Understanding the Attitude and Intention towards Adopting Virtual Reality Technology in Classroom

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***Abstract*—Virtual Reality (VR) has been known to be a technology that can closely replicates an environment that simulates a physical presence in places in the real world or an imagined world, and allowing the user to interact within that world. In recent years, there has been a lot of buzz about applying virtual reality technologies to classroom instruction, since these technologies can artificially create sensory experiences (including sight, touch, hearing, and smell), which could highly enhance the whole learning experience. With the advancement of affordable VR gear such as Google cardboard, and various VR 360 videos capture devices, virtual reality is ready to make an impact in classroom on a daily basis from the technological perspective. However, whether the acceptance of such technology is positive, by all stakeholders such as educators, parents, and students, will become a critical factor to the successful deployment of the education technology, and this part is yet to be understood.**

I. Introduction

When working with students in the 21^{st} century, the terms "engagement" and "emersive experience" have been one of the key success criteria for *Student Success*. When students are using appropriate instructional technology, they become an active participant in the learning process, critically think about the current issues in the society, analyze data, search information, and strive to create solutions to solve real world problems [1]. These type of project-based learning can motivate students to want to learn more and eager to share their findings and knowledge with others. Some students in the 21^{st} century learn better by "doing," rather than listening to lecture [2], and if there is a way for learners to interact with the multimedia footage and manipulate objects within a Virtual Reality (VR) environment, this process can help learners to better internalize the learning lessons and understand the material quicker.

VR has been known to be a technology that can closely replicates an environment that simulates a physical presence in places in the real world or a fictional world, and enabling the user to interact within that world. In recent years, there has been a lot of interest about applying VR technologies to educational environment, since these technologies can create sensory experiences (including sight, touch, hearing, and smell), which could highly enhance the whole emersive learning experience. With the advancement of affordable VR gear such as Google cardboard, and various VR 360 (Virtual Reality with 360-degree experience) videos capture devices, VR is ready to make an impact in classroom on a daily basis from the technological perspective. However, whether the acceptance of such technology is positive, by all stakeholders such as educators, parents, and students, will become a critical factor to the successful deployment of the education technology, and this part is yet to be understood.

In this paper, we will present our study on the attitude and intention towards adopting VR technology in classroom. We will adopt two well-established behavioral models, the Theory of Planned Behavior and the Technology Acceptance Model, and we can then examine the adoption attitude of the stakeholders, and how the effect of *subjective norm*, *perceived usefulness*, and *perceived ease of use* of the technology, can affect their intents of adopting this new technology into regular curriculum. Our study will also allow us to identify which factors that are influencing the subjects most, in order to give us a better idea what will be more important to the stakeholders.

II. Background

Learning through visual or tactile-kinesthetic [3] experience has been noted to be one of the effective ways to engage students in the 21^{st} century. From multimedia presentation to tablet and mobile technology video games, educational organizations have been challenged to adopt to the emerging technological environment that we live in today.

> "(In [4] and [5]), the authors made the connection between visual clues, the memory process, and the recall of new knowledge. The authors in [6] observe that the creative challenge of using moving images and sound to communicate a topic indeed engaging and insightful, but adds that it also enables students to acquire a range of transferable skills in addition to filmmaking itself. These include research skills, collaborative working, problem solving, technology, and organizational skills. [7]
>
> In some cases, video can be as good as an instructor in communicating facts or demonstrating procedures to assist in mastery learning where a student can view complex clinical or mechanical procedures as many times as they need to. Furthermore, the interactive features of modern web-based media players can be used to promote 'active viewing' approaches with students. [8]"

This not only changes the way educators deliver message, but also changes the depth of engagement level in the classroom. As the engaging experience become the key to our learning environment, educators are challenged to find innovative ways deliver the lesson, and in recent years, there has been a lot of conversations about applying virtual reality technologies to classroom instruction.

