive impact on ATU and BI [40], [49]. Thus, for the purpose of the present study, the following hypotheses are proposed:

H1: ATU will have a significant influence on BI.
H2: PEU will have a significant influence on ATU.
H3: PU will have a significant influence on ATU.
H4: PEU will have a significant influence on PU.

B. EXTENDED TAM

1) TECHNOLOGICAL PEDAGOGICAL AND CONTENT KNOWLEDGE (TPACK)

TPACK is a theoretical framework that illustrates knowledge areas for teachers' technology integration [55]. TPACK has its root in Shulman's [56] idea that emphasizes pedagogical knowledge (PK), content knowledge (CK), and pedagogical content knowledge (PCK) for teaching. Adding technology knowledge to each knowledge base, the idea of having technology knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPCK) for technology integration is developed [55].

Thus, it provides an understanding of the complexity of relationships between students, teachers, content, methods, and technologies [57].

TPACK is known to affect teachers' acceptance and integration of technology [38], [39], [58], and a professional development of TPACK resulted in a positive effect on integrating technology in classrooms [59], [60]. Particularly with TAM, TPACK was found to positively influence PEU and PU [40], [41], [61]. Given that AR and VR are newly emerged technologies in education, we attempt to explore how TPACK as an external variable affects factors in TAM by testing the following hypotheses:

H5: TPACK will have a significant influence on PU.
H6: TPACK will have a significant influence on PEU

2) SOCIAL NORM (SN)

Social norm (SN) refers to the perceived social pressure on whether to perform behavior [62]. That is, SN means the influence of others on the decision of certain behavior (e.g., using technology) [30] and works as a rationale for people to choose to perform the behavior [63].

Early studies on TAM did not find the significant influence of SN. In later studies, however, SN was confirmed as an important direct determinant of intention, especially when organization-wide technology use was mandated [63], [64]. Numerous studies support the positive effect of SN on PU [42], [63], [65], [66] and a meta-analysis study of the technology acceptance model reported a significant correlation between SN and PU (91.6%) [64]. When new technologies are introduced and even required to use, teachers are more likely to be dependent on social norm and organizational control over their educational beliefs, which may later lead to teachers making their own decision regardless of external influences [46], [49]. Given that AR and VR are recently introduced to teachers, the present study included SN, instead of belief, as one of the influencing factors to their intention to use the technologies. Along the line of previous studies, we propose the following hypotheses:

H7: SN will have a significant influence on PU.

3) MOTIVATIONAL SUPPORT (MS)

Teacher's decision to integrate technology is influenced by not only knowledge or beliefs of individual teachers, but also culture of school, school district, and even local community teachers belong [27]. Ertmer and Ottenbreit-Leftwich asserted that the characteristics of school culture might facilitate or hinder teachers' technology integration, emphasizing the importance of having supportive culture [24]. Among supportive culture, that of school level covers a school's leadership, readiness, and openness to technology, and support and encouragement from school administrators and peer teachers, which influences teachers' technology practice in direct or indirect ways [27]. In order words, school supportive culture refers to an atmosphere in which school members discuss use of technology together, encourage each other, and share ideas.

Motivational support (MS) we used as an external factor in the current study includes support from school leadership and peer teachers, which is a crucial part of supportive culture as proved by Jung *et al.* [27]. Literature on school administrators' support reported its major role in teachers' use of technology for teaching and learning activities [67]. The support from school administrators can be represented as technology leadership [69], which includes preparing technological equipment, encouraging teachers, and sharing visions [69]. In addition, support from peer teachers has a positive effect on the acceptance of technology [70] and collaboration among teachers is found to play a crucial role for integrating technology in the classroom [71], [72]. When a teacher perceives support from school administrator and peer teachers, the use of technology in classroom is more likely to be recognized something doable, which might influence the teacher's perceived ease of use. Accordingly, we propose the following hypotheses:

H8: MS will have a significant influence on PEU.

