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Attitudes of German University Students towards the Integration of Innovation Information Technology*

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This study was conducted to clarify the relationship of student attitude, subjective norm and perceived behavioral control to the intention of university student's use of innovative information technology for learning and their thoughts about integrating innovative information technology into instruction in Germany. Research subjects were 270 students pursuing different academic degrees at Ilmenau University of Technology. The data were collected by web-based questionnaires. Quantitative analytical methods, including descriptive statistics, reliability analysis, one-way ANOVA, regression analysis, confirmatory factor analysis and a structural equation model were employed using SPSS and AMOS statistic software. The results show that the perceived behavioral control variable has a relationship to students' behavioral intention. Attitudes toward the behavior and perceived behavioral control can predict the intention of the use of innovative IT and for learning in TU Ilmenau students. In addition, most students have positive attitudes toward the use of innovative IT in their tuition, and believe that university instructors and students should be trained to use integrating innovative IT in teaching.

Keywords: behavioral intention; instruction with innovative information technology; theory of planned behavior

1. Introduction

Information Technology (IT) has become a key part of today's teaching and its learning strategies are increasingly becoming a mainstream feature in higher education. Recommendations for the transformation of schools and for innovative teaching practices have been expressed in many countries, such as Japan, the United States, and a number of European countries [1–2]. Integrating IT into instruction has become a global educational objective. For example, in Taiwan, the Industrial Development Bureau of the Ministry of Economic Affairs has also implemented a policy of e-learning from 2007 to 2011 in order to promote the productivity of teaching and learning in the classroom. To improve the quality of learning and teaching, the educational authority also regards IT as an educational tool that will inevitably grow in importance [3]. In addition, a large body of research has focused on the effects of technology on student achievement, their self-conceptualization, and their attitudes towards e-learning. Fewer studies have attempted to look at how teachers integrate innovative information technology into engineering education at the university level [4–5]. Selim [6] also puts emphasis on the need to investigate how instructional technologies can be integrated to improve the learning process. However, it is also important to understand how students think about innovative information technology for learning during the teaching process and behavior intention. Thus, discovering the students' attitudes and thinking can be useful to instructors for instructional design and serve as a method of using integrated IT in university curricula [7].

2. Review of the related literature

2.1 Theory of planned behavior

The Theory of Planned Behavior (TPB) is a theory about the links between attitudes, belief and behavior. It was proposed by Icek Ajzen [8] in his article

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'From intentions to actions: A theory of planned behavior.' According to Ajzen, TPB helps us to understand how we can change the behavior of people, and predict deliberate behavior, because the behavior can be deliberated on and planned [9–11]. TPB has its roots in the theory of reasoned action (TRA), which was brought forward by [12]. A high correlation of attitude toward behavior and subjective norms to behavioral intention has been confirmed in many studies [13–14]. Briefly, the TPB [8–9] has three main conceptual determinants of intention. The first predictor is the attitude towards the behavior, which refers to the degree to which a person has a favorable or unfavorable evaluation of a specific behavior. The second predictor is a social factor, termed the subjective norm, which refers to the perceived social pressure to carry out or not carry out the behavior. The third predictor is perceived behavioral control, defined by Ajzen as '. . . people's perception of the ease or difficulty of performing the behavior of interest' [11]. Based on the TRA and TPB we can understand that university students could be affected by their attitudes and beliefs when they incorporate IT into their learning.

In recent years there has been an increasing focus on the model of theory of planned behavior in Taiwan. It has been popularly applied to studies of the relations among beliefs, attitudes, behavioral intentions and behaviors in various fields such as individual/organizational behavior, public relations, campaigns, healthcare, e-commerce, management, human resources, and computer system design. A number of studies conducted in the last years have used the theory of planned behavior in an attempt to understand peoples' intentions to engage in a number of activities. These have been quite diverse and have included activities such as smoking cessation, educational decision, customer behavior, volunteer enrollment, and engagement with leisure activities [15–18], yet fewer studies have examined student attitudes towards the use of ICT interactions in higher education [19]. These studies indicate that the application of the theory of planned behavior deals with attitudes, subjective norms, and perceived behavioral control. However, TPB is less often used to examine e-learning issues—in particular, university students' attitudes towards using innovative IT for learning. Here, this study used a quantitative questionnaire to explore the relations between attitudes, belief, and the behavior of German university students toward the integration of innovative information technology into instruction.

2.2 European Information Technology for Higher Education

In recent years, the European Union (EU) government has emphasized integrating IT into European curricula in higher education by establishing some EU transnational projects such as i2010, BIT2010, eEurope2005, and U Teacher [7]. To integrate informational technology into education and training systems is particularly emphasized in European countries [20–21]. Take the i2010 initiative, for instance. The i2010 strategy is the EU policy framework for the information society and media. It promotes the positive contributions that information and communication technologies can make to the economy, society and personal quality of life. The European Commission presented it in June 2005 as the new initiative for the years up to 2010. In addition, it is very important to understand how students think about IT for learning during the teaching process. Discovering a student's thinking and behavior intent can be provided for in instructional design and it can serve as a method of using integrated IT in university curricula.

For the past few years, a Europe Action Plan has been dedicated to education through an e-learning initiative. Its objectives are to incorporate ICT into higher education. This is the reason for much research to explore ICT on this issue. For example, [22] describes the results of a research study on e-learning across Europe, with his main focus on the learners and their needs. He found that the need for innovation in eLearning is not in the area of technological innovation, but rather pedagogical innovation. However, today's technological opportunities can be used for pedagogical innovation. As shown in [23], for example, knowledge engineering and data mining technologies are used to optimize university curricula with respect to individual profiles and chances of success. This provides an increased value for the learners and should therefore play a more important role in eLearning projects. Knauf's study forms a fundamental base for the current study's attention to European students' perspectives. Salajan [21] studied e-learning programs for higher education systems of the member states of the European Union. The study investigated many aspects of an e-learning program and other e-learning actions within other European programs through a series of in-depth open-ended interviews with academics and researchers in order to investigate their interactions with European-funded programs in e-learning. This study points out that European 'technocracy' is the main reason for failing to induce sweeping changes in European higher education. It is necessary for universities and national governments to take measures that can hasten the appropriation of ICTs in higher education. In learning how to integrate innovative IT into instruction at TU Ilmenau, researchers use: (1) the integration of 3D virtual space into instruction and research and

(2) the university's Remote Engineering Application Laboratory.