First of all, the 360 video VR experiential learning experience can open the door to limitless possibilities in todays educators teaching methods. As a result, students will be inspired and motivated in the learning experience and will want to continue the learning after the class and seek to solve the long term problem. Furthermore, the 360 videos can be, now, uploaded directed on the web (e.g., youtube) making it more approachable and easier to view.

With the modern technology such as the Virtual Reality (VR) which is known to be a technology that can closely replicates an environment that simulates a physical presence in places in the real world or an imagined world, this can inspire learners to have an immersive experience in that world. Furthermore, the integration of VR technology and the 360 degree view of video can create an opportunity for the audience to learn from immersive experience of places and events through sights, sounds, and interaction.

Imagine a digital storytelling and narrative construction class environment with VR 360 video technology. There will be 360 view of the sights, surrounding sound experience, in addition to the interactive experience. The integration of VR and the 360 video can empower learners to develop some of the essential skills such as critical thinking, problem solving and creative thinking skill, combined with a tactile-kinesthetic experience enabled by the technology.

III. Conceptual Framework and Methodology

In this study we investigate the attitudes and behavioral intention of consumers on the adoption of virtual reality in classroom. We will also study the effect of *subjective norm* on one's choice of adopting such technology. The authos in [9] suggested that "word-of-mouth" has a tremendous impact on ones choice of adoption, and the words from family member and close friends or colleagues are among the most powerful. We are interested to see what will be the effect of these influences, which the authors called subjective norm [10], on one's choice of adoption.

Obviously, it is not possible for one to use VR technologies if one does not know how to operate a similar device. The authors in [11] suggested that the perception one has of his/her ability to operate a computer has a strong relation to ones intention to surf the web, so we will investigate how one's perception on technical barriers, or *perceived behavioral control* [12], affects one's choice of adoption to VR technologies.

In order to incorporate attitude, subjective norm and perceived behavioral control into our study, we propose to use the *Theory of Planned Behavior (TPB)* as the conceptual framework. According to TPB, users intention can be modeled as the weighted sum of their attitudes towards the behavior, their subjective norm, and their perceived behavioral control.

A. Theory of Planned Behavior

Attitude towards a behavior is defined as "a person's general feeling of favorableness for that behavior" [10]. A person's attitude towards a behavior is determined by a set of salient beliefs – a small number of beliefs that a person can attend to at any given moment – one holds about performing the behavior. To predict attitude (A) from beliefs, the authors in [10] modeled attitude as a function of the products of one's salient belief (b) that performing the behavior will lead to certain outcome, and an evaluation of the outcomes (e) corresponding to that belief. Mathematically, we can defined attitude as:

$$A = \sum_i b_i e_i \tag{1}$$

Subjective norm of a person is "the perception that most people who are important to him/her think he/she should or should not perform the behavior in question" [10]. As the authors implied, in forming a subjective norm, an individual takes into account the normative expectations of other sources that are important to him/her. Like attitude, subjective norm (SN) can be modeled as a function of the products of ones normative belief (NB) and his/her motivation to comply (MC), which can be expressed mathematically as:

$$SN = \sum_j NB_j MC_j \tag{2}$$

Perceived behavioral control did not appear in the original Theory of Reasoned Action [13]. The author in [12] extended the original theory by proposing an additional construct to the model in order to account for situations where an individual has less than complete control over the behavior. Perceived behavioral control is "people's perception of the ease or difficulty of performing the behavior of interest" [14]. The Theory of Reasoned action assumes that one can have total control of his or her behavior, but if behavior is not under complete volitional control, the performers need to have the requisite resources and opportunities in order to perform the behavior. The perception of whether they have the resources will affect their intention to perform the behavior, as well as the successful performance of the behavior.