TABLE 1. **Demographic information of the participants.**

		n	%
Gender	Male	95	32.5
	Female	197	67.5
Years of Teaching	1-5	84	28.8
	6-10	64	21.9
	11-15	48	16.4
	16-20	51	17.5
	over 21	44	15.1
	Missing	1	0.3
Total		292	100.0

IV. METHOD

A. PARTICIPANTS[1]

Participants in the study were 292 in-service elementary school teachers in Korea. An invitation to complete an online survey was distributed to teachers, and they answered the survey on a voluntary basis. The online survey link was open for 4 weeks, which recorded 295 responses. Three responses were excluded for analysis due to incompletion, resulting in a total of 292 responses included in the analyses. The demographics of the current study include 67.5% female and 32.5% male teachers. Their teaching experiences ranged from one to more than 21 years, with the largest number of respondents (28.8%) having one to five years of teaching experience (see Table 1).

B. RESEARCH CONTEXT

The current study was conducted in South Korea, where the Ministry of Education has been making great efforts to encourage teachers to use AR and VR embedded in digital textbooks. The digital textbooks are readily accessible for all grade levels of students from elementary to high schools. It is not a digital version of paper-based textbooks: it is an application that can be installed on a tablet and provides multimedia-based resources, evaluation materials, and learning management system for supporting student learning.

The use of digital textbooks creates an environment that increases students' engagement in learning by allowing them to use various educational contents and resources in and outside of the digital textbooks [73]. Infrastructures for using digital textbooks were also prepared: tablet PCs and Wi-Fi access have been placed in all elementary and middle schools [74], [75].

In Korean elementary schools, in particular, AR and VR have been used mostly in Social Studies, Science, and English. Social Studies and Science digital textbooks usually have many AR and VR-based contents, which promotes student learning with visual and auditory resources. For example, using VR, students can explore the inside of the human

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[1] For this study, an IRB approval from local ethical review board is not required as the study is in the boundary of educational practices described in the education law of Korea.

TABLE 2. List of constructs and corresponding items.

Construct	# of items	Sample items	Source	Reliability (Cronbach's α)
TPACK	3	I can use strategies that combine content, AR/VR technologies and teaching approaches that learned about in my coursework in my classroom.	Chai, Koh, Ho, & Tsai [78]	.920
SN	3	It is necessary to perform synchronous AR/VR in a way that addresses the need of society.	Kang & Shin [79]	.829
MS	6	Other teachers encourage me to integrate AR/VR in teaching and learning.	Papanastasiou & Angeli [80]	.903
PEU	3	I believe that AR/VR would be easy to operate.	Chai et al. [78]	.829
PU	3	I believe that AR/VR would be useful for my learning.	Chai et al. [78]	.854
ATU	3	I am confident about using AR/VR for my courses.	Chai et al. [78]	.905
BI	3	I intend to take a synchronous AR/VR in the next term.	Kang & Shin [78]	.883

TABLE 3. Descriptive statistics and discriminant validity.

Measurement Variable	1	2	3	4	5	6	7
1. TPACK	-						
2. SN	$.200^{**}$	-					
3. MS	$.249^{**}$	$.418^{**}$	-				
4. PEU	$.614^{**}$	$.282^{**}$	$.282^{**}$	-			
5. PU	$.577^{**}$	$.372^{**}$	$.191^{**}$	$.528^{**}$	-		
6. ATU	$.694^{**}$	$.269^{**}$	$.218^{**}$	$.773^{**}$	$.512^{**}$	-	
7. BI	$.616^{**}$	$.354^{**}$	$.326^{**}$	$.694^{**}$	$.663^{**}$	$.593^{**}$	-
Mean	3.44	4.00	3.51	2.84	3.73	2.90	3.40
Standard Deviations	1.020	.727	.785	.975	.872	1.058	.932
Skewness	-.481	-.511	-.089	.101	-.920	.197	-.507
Kurtosis	-.124	.337	-.003	-.349	1.165	-.493	.279

$^{**}p < .01$

body as if they are in a little spaceship that moves around in the body. They can also vividly experience how fossils are formed with AR-based learning contents. With the AR and VR-based contents in digital textbooks, students can explore places and manipulate objects without limitations and boundaries. By doing so, it is designed to not only enhance students' learning of content but also have them enjoy the process of learning [76].