1. *Integration of 3D virtual space into instruction*: The Virtual Reality Competence Centre of TU Ilmenau combines the multidisciplinary and technical competences and experiences across TU Ilmenau in the fields of virtual and augmented reality, virtual prototyping, real-time rendering, usability engineering, industrial information systems, media design, media psychology, and industrial engineering. The centre operates the integration of such IT incorporating into instruction by such 3D virtual materials as 3D books, virtual factories, virtual molecular cells, mechanical engineering, car design, and other engineering education applications. Many of these applications have the advantage of helping students understand the complexity of knowledge, and helping students to understand abstract formulae by 3D instructional examples, as well as using the virtual factory to reduce the risk of on-the-job practice.
2. *Remote Engineering Application Laboratory*: The instructional concept of the Remote Lab has been designed and developed by the 'Integrated Communication Systems Group' at the university to deal with the design of a complex digital control system in order to promote student learning in engineering education. Henke *et al.* [24] have pointed out that learning design of control systems requires not only deep theoretical knowledge but also the practical experience that can be acquired in the laboratory. The goal of the remote lab is to examine and implement new techniques for a development and training system based on Finite State Machines. Their contribution is to present means and methods required for providing this tool set web-wide for a large user base that is independent of the operating system. The instructor can operate the remote system and connect to the real laboratory. On the other hand, students can learn flexibility and learn individually and it also allows convenient access at any time or any place.

Past researchers have investigated the fact that IT plays an indispensable role in higher education, and is integrated into many subjects, curricula, learning materials, and teaching and learning environments. A comprehensive literature review [25–27] suggests that the three main factors affecting teachers' use of IT in instruction are: the teacher's personal factors (attitudes, beliefs, knowledge, skills, and professional development); instructional resources; and school context factors (curricular, institutional, and key persons promoting ICT). TU Ilmenau has tried to incorporate innovative IT into instruction through 3D virtual spaces and their Remote Engineering Application Laboratory. After reviewing related research of TPB, studies verified that attitude [19, 28–29], subjective norm [30], and perceived behavioral control [28] variables have a relationship to behavioral intention [31–32]. Prior studies have found that both TAM and TPB predict behavioral intention well, with the impact of the TAM being more robust than that of TPB [28, 32]. However, Mathieson [32] pointed out that TAM supplies only very general information about ease of use, while TPB delivers more specific information. Measuring the system's performance on various outcomes serves as the justification for choosing TPB to be the main theoretical framework of this research.

3. Methodology

3.1 Description of the methodology

This research takes a mixed-methodology approach to the analysis of the data, being both qualitative and quantitative. A literature review and expert consultant were used to construct the questionnaire and conceptual framework. The questionnaire method was used to verify the structural model and each hypothesis. Research samples were from Ilmenau University of Technology students in Germany. It took one year to conduct this study from April 2008 to April 2009. During the period from April to September 2008, the researcher mainly revised and evaluated [33] the questionnaire, ran a pilot questionnaire, observed classes, collected data, and informally interviewed university students and instructors in order to get feedback to revise the original questionnaire content. The survey was collected between April 2008 and March 2009 and analysis performed.

3.2 Design of the study and hypotheses

The relationships among selected variables (gender, age, and academic degree) were used in examining the behavioral intention of the students' use of innovative information technology for learning. The study was designed to test the following hypotheses:

H1: There is significant difference between background information variables (gender, age, and academic degree) and dependent variables (attitude, subjective norm, perceived behavioral control and behavioral intention).

H1-1: There is significant difference between gender and dependent variables.

H1-2: There is significant difference between different ages and dependent variables.

H1-3: There is significant difference between

different academic degrees and dependent variables.

H2: There is a significant relationship between attitude and behavioral intention in the use of innovative IT for learning.

H3: There is a significant relationship between subjective norm and behavioral intention in the use of innovative IT for learning.

H4: There is a significant relationship between perceived behavioral control and behavioral intention in the use of innovative IT for learning.

The proposed model (see Fig. 1) represents the theory of planned behavior for student use of innovative IT for learning.

3.3 Research sample and selection of subjects

A small pilot study was conducted on 20 students with the aim of testing data collection procedures. The pre-testing and the pilot study led to some small modifications of the questionnaire. Students who took part in the pilot study were excluded from the subsequent formal study. Furthermore, informal interviews were conducted with these students about the questionnaire content and their perspectives of integration of IT into learning. For more details see [7]. The formal survey subjects were the TU Ilmenau students at different academic degree levels, including diploma, Bachelor's, Master's, and doctoral students. A total of 6252 questionnaires were distributed to all students by e-mail. 270 students agreed to accept the survey and fill out the online questionnaire. Since one questionnaire was incomplete, a total of 269 usable surveys were used.

3.4 Research instruments

The items in the questionnaire were designed to represent the concepts identified in the literature review and theory of planned behavior. The main questionnaire items were a revised version of the content of [33] attitudes towards the use of instructional technology questionnaire. The initial questionnaire contained three parts (see Appendix 1). Part 1 of the survey consisted of 41 questions. Each construct was evaluated using a 5-point Likert-type scale as follows: '5'—strongly agree; '4'—agree; '3'—neutral; '2'—disagree; '1'—strongly disagree. Part 2 of the survey consisted of background information: gender, age, country, academic degree, and major subject. Part 3 of the survey consisted of five open-ended questions exploring students' thoughts about integrating IT into instruction in the university. In addition, in this questionnaire, we

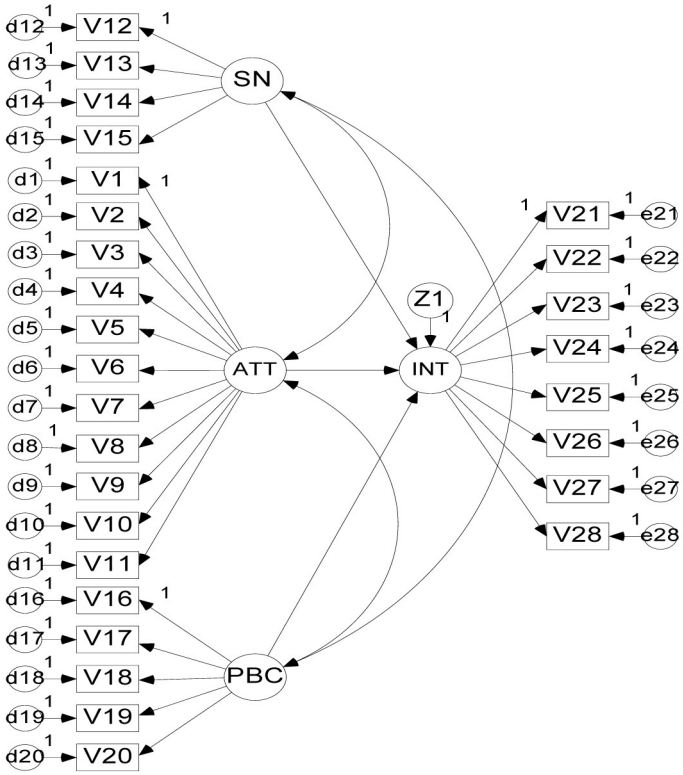

Fig. 1. Framework of structural equation modeling. ATT: attitude; SN: subjective norm; PBC: perceived behavioral control; Intention: intention in use of innovative IT for learning.