Perceived behavioral control (PBC) can be modeled as a function of control beliefs (CB), which is the perception of the presence or absence of requisite resources and opportunities needed to carry out the behavior, and perceived facilitation (PF), which is ones assessment of the importance of those resources to the achievement of outcomes [15]. PBC can be mathematically defined as:

$$PBC = \sum_k CB_k PF_k \tag{3}$$

In this study, we surveyed college students on their attitudes towards using VR in classrom, and what their friends and family think about it. We also surveyed about the equipment or skills they possess to use the service if they decide to do so. The result is then compared to their self-reported intention on adopting VR technologies, using the Theory of Planned Behavior to serve as the framework.

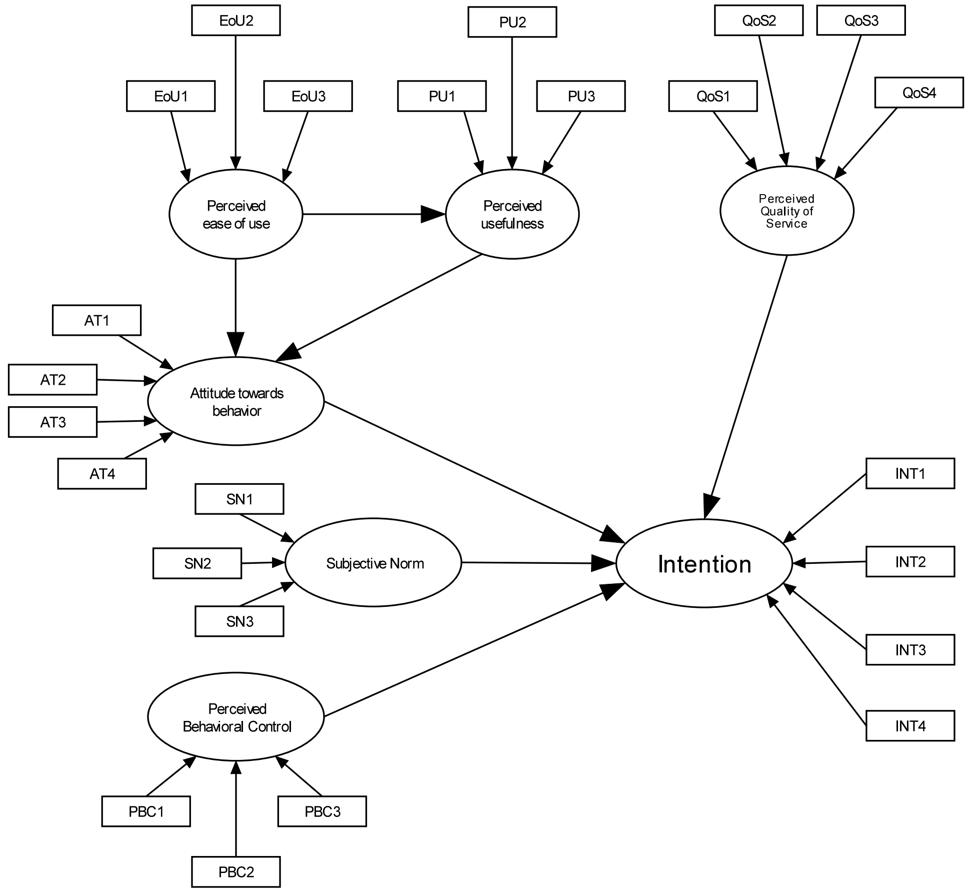

Fig. 1. Structural Model for the study

B. Technology Acceptance Model

For users' attitude towards adoption of information technology, the Technology Acceptance Model (TAM) [16], which is derived from the Theory of Planned Behavior, provided two major constructs for consideration, namely perceived ease of use and perceived usefulness. These two construct have been considered immensely in TAM. According to [16], "people tend to use or not use an application to the extent they believe it will help them perform their job better," and "the degree to which a person believes that using a particular system would enhance his or her job performance." The author also suggested some important measures to evaluation the perceived ease of use and we will use them in our study. TPB and TAM, both of which have strong behavioral elements, assume that when someone forms an intention to act, that they will be free to act without limitation. In the real world there will be many constraints, such as limited ability, time constraints, environmental or organizational limits, or unconscious habits which will limit the freedom to act [17].