For teachers whose school use digital textbooks, professional development (PD) programs are provided. The technology PD offers different programs, which covers the following three topics: (a) understanding school technology development and infrastructure plan, (b) utilizing digital textbooks for teaching and learning, and (c) using AR and VR technologies in classrooms. First, in understanding school infrastructure plan, teachers are provided explanations on how wireless infrastructure is operated and managed in schools so that they could use the wireless system in their school better. Second, for utilizing digital textbooks in classrooms, teachers are trained to select teaching methods and applications that are best suitable for integrating digital textbooks. Third, for the use of AR and VR technologies, teachers learn technical skills such as how to do mirroring to show VR contents on teachers' screen to students, how to use a marker to operate AR. It also includes discussions on AR and VR contents that are effective for students' learning,

TABLE 4. **Measurement model results.**

Factor	Variable	Estimate (STDY)	*S.E*	*p*
TPACK	TPACK1	1.000 (.935)	-	-
	TPACK2	1.016 (.953)	.033	.000
	TPACK3	.841 (.794)	.044	.000
SN	SN1	1.000 (.674)	-	
	SN2	1.194 (.932)	.094	.000
	SN3	.927 (.816)	.076	.000
MS	MS1	1.000 (.779)	-	
	MS2	1.028 (.747)	.075	.000
	MS3	1.095 (.832)	.072	.000
	MS4	.917 (.804)	.064	.000
	MS5	1.140 (.807)	.079	.000
	MS6	.829 (.727)	.065	.000
PEU	PEU1	1.000 (.756)	-	
	PEU2	1.207 (.868)	.078	.000
	PEU3	.910 (.693)	.076	.000
PU	PU1	1.000 (.825)	-	
	PU2	.992 (.863)	.054	.000
	PU3	1.010 (.752)	.047	.000
ATU	ATU1	1.000 (.870)	-	
	ATU2	.992 (.824)	.049	.000
	ATU3	1.010 (.889)	.039	.000
BI	BI1	1.000 (.863)	-	
	BI2	1.160 (.874)	.063	.000
	BI3	.979 (.806)	.061	.000

	χ^2	*df*	CFI	TLI	SRMR	RMSEA (LO90 - HI90)
Model Fit	532.599 (< .001)	231	.942	.930	.062	.067 (.059-.074)
Fit Criteria		-	> .90	> .90	< .08	< .08

how to integrate them in classrooms, and what questions can be provided to students to enhance their learning with the AR and VR contents.

C. INSTRUMENT

The pre-existing instruments were employed for the study to measure teachers' TPACK, SN, MS, PEU, PU, ATU, and BI. Wording in survey items were modified to reflect the context of this study by three experts holding doctoral degrees in educational technology. The questionnaire used a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The first part of the questionnaire collected participants' demographic information. The second part contained 24 items measuring seven constructs related to use of AR and VR: three items for each construct except six items for MS. Table 2 shows sample question items, sources, and Cronbach's alpha of each construct. The Cronbach's alpha scores showed internal consistencies for items with each construct showing either good ($0.8 \leq \alpha < 0.9$) or excellent ($0.9 \leq \alpha$) [77].

D. DATA ANALYSIS

We first performed descriptive statistics and correlation analysis and checked for multivariate normality by examining the skewness and kurtosis. Then, confirmatory factor analysis

TABLE 5. Hypothesis testing results.