Table 1. Alpha coefficients of the formal study ($N = 269$)

Factor	Item numbers	Cronbach's alpha
Attitude toward the behavior	1~11	0.857
Subjective norm	12~15	0.783
Perceived behavioral control	16~20	0.684
Intention to use IT for learning	21~28	0.733
Overall instrument	28	0.887

defined innovative Information Technology for Learning (ITL) as follows: the students' use of a remote engineering and virtual laboratory, or the use, during the learning processes, of a virtual campus and e-learning technology.

3.5 Reliability of research instrument: Formal study

The Cronbach's alpha coefficients' test was conducted a second time for the TPB theory constructs by using completed questionnaires from the 269 respondents. Table 1 shows the Cronbach's alpha coefficients for each theoretical construct in this study: coefficients for attitude, subjective norm, perceived behavioral control, and intention and are 0.857, 0.783, 0.684, and 0.733, respectively. The overall alpha coefficient of 0.887 was acceptable. As shown in Table 1, the values are either close to or above 0.70. Although the numbers are not as high as those obtained in Mak's studies that used the same items, they are in a range that is deemed acceptable, based on common threshold values recommended by the literature [34]. Thus, the formal survey instrument consisted of 28 structural questions and five open-ended questions.

3.6 Analysis of data

Data analysis methods were as follows:

1. Descriptive statistics were used to determine background information of the respondents.
2. One-Way Analysis of Variance (ANOVA) test was performed to determine the differences that emerge between the selected variables and the intention to use innovative IT for learning. The rejection level of the hypotheses was set at α= 0.05.
3. Structural equal modeling analysis was used to determine if a relationship exists between the intention to use IT for learning and the three main components of the theory of planned behavior: attitude, subjective norm, and perceived behavioral control.
4. The assessment of the model fit was based on the goodness-of-fit Index (GFI > 0.90), adjusted GFI, (AGFI > 0.90), standardized RMR (Standardized RMR < 0.50) Root-Mean-Square Error of Approximation (RMSEA < 0.50) and chi-square to the degree of freedom ratio (χ^2/df < 2.00). Quantitative data were analyzed using the statistical software for SPSS and AMOS.
5. In addition, qualitative data were analyzed and collected from open-ended questions in the questionnaire. These students were asked to state their thought about integrating IT into teaching and learning in the university. They were asked to use their own words and statements were suggested in English. These responses to qualitative information were reduced and put through content analysis organizing the data, establishing code, classifying into main categories, and analyzing and interpreting the appropriate concepts.

4. Findings and discussion

4.1 Background information of respondents

In this formal survey, there are 170 males and 99 females. Over 60% of the respondents are male. There are 102 students (37.9%) from 15 to 20 years old, 130 students (48.3%) from 21 to 25 years old, 28 students from 26 to 30 years old, and nine students over 31 years old. Thus, almost all students are 15–25 years old. Only nine respondents are international exchange students, with the rest from Germany. There are 63 diploma students (23.4%), 135 bachelor's degree students (50.2%), 59 master's degree students (21.9%), and 12 doctoral students (4.5%).

4.2 Relationship of background Information variables toward dependent variables (attitude, subjective norm, perceived behavioral control and behavioral intention)

H1-1: There is significant difference between gender and the dependent variables.

After independent sample t-test analysis, these results were as shown as follows: (1) With regard to the attitude towards behavior, the results are: t = 1.340, df = 267, p = 0.181 > 0.05. Thus, there is no significant difference between gender and attitude in the behavior. (2) With regard to the subjective norm, the results are: t = 0.667, df = 267, p = 0.505 > 0.05. Thus, there is no significant difference between gender and subjective norm. (3) With regard to the perceived behavioral control, the results are: t = 2.580, df = 267, p = 0.010 < 0.05. Thus, there was a statistically significant difference between gender and perceived behavioral control. The mean of males' (M = 16.21) perceived behavioral control variable is higher for females (M = 15.16). (4) With regard to the behavioral intention, the results are: t = 0.011, df = 267, p = 0.991 > 0.05.

Thus, there is no significant difference between gender and behavioral intention.

H1-2: There is significant difference between age and the dependent variable.
In order to ascertain whether or not there is significant difference between age and the dependent variable, one way ANOVA was used. The ANOVA analysis was for age and the four variables; these results are shown as follows: (1) With regard to attitudes toward the behavior variable, the F value is significant ($F = 4.16$; $p < 0.05$), so we reject the null hypothesis. Based on this result, there is a significant difference between different ages and attitudes toward behavior. Continued analysis was performed with posteriori comparison. (2) With regard to the subjective norm variable, the F value is not significant ($F = 1.97$; $p > 0.05$); thus, we accept the null hypothesis. There is no significant difference between different ages and the subjective norm. (3) With regard to the perceived behavioral control variable, the F value is significant ($F = 3.04$; $p < 0.05$), thus we accept the null hypothesis. Based on the result, there is a significant difference between different ages and perceived behavioral control. Continued analysis was performed with posteriori comparison. (4) With regard to the intention to use IT for the learning variable, the F value has a significant difference ($F = 4.22$; $p < 0.05$); thus, we reject the null hypothesis. Based on the result, there is a significant difference between different ages and intention to use IT. Continued analysis was performed with posteriori comparison. Scheffé posteriori comparison shows the results of posteriori comparisons for three variables (subjective norm, behavioral control, intention to use IT for learning). The variable of perceived behavioral control and the variable of intention to use IT for learning are not significant among different age groups. For the attitude toward the behavior variable, there is a significant difference between the 26–30 age group and the 15–20 age group. 26 to 30 year-old students have a stronger attitude toward behavior than do 15 to 20 year-old students. In general, students over 26 years old are Master's or doctoral students, and have higher attitude toward the behavior, subjective norm, perceived behavioral control, and intention to use IT for learning.

H1-3: There is significant difference between different academic degrees and dependent variables.
In order to determine whether or not there is significant difference between academic degrees and the dependent variable, one way ANOVA method was used. ANOVA analysis was between different academic degrees and four variables; these results are shown as follows: (1) With regard to the attitude toward the behavior variable, the F value does not show a significant difference ($F = 0.38$; $p > 0.05$); thus, we accept the null hypothesis. There is no significant difference between different academic degrees and attitude toward the behavior. (2) With regard to the subjective norm variable, the F value shows a significant difference ($F = 2.89$; $p < 0.05$); thus, we reject the null hypothesis. Based on this result, there is a significant difference between different academic degrees and the subjective norm. Continued analysis was performed with posteriori comparison. (3) With regard to the perceived behavioral control variable, the F value does not show a significant difference ($F = 0.31$; $p > 0.05$), thus we accept the null hypothesis. There is no significant difference between different academic degrees and perceived behavioral control. (4) With regard to the intention to use IT for the learning variable, the F value does not show a significant difference ($F = 2.09$; $p > 0.05$), thus we accept the null hypothesis. There is no significant difference between different academic degrees and the intention to use IT for learning. Scheffé posteriori comparison is shown the results of posteriori comparison for the subjective norm. There is a significant difference between Bachelor's degree students and diploma students. Bachelor's degree students have a higher subjective norm than diploma students. Since Bachelor's students are partially composed of freshmen and sophomore students who have less higher education experience than students pursuing other degrees, they are more likely to follow university rules. In contrast, other degree students have studied at the university for longer, developing coping strategies with regard to rules and regulations: they know better which norms must be obeyed. Doctoral students have the highest means among the attitude toward the behavior, perceived behavior control, and intention to use IT for learning. Diploma students have the lowest means among the four variables.