Earlier research on the adoption of innovations also suggested a prominent role for perceived ease of use (EOU). Authors in [18] analyzed the relationship between the characteristics of an innovation and its adoption, finding that compatibility, relative advantage, and complexity had the most significant relationships with adoption across a broad range of innovation types. Authors in [19], [20] studied perceived usefulness in terms of a fit between systems, tasks and job profiles, using the terms "task fit" to describe the metric.

The authors in [21] have developed Davis' model into what they call the Usefulness/EOU Grid, which is a 2-by-2 grid where each quadrant represents a different combination of the two attributes. In the context of software use, this provides a mechanism for discussing the current mix of usefulness and EOU for particular software packages, and for plotting a different course of action if a different mix is desired, such as the introduction of even more powerful software.

It was suggested in [22]–[25] that service quality, as perceived by customers, stems from a comparison of what they feel service firms should offer with their perceptions of the performance of firms providing the service. Perceived service quality is therefore viewed as the degree and direction of discrepancy between consumers' perceptions and expectations.

Combining all the above constructs, the detailed model of this study, including the relation between constructs and the use of measures for each construct, is shown in Figure 1. The survey questions are designed based on this model.

C. Analytical Model

The analytical model used for analyzing the survey is the structural equation model (SEM) [26]. SEM is an extension of the general linear model (GLM) that enables a researcher to test a set of regression equations simultaneously. SEM software can test traditional models, but it also permits examination of more complex relationships and models, such as confirmatory factor analysis and time series analyses.

In SEM, the nomenclature is a little bit different from conventional statistics: Independent variables, which are assumed to be measured without error, are called exogenous or upstream variables; dependent or mediating variables are called endogenous or downstream variables. Manifest or observed variables are directly measured by researchers, while latent or unobserved variables are not directly measured but are inferred by the relationships or correlations among measured variables in the analysis. This statistical estimation is accomplished in much the same way that an exploratory factor analysis infers the presence of latent factors from shared variance among observed variables. SEM users represent relationships among observed and unobserved variables using path diagrams. Ovals or circles represent latent variables, while rectangles or squares represent measured variables. Residuals are always unobserved, so they are represented by ovals or circles.

This research is a study with quantitative measurement. To avoid misleading regression estimates and to secure correct conclusions, SEM is used to take measurement error into consideration. We use the analysis of moment structures (AMOS) software to investigate the influence of various factors on the intention of adopting VR technology. SEM procedures can be used to test the model fitness and explore the possible relationships between the model constructs. Structural equation modeling has many advantages over path analysis or regression analysis, especially when the observed variables contain measurement errors and the interesting relationship is among latent variables.

D. Data Collection and Analysis

Paper survey with all the twenty four questions in a shuffled order was distributed to several groups of college students. Confirmatory factor analyses (CFAs) were performed using the AMOS software for the factor analysis of the measurement models. Using CFAs, we assessed the validity of the proposed model as shown in Figure 1. A mixture of fit-indices was employed to assess the overall fit of the measurement models. The ratio of chi-square to degrees of freedom (χ^2/df) will be computed, with ratios of less than 3.0 indicating a good fit.

However, since absolute indices can be adversely effected by sample size, five other relative indices were computed to provide a more robust evaluation of model fit. The goodness of fit index (GFI) varies from 0 to 1, but theoretically can yield meaningless negative values. By convention, GFI should by equal to or greater than 0.90 to accept the model. The adjusted goodness-of-fit index (AGFI) is a variant of GFI which uses mean squares instead of total sums of squares in the numerator and denominator of (1 - GFI). It, too, varies from 0 to 1, but theoretically can yield meaningless negative values. AGFI should be at least 0.80 to indicate a good fit. The comparative fit index (CFI) is the comparative fit index, which varies from 0 to 1. CFI value that is closer to 1 indicates a better fit, and values above 0.90 indicates an acceptable fit. The incremental fit index (IFI) is not guaranteed to vary from 0 to 1, with an IFI value closer to 1 indicates a better fit and values above 0.90 an acceptable fit. The Tucker and Lewis index (TLI), also called the Bentler-Bonett non-normed fit index (NNFI), is not guaranteed to vary from 0 to 1. TLI value closer to 1 indicates a better fit, and a value of 0.90 or above indicates acceptable fit.