Hypothesis	Path	Estimate	Est./S.E	*p*	Hypothesis Result
H1	BI ← ATU	.731	20.653	.000	Supported
H2	ATU ← PEU	.882	22.347	.000	Supported
H3	ATU ← PU	.123	2.316	.021	Supported
H4	PU ← PEU	.188	2.037	.042	Supported
H5	PU ← TPACK	.453	5.360	.000	Supported
H6	PEU ← TPACK	.713	19.527	.000	Supported
H7	PU ← SN	.268	5.008	.000	Supported
H8	PEU ← MS	.103	2.100	.036	Supported

	χ^2	*df*	CFI	TLI	SRMR	RMSEA (LO90 - HI90)
Model Fit	676.422 (< .001)	241	.916	.904	.089	.079 (.072-.086)
Fit Criteria		-	> .90	> .90	< .08	< .08

(CFA) was conducted to confirm the validity and reliability of the measurement scale, which is a pre-requisite for structural equation modeling (SEM). The standard for minimum sample size varies by disciplines, but in social sciences, over 200 is generally considered enough for multivariate analysis [81]. We met the standard by having 292 study participants. Finally, SEM was conducted to examine the structural relationships between the seven constructs using the maximum likelihood estimation. The maximum likelihood estimation requires the minimum sample size > 200, which was met in this study [82]. Acceptable fit was indicated as the ratio of chi-square to the degrees of freedom (χ^2/df) < 3.0, Comparative Fit Index (CFI) > .90 [83], Root Mean Square Error of Approximation (RMSEA) < .08, and Standardized Root Mean Square Residual (SRMR) < .08 [84], [85]. Finally, we tested the hypothesis and checked the indirect effects between variables.

V. RESULTS

For the current study, we first checked normality of the data collected, and proceed to CFA and hypothesis testing. The results of each procedure are described in detail below.

A. MULTIVARIATE NORMALITY

To satisfy normality, the values of skewness should be lower than 3 and the kurtosis lower than 10 [86]. The skewness and kurtosis values of the study were found to be satisfactory, with the range from |.089| to |.920| and from |.003| to |1.165|, respectively. The correlations among the variables were statistically significant ($p < .05$) (see Table 3).

B. CONFIRMATORY FACTOR ANALYSIS

We conducted CFA to check the factor loading and each variable converges to factor. In the study, the factor loadings of all the items were significant, ranging from 0.727 to 0.953. Therefore, all items obtained convergent reliability. All fitness indexes of the CFA model seemed desirable ($\chi^2 = 532.599$; $df = 231$; CFI = .942; TLI = .930; SRMR = .062; RMSEA = .067).

C. HYPOTHESIS TESTING RESULTS

To test the hypotheses, the statistical significance of the path coefficient between the variables was examined. The results confirmed that the research model is appropriate for path analysis; SRMR slightly crossed the fit criteria, but all other indices had a good fit ($\chi^2 = 532.599$; $df = 231$; CFI = .942; TLI =.930; SRMR = .062; RMSEA = .067). Path analysis results confirmed the followings:

First, ATU had a significant influence on BI (β =.731, $p <$ .001), and PEU (β =.882, $p <$ .001) and PU (β =.123, $p <$ .020) had a significant influence on ATU.

Second, TPACK (β = .453, p <.001), SN (β = .268, p <.001) and PEU (β = .188, p <.044) had a significant influence on PU.

Third, TPACK (β = .713, p < .001) and MS (β = .103, p < .038) had a significant influence on PEU.

To identify indirect effects between variables, mediation analysis was performed. The analysis results confirmed the followings:

First, PEU (β = .644, p < .001) and PU (β = .090, p < .023) had a significant influence on BI mediated by ATU.

Second, TPACK (β = .628, p < .001) and MS (β = .090, p < .036) had a significant influence on ATU mediated by PEU.

Third, SN (β = .033, p < .043) had a significant influence on ATU mediated by PU. However, TPACK (β = .056, p < .058) had a non-significant influence on ATU mediated by PU.