4.3 Structural equation modeling analysis

H2: There is a relationship between attitude and behavioral intention to use innovative IT for learning.

H3: There is relationship between subjective norm and behavioral intention to use innovative IT for learning.

H4: There is relationship between perceived behavioral control and behavioral intention to use innovative IT for learning.

4.3.1 Confirmatory Factor Analysis

The questionnaire was analyzed by Exploratory Factor Analysis (EFA) during the pilot study process. AMOS 16.0 was then used to confirm factors

by Confirmatory Factor Analysis (CFA) for use in the formal study. The method of maximum likelihood was used to evaluate factorial validity. Structural Equation Modeling (SEM) is a statistical technique that combines the measurement model (Confirmatory Factor Analysis) and the structural model (Regression or Path analysis) into a statistical test. Byne [35] asserted that SEM also allows for estimating error variances, and is able to incorporate both observed and latent variables. This SEM statistical test was conducted to clarify the relationship between attitude, subjective norm, and intention of the students' use of innovative information technology for learning. The initial proposed SEM measurement model was composed of twenty eight observed variables and the covariance matrix of these variables was used to conduct a CFA. The estimated methods of structural equation modeling such as maximum likelihood and generalized least square were greatly affected by the variable distribution. Kline [36] identified threshold values of ±3 for skewness and ±10 to ±20 for kurtosis. The means of the attitudes, subjective norm, perceived behavioral control and intention responses ranged from 2.22 to 3.92. The standard deviation responses ranged from 0.862 to 1.157. The skewness represents responses ranging from –0.928 to 0.073, which indicated that data were skewed left. The kurtosis responses ranged from –0.993 to 0.757, which indicated that V2, V3, V4, V5, V8, V9, V12, V16, V17, V18, V19, V20, V22, V23, V24, V25, V27, and V28 had flat distributions and V1, V6, V7, V10, V11, V13, V14, V15, V21, and V26 had peaked distributions. Based on these findings, these values of skewness and kurtosis can be also accepted in the scope. Therefore, the maximum likelihood method was used to estimate the SEM model.

The p-values for V23, V24, V25, and V28 were not significant as they are above 0.000. In addition, factor loading was lower than 0.5 for V2, V3, V5, V9, V12, V16, V17, V23, V24, V25, V27 and V28. Based on these results, V2, V3, V5, V9, V12, V16, V17, V23, V24, V25, V27, and V28 were deleted. The overall fit of the initial proposed model appeared to be unsatisfactory (see Table 2), as none of the goodness-of-fit indices, GFI, AGFI, or CFI reached the required 0.90. The RMSEA value is 0.10, which is higher than the tolerable value 0.05. The χ^2/df ratio is 3.91, which was higher than the 2.00 limit. The standardized RMR is 0.00, which fits an index lower than 0.05. Therefore, the initial proposed model was rejected.

4.3.2 Modification of the Theory of Planned Behavior Model

After deleting some observed variables, a second TPB model was proposed. All observed variables are significant, and the factor loading is nearly equal to or higher than 0.5. The overall fit of the second proposed model appeared to be satisfactory. In terms of evaluating the model's fit, Bagozzi and Yi [37] proposed three main evaluative methods, including (1) preliminary fit criteria, (2) overall model fit, and (3) internal structure fit of the model. The second TPB model results were analyzed by these three criteria and are presented in Table 3.

1. *Preliminary fit criteria*: All residual variances are positive values, and residual variance $p < 0.01$. Absolute values of observed variables' correlations are between 0.19 and 0.80, such that fit an index not near 1. Factor loading of observed variables is between 0.55 and 0.90, which fits the index between 0.5 and 0.95.
2. *Overall model fit*: In terms of χ^2 significance, it is not a fit, but rather a reference value, because the χ^2 value will change with the size of the sample. In addition, goodness-of-fit indices GFI and AGFI reach the point of 0.90. NFI value is 0.67, which does not reach the fit value of 0.90. IFI and NNFI values are 0.86 and 0.81 near the 0.90 acceptable value. The RMSEA value is 0.04, which fits an index lower than 0.05. The χ^2/df ratio is 1.53, which fits an index below the 2.00 limit. The standardized RMR is 0.05, which does not fit an index below 0.05, but it is an acceptable value. Therefore, the second proposed model is accepted, and the standardized and unstandardized models of TPB are presented in Figs 2 and 3.
3. *Fit of internal structure of model*: Composite reliability and average variance extracted by latent variable and the evaluative results of the internal structure of the model. The individual item reliability is between .30 and .81, with some not higher than 0.50. The composite reliability is between 0.44 and 0.81, not entirely higher 0.60, but within an acceptable range. These average variances extracted are between 0.22 and 0.59, which are not entirely higher than 0.50. The standardized residuals value is $p < 0.5$, which fits an index lower than 0.50. These standardized residuals are between –1.46 and 2.48, which also does not fit an index lower than 1.96, but it is still in an acceptable range. To sum

Table 2. Confirmatory factor analysis of initial TPB model

Index	RMSEA	χ^2	df	χ^2/df	*p*	GFI	AGFI	CFI	RMR	SD RMR	ECVI
	0.10	1364.38	349	3.91	0.00	0.72	0.67	0.66	0.17	0.00	5.52

Table 3. Evaluative results of the second TPB model by the three criteria

Fit indices	Research result	Evaluation
Preliminary fit criteria		
All residual variance are positive values	Yes	Fit
Residual variance $p < 0$ .01	Yes	Fit
Absolute value of observed variables' correlations are not near 1	Between 0.19 and 0.80	Fit
Factor loading between 0.5 and 0.95	Between 0.53 and 0.90	Fit
Overall model fit		
χ^2 $p > 0.05$	128.38, $p < 0.001$	Reference value
χ^2/df < 2	1.53	Fit
GFI > 0.9	0.94	Fit
AGFI > 0.9	0.91	Fit
SRMR < 0.05	0.06	Acceptable
Δ_1 (NFI) > 0.9	0.67	Not fit
Δ_1 (IFI) > 0.9	0.86	Acceptable
NNFI (TLI) > 0.9	0.81	Acceptable
RMSEA < 0.05	0.04	Fit
Fit of internal structure of model		
Individual item reliability > 0.5	Between 0.30 and 0.81	Not fit
Composite reliability > 0.6	Between 0.44 and 0.81	Acceptable
Average variance extracted > 0.5	Between 0.22 and 0.59	Not fit
All estimated value $p < 0.5$	$p < 0.5$	Fit
Standardized residuals <1.96	Between –1.46 and 2.48	Acceptable

