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A Study on the Factors Affecting Student Behavior Intention to Attend Robotics Courses at the Primary and Secondary School Levels

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Abstract**—**In order to explore the key factors affecting the robot program learning intention of school students, this study takes the technology acceptance model as the theoretical basis and invites 167 students from Jiading District of Shanghai as the research subjects. In the robot course, the model of school students on their learning behavior is constructed. By verifying the causal path relationship between variables, it is concluded that teachers can enhance students' perceptual usefulness to robotics courses by enhancing subjective norms, entertainment perception, and reducing technical anxiety, such as focusing on the gradual progress of programming and analyzing learner characteristics. Students can improve perceived ease of use by enhancing self-efficacy. At the same time, robot hardware designers can optimize in terms of entertainment and interactivity, which will directly or indirectly increase the learning intention of the robot course. By changing these factors, the learning behavior of primary and secondary school students can be more sustainable.

Keywords**—**TAM, learning behavior intentions, robot courses, primary and secondary school students.

I. Introduction

WITH the deep integration of information technology and learning behavior, the robotic curriculum in primary and secondary schools has been popular. Some provinces in China have incorporated robot teaching content into primary and secondary school information technology, comprehensive practice and science curriculum, which represents the advent of robot education era. Project-based learning emphasizes the use of both hands and brains in robot design and programming. The robot course has become an important carrier for cultivating the scientific literacy and innovation ability of primary and secondary school students. There are hundreds of schools in China that offer robotics courses to students. The mainstream teaching methods are mainly in the two directions of programming teaching and robot competition training (such as VEX and FRC). Students can improve their engineering ability and develop computational thinking through robotics courses. To explore which factors will affect students' learning intentions for robots is very important and imperative in the education process and teaching feedback.

II. Literature Review

A. Technology Acceptance Model

American scholar Davis proposed the Technology Acceptance Model (TAM) to explore the factors that influence the acceptance of computers by the public. The model believes that perceived usefulness and perceived ease of use can influence the intention of people. Perceived usefulness refers to an individual's perception of whether a technology can improve performance [1]. Perceived ease of use refers to an individual's perception of the ease with which a technique is made. Venkatesh and Bala refined the external variables in TAM2 and proposed the TAM3 model. In the TAM3 model, external variables that influence perceived usefulness include subjective norms, work relevance, and achievement. Variables that affect ease of use include computer self-efficacy, external support, computer anxiety, entertainment perception, and objective utility [2]. This paper studies the key factors of the learning behavior intention of primary and middle school students' robot project. Therefore, the scale has been modified based on the TAM3 model to form a factor model for learning behavioral intentions, as shown in Fig. 1.

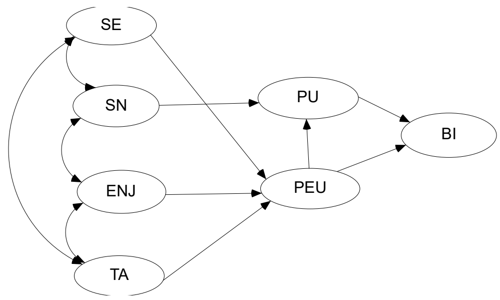

Fig. 1 Influential factors model of learning behavior intention

B. Robot Program Curriculum

Abstraction and procedure are reflected in the robot course. In the first stage, students not only need to design a robot's trajectory and mechanical motion scheme, but also consider whether the robot's motion can be achieved with the learned algorithms and programming skills. In the second stage, the demand analysis is a description of the robot behavior, and also reflects the students' positive thinking in abstraction and design ability. In this session, students can consolidate the previous programming knowledge and new skills. In the third stage, the user enters the evaluation section of the robot program learning, and the students deepen the understanding of the design of the works through display of the group program works. The robot course in the K12 field should be open and exploratory. Students can try, explore, and evaluate which is conducive to master the programming skills by imitating the code, asking

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questions, and trying to operate the robot [3]. In the classroom, teachers can use some formative evaluation scales to guide students to think, discuss and communicate, so as to improve students' ability to solve problems.

III. Research Process

A. Research Subjects

This study used 167 middle school students in a school in Jiading District of Shanghai as subjects. The closed-structure questionnaire was used in the pre-test and formal research. The questions were divided into seven dimensions. The 5-point Lee's integral scale was used to focus on the factors affecting the learning behavior of the student robot course and the causal path of the latent variable.

B. Research Methods

Literature research method: This study refers to the literature of robot course, with reference to TAM3.0, setting self-efficacy, subjective norms, entertainment perception, technical anxiety, four external potential variables, and constructing the influencing factor model of middle school students' robot course learning behavior intention.