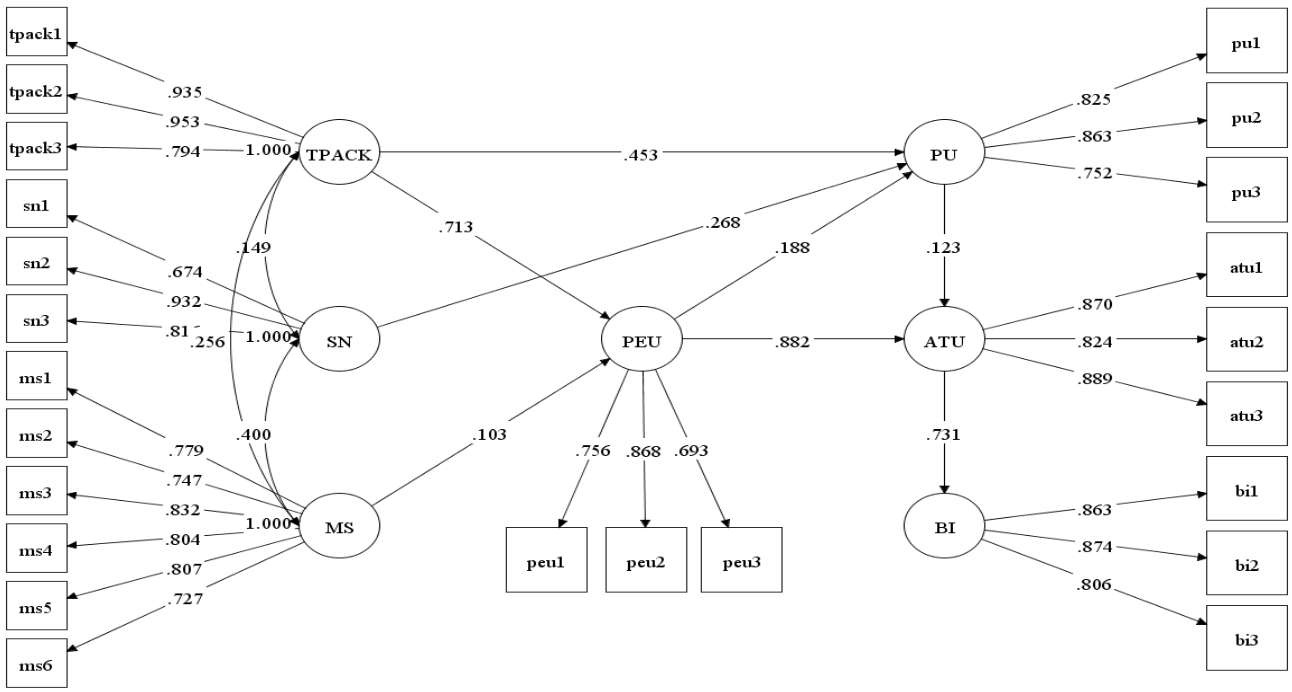

FIGURE 1. Path coefficients of the research model.

TABLE 6. Indirect effects of research model.

Path			Indirect Effect (STDY)	S.E	*p*
BI	← (ATU) ←	PEU	.644	.043	.000
BI	← (ATU) ←	PU	.090	.039	.023
ATU	← (PEU) ←	TPACK	.628	.036	.000
ATU	← (PU) ←	TPACK	.056	.029	.058
ATU	← (PEU) ←	MS	.090	.043	.036
ATU	← (PU) ←	SN	.033	.016	.043

VI. DISCUSSION AND CONCLUSION

This study explored teachers' perception of integrating AR and VR for teaching and learning, and factors affecting their perception by using the framework of eTAM. The eTAM in the current study consists of three exogenous factors (i.e., TPACK, SN, and MS), which can be considered as individual, social, and environmental factors, respectively. The results of the study are as follows.

First, the study result confirmed that TPACK influenced PU and PEU significantly and had an impact on ATU after being mediated by PEU. This means that teachers with knowledge for AR/VR-based instruction are highly aware of the usefulness and ease of AR/VR use in teaching and learning. This is aligned with the results of previous studies demonstrating a positive relationship between teachers' TPACK and their perception (e.g., [67], [87], [88]). However, TPACK was not found to affect ATU after being mediated by PU. Given that TPACK refers to a set of knowledge teachers would need for technology integration, it is possible to assume that having TPACK is more closely related to PEU than PU. In addition, as PU is concerned with the value of and attitudes toward technology for instruction [47], newer technologies like AR and VR may not have been perceived educationally useful among teachers yet.