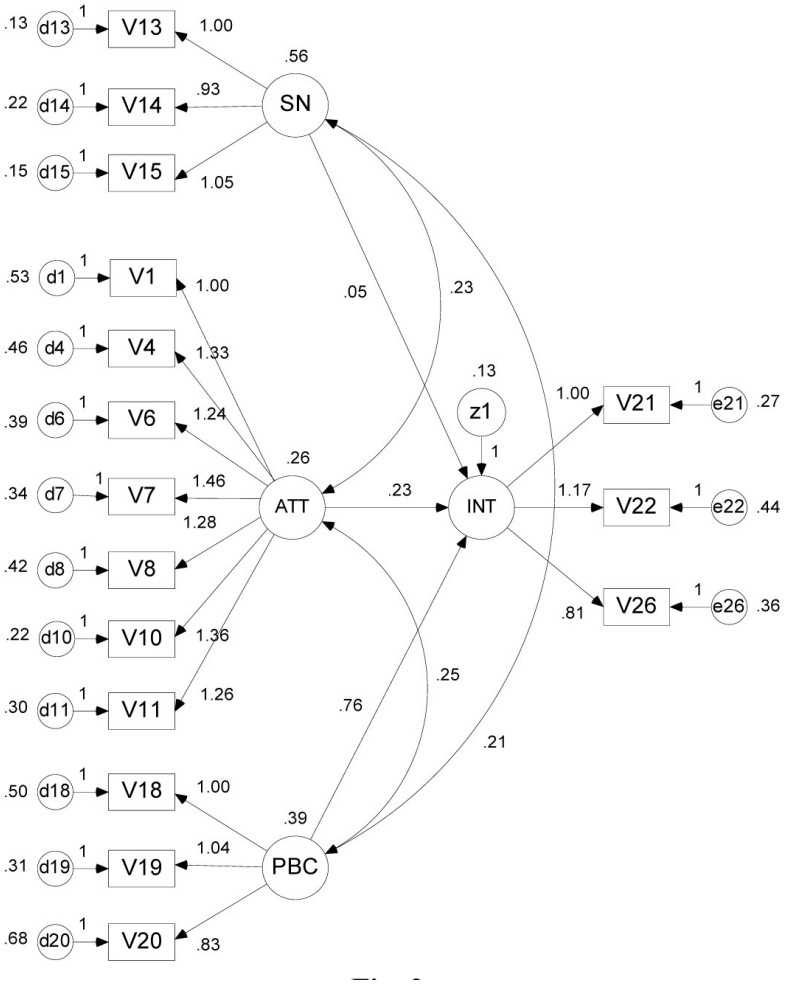

Fig. 2. Unstandardized model of TPB (2nd model).

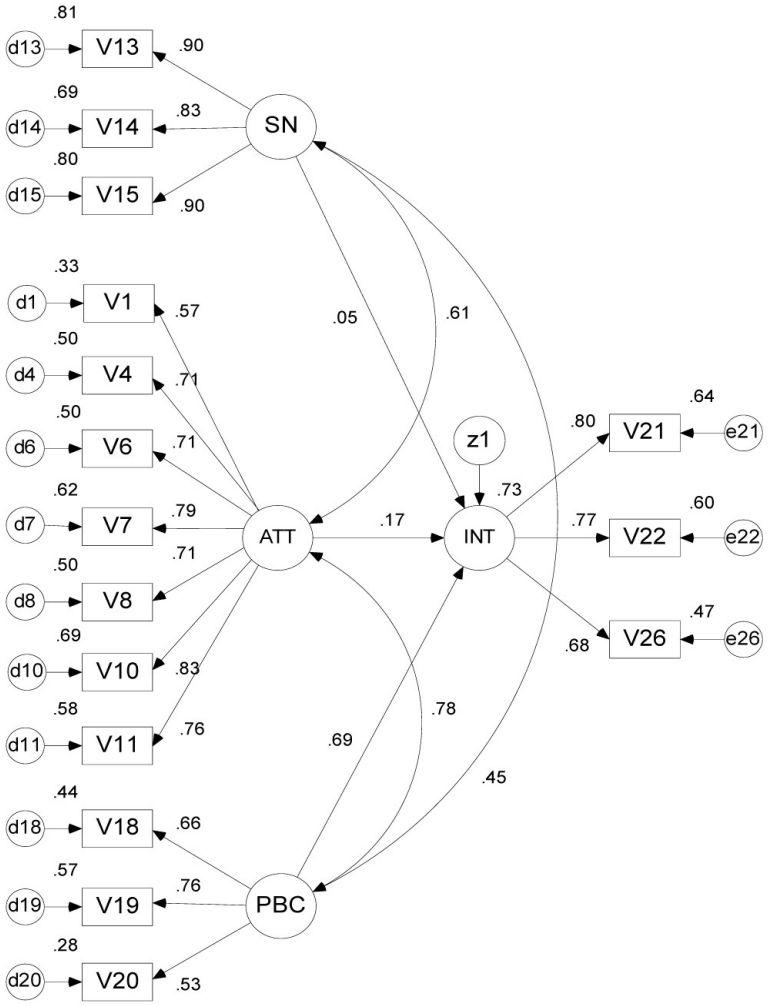

Fig. 3. Standardized model of TPB (2nd model). ATT: attitude; SN: subjective norm; PBC: perceived behavioral control; Intention: intention in use of innovative IT for learning.

up, these three main evaluative methods' analysis of the overall fit of the second proposed model appears to be satisfactory in the goodness-of-fit indices. Therefore, the second proposed model is accepted (see Figs 2–3).

Finally, the relationship of latent variables used in examining the prediction of the dependent variable was explored. A regression analysis was run by using the following model: Intention = Attitude + Subjective norm + Perceived behavioral control. Table 4 shows that only the attitude toward the behavior and perceived behavioral control can predict the intention to use innovative IT for learning (R Square = 0.46). This regression model was able to explain a significant degree of variation in responses

Table 4. Regression analysis model summary

					Change statistics				
Model	**R**	**R square**	**Adjusted R square**	**Std. error of the estimate**	**R square change**	**F change**	**df1**	**df2**	**Sig. F change**
1	0.62a	0.38	0.38	1.90	0.38	164.95	1.00	267.00	0.00
2	0.68b	0.46	0.46	1.78	0.08	39.87	1.00	266.00	0.00

a. Predictors: (Constant), PBC
b. Predictors: (Constant), PBC, ATT

with $F = 164.95$ and a level of significance of $p = 0.00$.