Questionnaire method: Refers to the TAM questionnaire to compile a scale of learning behavioral intentions of middle school students' robot courses. After a small-scale pre-test and revision of the questionnaire according to expert advice, the Likert 5-point scale is used (where, 1 indicates totally disagree and 5 means totally agree). The questionnaire consists of 28 questions covering seven dimensions of perceived usefulness, perceived ease of use, self-efficacy, enjoyment perception, subjective norms, technical anxiety and behavioral intentions [4]. According to the reliability of Cronbach's Alpha test questionnaire, KMO=0.805, $p=0.000<0.01$ was obtained by factor analysis, after three revisions, the final questionnaire was formed and distributed online.

Statistical analysis method: This study uses social science statistical software SPSS 23.0 and structural equation modeling software Amos 17.0 to analyze the data.

C. Research Variables and Hypotheses

In this study, several key factors affecting learning intentions were discovered through classroom observation combined with the TAM3.0 scale. They jointly influenced whether students are willing to participate in the follow-up robot course.

There are two mediator variables, perceived usefulness (PU) and perceived ease of use (PEU), as well as four external variables: Self-efficacy (SE) means students' self-awareness; enjoyment perception (ENJ) means robotic curriculum fun; subjective norms (SN) means teachers will recommend students to participate in robotics courses; and technical anxiety (TA) means the anxiety of students in the robotics course due to technical difficulty, such as learned helplessness. The result variable is behavioral intent (BI). The hypothetical path relationship between each variable is shown in Table I.

TABLE I
HYPOTHETICAL PATH DESCRIPTION

	Hypothesis	Independent variable	Dependent variable
H1	Entertainment perception has a positive direct impact on perceived ease of use.	ENJ	PEOU
H2	Self-efficacy has a positive direct impact on perceived ease of use.	SE	PEOU
H3	Subjective norms have a positive direct impact on perceived usefulness.	SN	PU
H4	Perceived usability has a positive direct impact on perceived usefulness.	PEU	PU
H5	Perceived usefulness has a positive direct impact on behavioral intentions.	PU	BI
H6	Perceived ease of use has a positive direct impact on behavioral intentions.	PEU	BI
H7	Technical anxiety has a negative impact on perceived ease of use.	TA	PEU

IV. Data Analysis

A. Descriptive Statistical Analysis

This study distributed 170 questionnaires and used IBM SPSS software for descriptive statistical analysis. By eliminating invalid questionnaires, 167 valid questionnaires were obtained in the end, for a return rate of 98.2%. There are 24% of women and 76% of men in the study. In robotic robot manipulation, programming is obviously more interesting for boys than girls, as the ratio of male to female students is greater than 3:1. However, there are also some female students who are interested in programming robots and continue to achieve good results in the robotics competition. In this study, junior high school students accounted for 28.7% and primary school students accounted for 71.3%. Primary school students prefer to participate in robotics courses because junior high school students have heavy pressure and relatively have less time. From the overall time of students participating in the robot course, 80.8% students' robot learning experience is less than half a year, 7.2% is half a year to one year, and 12% is more than one year. Meanwhile, 84.4% of students can only use robots in the classroom, which means they cannot get access to the robots at home. The descriptive statistics of the demographic variables of the robot and its hardware suite are shown in Table II.

B. Reliability Analysis

Using the Reliability Analysis in SPSS, the intrinsic reliability of the model is measured. According to the statistical regulations: "If α is greater than or equal to 0.7, the reliability of the measurement model is good". The alpha values of the measurement items in the questionnaire are shown in Table III. The Cronbach's α coefficient of the total amount table is as shown in Table IV and all of them meet the requirements. Therefore, the scale reliability of this study is qualified.

C. Correlation Analysis

Using Pearson correlation analysis in SPSS, perceived usefulness and perceived ease of use are the intermediate links between external variables affecting behavioral intentions, and the determinants of significant linear correlation with perceived usefulness are subjective norms and self-efficacy, enjoyment perception and perceived ease of use. The decisive factors that have a significant linear correlation with perceived ease of use are self-efficacy, entertainment perception, subjective norms, and technical anxiety. Specific related parameters are shown in Table V.

TABLE II
DESCRIPTIVE STATISTICS

Question	Item	Frequency	Percentage (%)	Mean	Standard deviation
Gender	male	127	76.0	1.24	0.428
	female	40	24.0		
Grade	primary	119	71.3	1.29	0.454
	secondary	48	28.7		
How long do you study robots?	< 0.5	135	80.8	1.31	0.678
	0.5-1	12	7.2		
	>1	20	12.0		
Can you get access to robots at home?	yes	26	15.6	1.84	0.364
	no	141	84.4		

TABLE III
RELIABILITY ANALYSIS OF 7 DIMENSIONS

Latent Variable	Numbers of Observable indicator	Cronbach's α
PU	4	0.853
PEOU	4	0.868
SE	4	0.895
SN	3	0.904
ENJ	3	0.852
TA	3	0.957
BI	3	0.915