Second, the results indicated that SN influenced PU. It also had an impact on ATU after being mediated by PU. SN, as responses and attitudes to social demands and values for technology-integrated lesson [63], has been reported as a major influencer on the acceptance of new technologies [79], [89]. Likewise, the present study showed that, when the perceived level of SN is high, it is more likely to affect PU and ATU after being mediated by PU. Thus, SN can play a pivotal role in attempting new technologies in classrooms.

Third, it was found that MS influenced PEU, which eventually influenced ATU after being mediated by PEU. Literature on technology integration emphasized that providing motivational support, including technology leadership from school administrators, teacher collaboration, and opportunities for teacher professional learning, to teachers for classroom use of technology is equally important to equipping technology infrastructure [68], [71], [90]. Similar to the previous studies, the current study result showed when MS is provided to teachers, they are more likely to perceive AR and VR technology easy to use for instruction. The high level of PEU, in turn, influences teachers' attitudes toward using AR and VR in practice.

Fourth, the study results indicated that PEU and PU influenced ATU, respectively, and PEU influenced ATU after being mediated by PU. This is similar to previous studies reporting a higher level of ATU when teachers perceive the technology is easy to use [66] and useful for instruction [79], [91]. However, considering that the introduction of new technologies such as AR and VR in instruction can still be unfamiliar practices for teachers, it would be essential to offer technology PD on how to integrate AR and VR in teaching and learning activities [24]. This way, teachers become comfortable and confident using the new technologies in classrooms.

Finally, the present study confirms that teachers' ATU influenced their BI for the educational use of AR and VR. This means that positive attitudes toward AR and VR-enabled instruction have an effect on the continuous use of them in the classroom. Previous studies also showed that attitude toward technology positively affects technology integration [42], [92]. The study results imply that promoting teachers' attitudes toward technology use would have a positive impact on the more use of AR and VR in classrooms.

VII. IMPLICATIONS AND LIMITATION

For teachers, the use of new technology in practice requires a significant change as it entails reforming existing teaching strategies. The results of the current study indicated that when emerging technologies is introduced, all of individual (i.e., TPACK), social (i.e., SN), and environmental (i.e., MS) factors surrounding teachers come into play, influencing teachers' PEU, PU, ATU, and ultimately BI. In this regard, providing PD that intends to make teachers feel familiar with the technology (and thereby perceiving the ease of using it) would help them integrate the technology into classrooms [22]. Given that PD can be an effective vehicle for teachers to enhance attitudes toward and beliefs of using technology for educational purposes [93], PD programs that are structured to promote positive attitudes toward and confidence for technology-integrated instruction need to be offered. For AR and VR-based instruction, for instance, PD can cover the following topics: an introduction to applications for AR and VR-based instruction; how to use markers for AR and HMD for VR. PD with detailed user manuals and demonstration on how the technologies can be used for classroom activities would help promote teachers' use of AR and VR. Furthermore, it would also be crucial to highlight how society is constantly changing and its evolving demand for future generations with examples of technology-integrated teaching practices from other teachers.

In addition, support from school administration and peer teachers should not be underestimated. The initial application of new technology in the classroom is often determined by the ideas and discussions among school members, which is demonstrated by MS and SN influencing BI through PU and ATU in our study. Support from administrators and peer teachers from personal learning networks was one of the elements that made teachers be able to use technology in an educationally sound way [67]. Moreover, technology leadership that includes sharing visions for technology integration, offering professional learning opportunities to teachers, and providing an educational technology specialist should be at work in order to achieve a meaningful technology integration [69].

Despite the implications, this study has limitations in that the study participants were in-service elementary teachers who covers all subject areas. The results may not be the same for teachers in middle and high school, where teachers teach their own subject area. Especially, in Korean context, less AR/VR contents are included in middle and high school digital textbooks compared to that of elementary level [48], which might hamper teachers in secondary education to perceive the educational benefit of AR and VR and to use them for instructional purposes. Furthermore, given the current study was performed in Korea, the contrasting study results might come out if it is conducted in other countries with different educational systems. In addition, as the present study analyzed solely quantitative data, adding qualitative data might help better understand preparedness and intention of teachers for AR/VR-based instruction.

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