TABLE I. FIT-INDICES USED IN THE STUDY

Fit Index	Abbreviation or Symbol	Acceptance Level
Chi-square : degrees of freedom	χ^2/df	< 3.00
Goodness of fit index	GFI	> 0.90
Adjusted goodness-of-fit index	AGFI	> 0.80
Comparative fit index	CFI	> 0.90
Incremental fit index	IFI	> 0.90
Tucker and Lewis index	TLI	> 0.90
Root mean sq. error approximation	RMSEA	< 0.08

TABLE II. RELIABILITY OF THE MEASUREMENTS

Construct	No. of items	Cronbach's α
Attitude (AT)	4	0.876
Perceived Usefulness (PU)	6	0.723
Perceived Ease of Use (EoU)	3	0.747
Perceived Quality of Service (QoS)	4	0.719
Subjective Norm (SN)	6	0.922
Perceived Behavior Control (PBC)	6	0.722
Behavioral Intention (INT)	4	0.936

Root mean square error approximation (RMSEA) is an absolute measure of lack of fit and takes into account parsimony as well as fit by examining discrepancy per degree of freedom. Evidence of excellent fit is considered to be for RMSEA values less than 0.05, and RMSEA values lower than 0.08 suggest reasonable fit. Values from 0.08 to 0.10 are indicative of moderate fit and values greater than 0.10 are taken to be evidence of a poorly fitting model.

Table I summarized the requirements for all the fit-indices used in the study.

E. Reliability and Validity of the Measurement

The reliability analysis verified the precision of the survey instrument and the internal consistency of the measure. The method we used for the process is Cronbachs α test, which is widely used for testing the internal consistency of the measurement and increasing the precision of the measurement instrument by precluding the obstructive items from the measurement.

IV. RESULTS AND DISCUSSION

We first check the reliability of the measurements, and the result is shown in Table II. As the table indicates, the reliability coefficients are all higher than the acceptable level of 0.7 [27], thus confirming the internal consistency and reliability of the scales.

When we check the fitness of the model, the result was not very satisfactory, with χ^2/df = 4.615, GFI = 0.705, AGFI = 0.636, CFI = 0.656, IFI = 0.660, TLI = 0.611, and RMSEA = 0.129. The standardize effects between latent variables are shown in Table III. From the goodness-of-fit indices, the model

TABLE III. STANDARDIZED EFFECTS BETWEEN LATENT VARIABLES IN ORIGINAL MODEL

Relation	Direct	Indirect	Total
Behavioral Intention			
AT	0.540		0.540
SN	0.030		0.030
PBC	-0.182		-0.182
PU		0.419	0.419
EoU		0.201	0.201
QoS	0.290		0.290
Attitude towards behavior			
PU	0.782		0.782
EoU	0.050	0.331	0.381
Perceived Usefulness			
EoU	0.425		0.425

TABLE IV. ESTIMATED REGRESSION WEIGHTS WITH HIGH MI IN ORIGINAL MODEL

Path	M.I.	Par Change
AT ← SN	41.217	1.153
PBC ← EoU	35.484	1.758
PBC ← QoS	31.861	0.888
EoU ← QoS	30.156	1.008

showed a poor fit with the data. Also, we recorded a negative weight between perceived behavioral control and intention, which is counter-intuitive. Therefore, we need to modify the model before meaningful interpretations can be made.