TABLE IV
TOTAL RELIABILITY

Cronbach's Alpha	Number
0.892	24

D.Convergent Validity Test

In order to judge whether the robotic course behavior intention analysis model constructed in this paper is suitable, the measurement model analysis is performed before the structural model analysis to verify the reliability and validity of the research model. In the previous test, the reliability test has been carried out, and this section focuses on checking for validity. The so-called validity means that the measurement tool is indeed measuring the concept to be explored. The measured variable has a KMO = 0.805 and sig. = 0.000, as shown in Table VI. It is suitable for factor analysis; therefore, AMOS 17.0 can be used to verify the factor analysis of this model, and to examine 24 observed variables. Correlation with seven latent variables, the aggregate validity means that the measurement indicators of the same latent variable will fall on the same factor level, and the measurement indicators are highly correlated [5]. The aggregation validity can be evaluated by the factor load, the combination reliability (CR) and the average variance extraction values (AVE) of the observed variables. The test results of the three indicators are shown in Table VII.

TABLE V
PEARSON CORRELATION ANALYSIS

	PU	PEU	SE	SN	ENJ	TA	BI
PU	1	0.494**	0.513**	0.406**	0.493**	-0.118	0.512**
PEU	0.494**	1	0.678**	0.359**	0.355**	-0.153*	0.403**
SE	0.513**	0.678**	1	0.442**	0.459**	-0.244**	0.577**
SN	0.406**	0.359**	0.442**	1	0.338**	-0.008	0.364**
ENJ	0.493**	0.355**	0.459**	0.338**	1	-0.293**	0.705**
TA	-0.118	-0.153*	-0.244**	-0.008	-0.293**	1	-0.409**
BI	0.512**	0.403**	0.577**	0.364**	0.705**	-0.409**	1

TABLE VI
KMO AND BARTLETT TEST

KMO of sampling adequacy		0.805
Bartlett's sphericity test	Chi-square	445.055
	Df.	21
	Sig.	0.000

First, Factor loading: In the factor structure, the larger the factor load value, the higher the correlation between the observed variable and the latent variable. Usually, the factor load of several observed variables around each latent variable is greater than 0.5. In the scale of the learning behavior intention of the primary and middle school students' robot course constructed in this paper, the factor load of the 24 observed variables through data analysis is shown in Table VII, and the factor load values of each of the measured variable are greater than 0.5, indicating that the observed and latent variables in this new model are highly correlated.

Second, Composite Reliability: The greater the value the combined reliability is, the higher the stability and internal consistency between several of the observed variables surrounding each latent variable is. In this scale, Table VII summarizes the CR values for the seven latent variables [6]. If the combined reliability of the latent variables represented by each observed variable is greater than 0.7, the internal stability is higher, indicating that the model combination reliability is good.

Third, Average Variance Extracted: AVE value greater than 0.5 indicates good polymerization validity. In this study of robot learning behavior intentions of students, AMOS-CR and AVE plug-in software is used to calculate the AVE value. As shown in Table VII, except for PU, SE and ENJ, the AVE values of the remaining four latent variables are all 0.7577~ 0.8597, thus, the model is fairly valid.

TABLE VII
CONVERGENT VALIDITY TEST RESULT

Latent Variable	Observable indicator	Loading	AVE	CR
PU	PU1	0.759	0.6416	0.8772
	PU2	0.779		
	PU3	0.865		
	PU4	0.797		
PEU	PEU1	0.917	0.7676	0.9295
	PEU2	0.835		
	PEU3	0.898		
	PEU4	0.852		
SE	SE1	0.826	0.688	0.898
	SE2	0.867		
	SE3	0.846		
	SE4	0.776		
SN	SN1	0.878	0.7577	0.9036
	SN2	0.883		
	SN3	0.850		
ENJ	ENJ1	0.875	0.6686	0.8578
	ENJ2	0.760		
	ENJ3	0.814		
TA	TA1	0.981	0.8597	0.9483
	TA2	0.914		
	TA3	0.884		
BI	BI1	0.940	0.8199	0.9313
	BI2	0.970		
	BI3	0.797		

E. Discriminant Validity

If the square root of each AVE value in the measurement model is greater than the correlation coefficient of each potential variable, the model has good discriminant validity. As shown in Table VIII, the values on the diagonal (AVE square root) are larger than the diagonal values of the peers and columns, that is, the model has good discriminant validity.