4.4 Qualitative data analysis

The qualitative data were collected from three parts of the formal questionnaire. Five questions were designed to explore students' thought about integrating IT into the instruction. The analysis results of open-ended questions follows.

Question 1: What do you think about information technology for learning (ITL) in the university?
A total of 269 students, here denoted as S1 to S269, participated in the questionnaire survey. There were 181 replies to Question 1. These qualitative questions were analyzed by content analysis by organizing the data, establishing a code, classifying into main categories, and finally analyzing and interpreting the concepts presented. The framework was first summarized for concept analysis in Question 1. The findings represents student thinking about information technology for learning in the university; there are 122 students who hold think positively toward IT for learning in the university, 21 students who hold negative thinking toward IT for learning in the university, and 16 students who hold both positive and negative thinking. There were 9 students who provided some suggestions, and 14 students who held other opinions and thoughts. On the whole, according to the findings shown in a research, the researcher found that most students think it is positive to use IT for learning in the university and IT for learning is helpful, useful, good, important, and necessary, some students who hold both positive and negative thinking provided some suggestions.

Question 2: What's the positive impact of information technology on teaching and learning?
Analysis of the 174 students' opinions produced seven conclusions from Question 2. Most students think IT can be used to facilitate teaching and learning, access information, be more interactive and communicative, provide rich learning resources, give flexible and individual learning, saves time, and presents teaching materials easily and efficiently.

Question 3: What are the negative impact of information technology on teaching and learning?
Analysis of the 150 students' opinions produced nine conclusions. Students pointed out 'they do not know how to use IT for effective learning methods', which is an important key point to promote IT for leaning. In addition, there were opinions on the negative impact of IT on teaching and learning, including IT lacks interaction, too much dependence on IT, easily distracted, wastes too much time, information is uncertain, costs too much, Using IT is generally unhealthy behavior, and results in one getting fat easily. Only nine students thought that there is no negative impact of IT on teaching and learning.

Question 4: What's the largest benefit of IT on your learning?
Analysis of the 147 students' opinions produced seven conclusions. The most students think 'Promoting student learning and understanding of knowledge easily' is the largest benefit of IT on their learning. Others pointed out different benefits, for example, enhancing individual learning and flexibility, getting information quickly and easily, providing rich information and knowledge, multimedia rich learning and enhanced visualization, promoting interaction and communication, and saving time and money.

Question 5: Do you have other suggestions for integrating information technology into teaching instruction in the university?
Analysis of the 60 students' opinions produced seven conclusions. Students proposed some of the same opinions and suggested integrating information technology into teaching instruction in the university. Students pointed out that university should provide more useful IT-based learning materials, providing educational training to instructors for integrating IT into instruction, standardized and effective e-learning platforms that can evaluate students' learning, and training that facilitates IT integration into student learning. Integration of IT into instruction requires further evaluation, and need more interaction. Only two students do not want to use IT for learning.

4.5 Discussion of findings

4.5.1 Discussions of quantitative data

The literature review found that prior research has not often explored the relationships between students' background information variables and dependent variables. The gender, age, and academic degree findings were described as follows:

About gender
This study finds no significant difference between gender and the three dependent variables (attitude towards the behavior, subjective norm and behavioral intention). However, there was a statistically significant difference between gender and perceived behavioral control. Males perceived behavioral control to be higher than did females. Another

finding in other studies—there is a statistically significant relationship between the attitudes of the students and gender, with women being more positive than men [39].

About age

The variables of subjective norm, perceived behavioral control and intention to use IT for learning do not exhibit significant difference among different age groups. Yet for the variable of attitude toward the behavior, there is a significant difference between the 26–30 age group and the 15–20 age group. That is, 26 to 30 year-old students have a more positive attitude toward behavior than do 15 to 20 year-old students. 15 to 20 year-old students have the lowest mean of attitude toward behavior, which suggests that this group of students have just entered university and most do not have a lot of experience in the integration of IT for learning. In addition, the 21–25 year-old group of students has the lowest mean of the subjective norm, perceived behavioral control, and intention to use IT for learning. The group of students over 31 years-old has the highest mean of the subjective norm, perceived behavior control and intention to use IT for learning. This suggests that the longer the students have access to higher education, the more positive their attitude towards the use of IT in learning will be.

About academic degree

TU Ilmenau provides different degrees, including Bachelor's, Master's, and doctoral degrees. Currently, it still provides a diploma degree, though its continuation is not certain. The diploma degree (from the Greek $\Delta\acute{\iota}\pi\lambda\omega\mu\alpha$, diploma) is used primarily in European countries including Germany, Austria, Switzerland, Estonia, Croatia, Serbia, Ukraine, Belarus, Greece, and Hungary. This research shows that there is no significant difference between the academic degree being pursued and the attitude perceived behavioral control, or intention to use IT for learning. However, there is a significant difference between different academic degrees and the subjective norm. This study finds that Bachelor's degree students have a higher subjective norm than diploma students**.** Bachelor students have the highest mean of subject norm compared with students studying for the other three degrees. This group of students is the youngest in the research sample in the new German education system, resulting in a higher attitude of subjective norm. Doctoral students have the highest mean in the attitude toward the behavior, perceived behavior control and intention to use IT for learning. These correspond very closely with the results of the different ages discussed in the preceding paragraph. Students over 31 years old also have the highest mean of perceived behavior control and intention to use IT for learning. Most students over 31 years old are doctoral students at the university. These results are most reflective of the fact that doctoral students are most likely to possess more active learning and self-control than those pursuing other degrees. The findings point out that these students appeared to have higher attitudes toward perceived behavior control when pursuing higher degrees. Diploma students have the lowest mean of subjective norm; perceived behavioral control, and intention to use IT for learning. This study infers that the reason for this is due to the students' relative inexperience.

About the TPB model

The alternative model attained satisfactory goodness-of-fit statistics (see Fig. 4). Figure 3 presents the structural coefficients (i.e., regression coefficients) and finds that the strongest predictor of intention was perceived behavioral control (0.69), followed by attitude (0.17) and subject norm (0.05). The two regression coefficients of attitude and subject norm do not show significant difference from intention, most likely because of the small sample size. In addition, this study finds that there are seven main factors affecting attitude: Save time, ITL increasing student learning, enriching learning methods, improving students' learning effectiveness, allowing the teacher to teach more by using ITL, enriching student learning methods by using ITL, and ITL causing positive changes to students' learning methods. Three main factors affecting subject norm were found: computer technology support staff, friends, and university administrators' use of ITL. Similarly, three main factors affecting perceived behavioral control were: ease for students to set aside time to work on ITL, adopting ITL for the course, and developing ITL learning materials. For intention, the three main factors are: student intent to use ITL in the semester, willingness to use ITL whenever they can, and setting aside time to work on ITL. A high correlation of attitude toward behavior and subjective norms to behavioral intention has been confirmed in many studies [12–14]. After regression analysis, the findings of this study, attitude toward the behavior and perceived behavioral control can predict the intention to use innovative IT for learning, while the subjective norm cannot predict the intention, results that have been found in prior studies [31, 28]. In addition, [38] pointed out that the impact of the TPB is more robust than the TAM. Further, that TPB can predict intention to use a new technology well has been confirmed in some previous studies [33].