There are many different ways to modify or re-specify a model, and we chose to use modification indices (MI). MI is often used to alter models to achieve better fit. In MI, improvement in fit is measured by a reduction in chi-square, and in AMOS, the modification indices have to do with adding arrows – high MI's flag missing arrows which might be added to a model. AMOS output will list the parameter, the estimated chi-square value for this path, the probability of this chi-square, and the "parameter change" (Par Change), which is the estimated new path coefficient when the model is changed. The actual new parameter value may be different from the estimation.

For MI for estimated regression weight, a list of high MI's is shown in Table IV. All other combinations are either having a low MI or a low Par Change, which have insignificant effects on improving the models goodness-of-fit.

For the two paths listed in Table IV that involves perceived quality of service (with perceived behavioral control and with perceived ease of use), the addition of two new arrows indicates that quality of service has a positive effect on both of them. The explanation of these relations could be the following: With a better quality of service, users are better supported by the service provider, which in turn creates an impression for the users that the service is easier to use. The users are also more likely to consider themselves capable of achieving what they want with a better service support.

It can be also noticed from Figure 1 that the path from perceived quality of service to behavioral intention is insignificant, and there is no reason to keep this arrow. On the other hand, even though the path from perceived ease of use to attitude, and the path from subjective norm to behavioral intention, are both insignificant, they are the established relations in TAM and TPB, respectively. Therefore, we will keep these two arrows in the new model.

TABLE V. STANDARDIZED EFFECTS BETWEEN LATENT VARIABLES IN THE MODIFIED MODEL

Relation	Direct	Indirect	Total
Behavioral Intention			
AT	0.286		0.286
SN	0.381	0.187	0.568
PBC	0.145		0.145
PU		0.165	0.165
EoU		0.200	0.200
QoS		0.137	0.137
Attitude towards behavior			
SN	0.650		0.650
PU	0.571		0.571
EoU	0.215	0.160	0.375
QoS		0.230	0.230
Perceived Behavioral Control			
EoU	0.691		0.691
QoS	0.076	0.431	0.507
Perceived Usefulness			
EoU	0.277		0.277
QoS		0.175	0.175
Perceived Ease of Use			
QoS	0.629		0.629

The modified model was analyzed again using AMOS, and the result is shown in Figure 2. This new model adequately reflects a good fit to the data, with χ^2/df = 2.193, GFI = 0.907, AGFI = 0.861, IFI = 0.927, TLI = 0.902, CFI = 0.925, and RMSEA = 0.074. All the items loaded significantly on the construct it was supposed to measure with $p < 0.05$. All but two of the path coefficients (perceived ease of use $\rightarrow$ attitude and perceived behavioral control $\rightarrow$ intention) are estimated with high significant level. The standardized effects between latent variables in the modified model are shown in Table V.

One objective of this study was to assess the applicability of TAM and TPB to the predicting of adoption behavior for VR technology. In addition to the TAM+TPB model studied by [28], which was also called "decomposed theory of planned behavior," we also used a new construct, perceived quality of service, to the model as suggested by [22] to make it richer in content and more applicable in general. The hypothesized model shown in Figure 1 did not show a good fit to the data. From the modification indices provided by AMOS, four additional paths were added and one path was removed. The modified model thus showed a good fit to the data collected.

The modified model concurred with what [28] found. Attitude toward behavior, subjective norm and perceived behavioral control all have positive effects on behavior intention (the TPB portion), and perceived usefulness and perceived ease of use both have positive effects on attitude, with perceived ease of use having positive effect on perceived usefulness (the TAM portion). This result shows the validity of using of TAM+TPB in the study of VR technology adoption.

Among the four added paths, two were originated from perceived quality of service, namely, perceived quality of service to perceived behavioral control and perceived quality of service to perceived ease of use. These two arrows indicate that quality of service has a positive effect on perceived behavioral control and perceived ease of use. The intuition on the introduction of the two arrows is the following: With better service quality, users are better supported by the service provider, which in turn creates an impression for the users that the service is easier to use. At the same time, users also considered themselves more capable of achieving what they

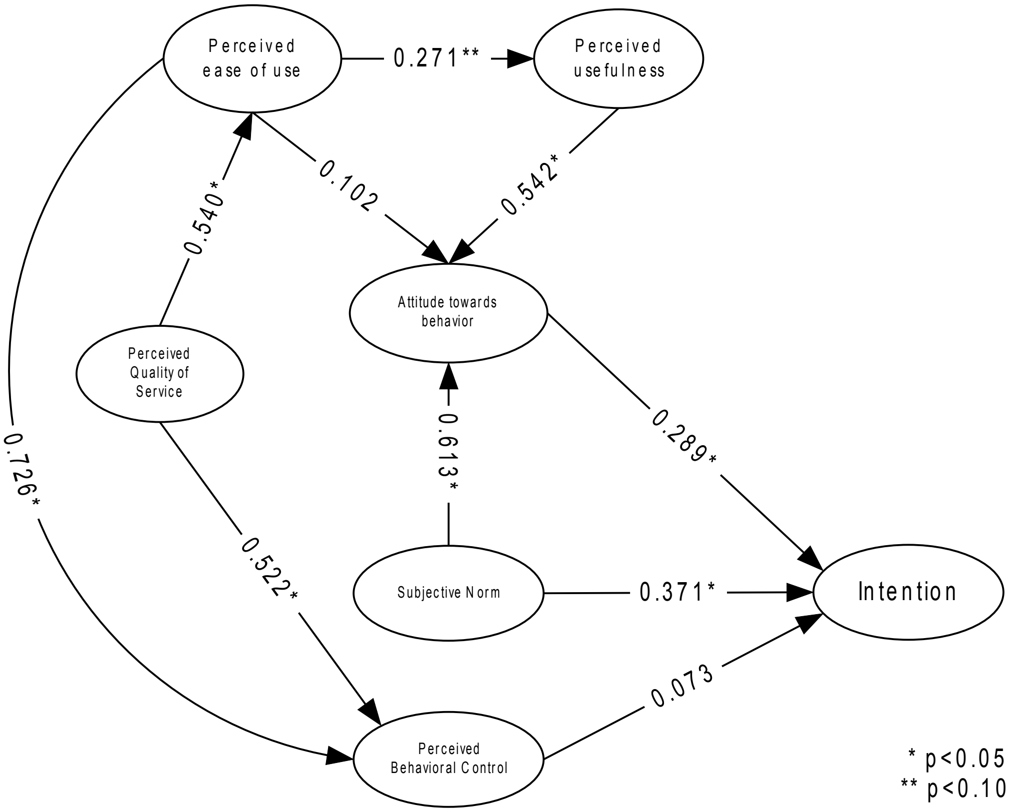

Fig. 2. CFA result for the modified model

want to do (better perceived behavior control) with a better service support. With standardize regression weights of 0.522 (QoS $\rightarrow$ PBC) and 0.540 (QoS $\rightarrow$ EoU), and a p-value of actually less than 0.001, there is a strong support from data that these two relations are valid.

Another new introduction is the arrow from perceived ease of use to perceived behavioral control. If one has the required skills and resources to use VR technology, the easier to use, the more confident (one think) one would be able to handle it. Clearly this relation may not apply to all situations in general, but it should be for most cases in technology related services. Finally, the arrow from subjective norm to attitude suggests that the attitude formation is affected by how significant others consider the performance of the behavior. As in TPB, the behavioral belief will affect ones attitude, and the question is how these beliefs are formed. One possibility is from ones family, colleagues, and peers, the people that are important to the individual. If this is the case, then the effect of these people on ones attitude formation cannot be ignored.

V. Conclusion

In this paper, we presented our study on the attitude and intention towards adopting VR technology in classroom. Our results showed that VR technology adoption can be modeled by a mixture of TPB and TAM, thus allow us to use the revised model we developed in the study to predict and identify the important factors for user adoption of VR technology, and facilitate the adoption process itself.

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