Keller and Cernerud [39] pointed out that in integrating IT into instruction, the key factor is to

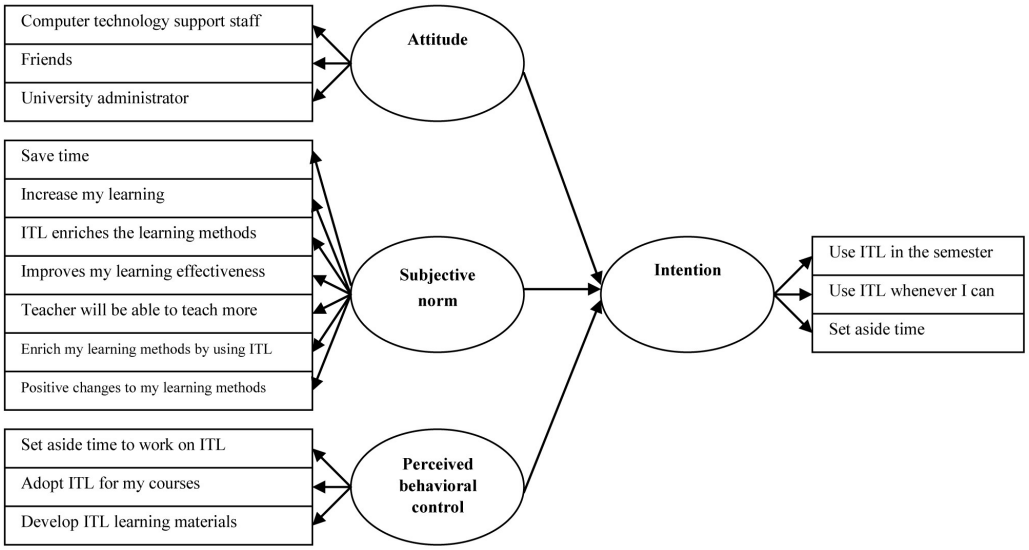

Fig. 4. Theory of planned behavior. Alternative model.

focus on teaching strategies, and students have fewer positive attitudes to using the e-learning platform. Some researchers provided different research results, such Jung *et al.* [29] whose exploration of university student attitudes towards using the e-learning system found a positive effect and the Siragusa and Dixon [19] study that found that students' attitude towards using IT interactive will have a positive effect. This study also found that TU Ilmenau student attitudes towards using innovative IT for learning would predict either, or have a positive effect. In conclusion, attitude, subjective norm, and perceived behavioral control variables have a relationship to students' behavioral intention that has been confirmed in prior studies [29–31]. However, an only perceived behavioral control variable has a relationship to students' behavioral intention in this study. Researchers think that the most likely reason is the small sample size. In addition, attitude toward the behavior and perceived behavioral control can predict the intention to use innovative IT for learning for TU Ilmenau students. The strongest predictor of intention in this study was perceived to be behavioral control.

4.5.2 Discussions of qualitative data

This research analyzed student opinions expressed in five qualitative questions and cross-linked associations (see Fig. 5) to explore the relationships. Figure 5 shows similar conceptions coded by shading, and these responses can be summarized by nine conclusions as follows:

1. Although a minority of students (11.54%) do not think of using IT for their learning and think that integrating IT into instruction is not a good learning method and is unnecessary in the university, most students think it is helpful, useful, good, important and necessary, is a meaningful learning method, should be a important part of university education, and can facilitate teaching and learning.
2. Integrating IT into instruction can help students easily understand complex concepts.
3. Integration of IT into instruction offers rich instructional resources.
4. Students have different opinions about the use of IT for learning; some think IT is a waste of time (10.67%) and costs too much (12.67%).
5. Students suggested that the university should teach students how to use IT for learning, and train them better in using effective learning methods while using IT, and to help keep students avoid becoming easily distracted during the learning processes. The result is the same as in adult learning principles for creating e-learning success; Cercone [40] pointed out that adults need scaffolding to be provided by the instructor. Scaffolding should promote self-reliance, and it should allow learners to perform activities that they were unable to perform without this support. These suggestions are related to prior studies, such as that by Jung *et al.* [29] who pointed out that teachers need to communicate the benefits of using the system to their students. Furthermore, training and support needs to be offered to students in order for them to learn how to use it.
6. Students suggested that instructors should themselves be instructed on integrating IT into instruction in order to avoid too much dependence on IT or its non-use. Some re-

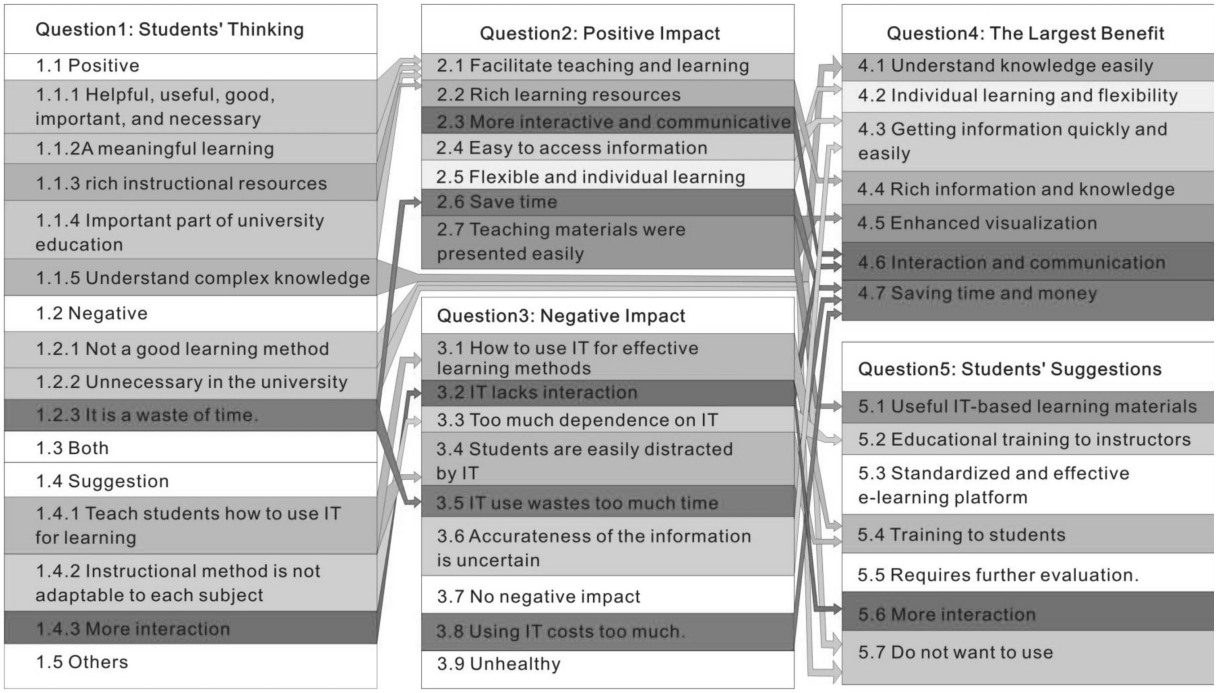

Fig. 5. Framework for concept analysis of all qualitative data.

searchers also gave the further recommendation that academic staff will need to reflect on their approach to teaching and learning and accept e-learning professional training specifically underpinned by pedagogy and not technology. To design a new role-based pedagogically-designed e-learning model is more important than innovative IT [41]. This should be underpinned by pedagogy and not technology. Teaching innovation will require new skills and ways of working, including finding innovative teaching methods.

7. Students emphasized that the interaction and communication between teachers and students, as well as peer-to-peer communication, is a very important issue in integrating IT into instruction. The findings are similar to those regarding the characteristics required by adult learners such that adults need dialogue and social interaction. They also need to collaborate with other students [40].
8. IT offers students easy and quick access to information and knowledge; nevertheless, the accuracy of the information is uncertain.
9. Integration of IT into instruction can promote individual learning and flexibility. These student opinions are similar to those found by Oliver [42], who describes e-learning as a combination of delivery and approaches including three attributes: flexible learning, blended learning, and online learning.

To sum up, students' expressed opinions are consistent with the Adult Learning Principles that suggest putting the learner back at the center of learning, so that students focus on the benefits from e-learning and practicality in solving problems. These correspond very closely with the opinions described by Cercone [40, p. 157], that adults generally need to feel that learning focuses on issues that directly concern them. They want to know what they are going to learn and why it is important; they need to see how it will apply to their lives and learning.

4.6 Limitations

The study results were based on analysis of a survey questionnaire that did not have high percentage response rates from a sample consisting of different academic degree students in a German university. There are a lot of unreturned questionnaires, what we will cause a non-responsive bias, which will also affect both the representation of the samples and the reliability of the quantitative results. In addition, researchers did not conduct group interview with students to gather more qualitative data in this study as the sources for future study and to compare with qualitative findings in order to discuss the results of quantitative and qualitative findings.

5. Conclusions

The main purpose of this study was to clarify the relationships of attitude, subjective norm, perceived

behavioral control with the intention of the TU Ilmenau students using innovative information technology for learning. According to the findings of this study, the males' perceived behavioral control variable is higher than that of the females. There is a significant difference between 26 to 30 year olds and 15 to 20 year olds, with the former having a higher attitude toward the behavior than the latter. 21 to 25 year-old students have the lowest mean of the subjective norm; perceived behavioral control, and intention to use IT for learning. Students over 31 years old have the highest mean of the subjective norm, perceived behavior control and intention to use IT for learning. This research also found that doctoral students have the highest means among the attitude toward the behavior; perceived behavioral control and intention to use IT for learning. To sum up, Bachelor students have a higher subjective norm than diploma students. Doctoral students have more active learning skills and self-direction than those pursuing other degrees.

According to the SEM analysis results, the alternative model of theory of planned behavior is goodness-of-fit and accepted. And the perceived behavioral control variable has been confirmed as related to students' behavioral intention. Based on the regression analysis findings, the strongest predictor of intention was perceived behavioral control. Attitude toward the behavior and perceived behavioral control can predict the intention to use innovative IT for learning for TU Ilmenau students. In addition, most students have positive opinions about using innovative IT for their learning. Integration of IT into instruction can help students to easily understand complex knowledge, offer students quick and easy access to information and knowledge as well as rich instructional resources, and can promote individual learning and flexibility. In addition, students provided some suggestions as follows: (1) the university should teach students how to use IT for learning well, and train them how to use effective learning methods when using IT. Further, the university should help students to avoid becoming easily distracted during the learning process. (2) Instructors should themselves be instructed on integrating IT into instruction in order to avoid too much dependence on IT or its non-use. (3) Students emphasized that the interaction and communication between teachers and students, as well as peer-to-peer communication, is a very important issue in integrating IT into instruction.

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Appendix 1: The initial questionnaire

PART 1: How much do you agree or disagree with the following statements concerning the *integration of innovative information technology for learning* (ITL) in university curricula.

Questions

1. ITI is too time consuming for me
2. ITL is too rigid to use in the classroom
3. ITL is unreliable to use in the classroom
4. ITL increases my learning
5. ITL reduces interactions between students and teachers
6. ITL enriches the learning methods
7. By using the ITL, I will improve my learning effectiveness
8. By using the ITL, my teacher will be able to teach more
9. Using ITL will reduce the interaction between the teacher and me
10. I will enrich my learning methods by using ITL
11. ITL will cause positive changes to my learning methods
12. The computer technology support staff suggest ITL applications for learning
13. I would like to adopt the computer technology staff's suggestions to use ITL
14. I would like to adopt my friend's suggestions to use ITL
15. I would like to adopt the university administrator's suggestions to use ITL
16. It is easy for me to obtain technology support for ITL
17. It is easy for me to obtain teacher's support for ITL
18. It is easy for me to set aside time to work on ITL
19. It is easy for me to adopt ITL for the courses I learn
20. It is easy for me to develop ITL learning materials

21. I intend to use ITL in the semester
22. I intend to use ITL whenever I can
23. I intend to seek technical support for ITL
24. I intend to seek teacher's support for ITL
25. I intend to obtain funding for ITL
26. I intend to set aside time to work on ITL
27. I intend to obtain appropriate equipment and facilities for ITL
28. I intend to receive ITL training

Part 2: Personal information

(1) What is your gender?
☐ Male ☐ Female

(2) How old are you?
☐ 15–20 ☐ 21–25 ☐ 26–30 ☐ 31–35 ☐ over 35 years old

(3) In which country do you learn?
☐ Austria ☐ Germany ☐ Sweden ☐ Poland ☐ Bulgaria ☐ Romania ☐ Slovenia
☐Other_____

(4) Which academic degree do you study now?
☐ Diploma ☐ Bachelor ☐ Master ☐ Doctorate ☐ Other
(5) What do you major in?_____

Part 3: Open-ended questions
(1) What do you think about information technology for learning (ITL) in the university?
(2) What's the positive impact of information technology on teaching and learning?
(3) What's the negative impact of information technology on teaching and learning?
(4) What's the largest benefit about ITL on your learning?
(5) Do you have other suggestions in integration information technology for teachers' instruction in the university?

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