TABLE VIII
DISCRIMINANT VALIDITY TEST RESULT

Variable	PU	PEOU	SE	SN	ENJ	TA	BI
PU	0.801						
PEOU	0.726	0.876					
SE	0.658	0.797	0.829				
SN	0.734	0.756	0.678	0.871			
ENJ	0.789	0.843	0.774	0.808	0.818		
TA	0.657	0.678	0.709	0.834	0.789	0.927	
BI	0.734	0.845	0.680	0.768	0.765	0.897	0.905

F. Structural Equation Model

In this study, AMOS17.0 software was used to construct the "Influencing factor model of the robot course learning behavior intention of the primary and secondary school students". This model includes four external variables, two mediation variables and one outcome variable. This step mainly tests the hypothesis model by SEM [7]. The fit degree of the structural model is evaluated. In Amos 17.0, the Maximum Likelihood Method is used to obtain the fitting index of the model; the path that does not meet the fitting index is changed scientifically. The standardized regression coefficient path diagram is drawn by Amos 17.0 as shown in Fig. 2. Usually, the path parameter is divided into two types, the load of the first actual project, that is, the coefficient between the latent variable and the observed variable in the measurement model; the second is the regression parameter, that is, the coefficient between each potential variable.

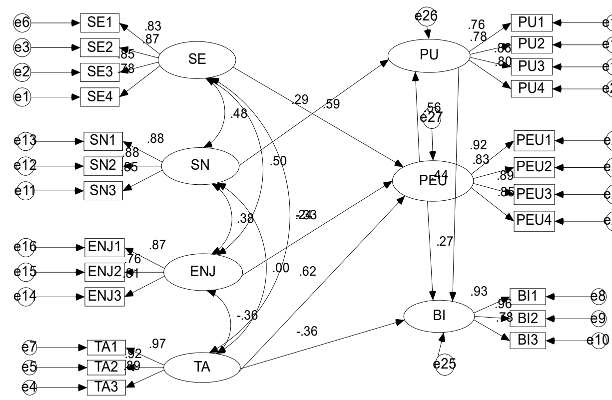

Fig. 2 Standardized Estimation Path

G. Model Fitting Test and Hypothesis Test Result

The parameters of the model fit can be obtained in the Amos 17.0 report. The absolute fit index has GFI, RMSEA, RMR, etc., while the relative fit index has NFI, TLI, CFI and so on. In the process of analysis using the structural equation model, the test method of the model is the maximum likelihood method, and the six fitting parameters are used to test the overall fitness of the model [8]. The six indices are: CMIN/DF, NFI, RMR, RMESA approximate error root mean square, GFI goodness of fit, AGFI adjusted goodness of fit. In the process of model correction, whether the definition is appropriate for the increase or decrease of parameters, and the actual adjustment of the paths and relationships between variables, it is also necessary to refer to these fitting evaluation indicators [9]; such that, GFI greater than 0.9 is better, RMR is less than 0.05, the smaller the better, the RMSEA is less than 0.1, the smaller the better, and the NFI is greater than 0.9, the closer to 1 the better; the final fitting report is shown in Table IX. The results of the hypotheses testing are shown in Table X.

TABLE IX
MEASURES OF GOODNESS-OF-FIT

Fit measurement	Values	Suggested value
CMIN/DF	1.874	<2
RMR	0.042	<0.05
RMSEA	0.132	<0.10
GFI	0.839	>0.90
AGFI	0.92	>0.90
NFI	0.75	>0.90

TABLE X
RESULTS OF HYPOTHESIS TESTING

No.	Hypothesis	Tested result
H1	Entertainment perception has a positive direct impact on perceived ease of use.	Yes
H2	Self-efficacy has a positive direct impact on perceived ease of use.	Yes
H3	Subjective norms have a positive direct impact on perceived usefulness.	Yes
H4	Perceived usefulness has a positive direct impact on perceived usefulness.	Yes
H5	Perceived usefulness has a positive direct impact on behavioral intentions.	Yes
H6	Perceived ease of use has a positive direct impact on behavioral intentions.	Yes
H7	Technical anxiety has a negative impact on perceived ease of use.	Yes
H8	There is a strong correlation between technical anxiety and self-efficacy.	Added
H9	There is a strong correlation between subjective norms and entertainment perception.	Added

V. RESEARCH CONCLUSIONS

Subjective norms have a positive impact on perceived usefulness. When a perceived important person in the life of a primary school student such as a parent and teacher, recommends for them to participate in the robotics courses, they will consider that learning robots is useful. The judgment of primary and secondary school students is easily influenced by the outside world and their instructors. If teachers take advantage of the subjective norm, the robot course learning behavior intention will be significantly improved.

Perceived ease of use has a positive impact on behavioral intentions. If primary and secondary school students feel that robot courses are not very hard for them, they intend to participate in future robot courses, which will improve learning persistence. If the robot programming courses and displacement operations are perceived as too difficult, this will reduce the enthusiasm of the students to participate; therefore, robot course developers need to ensure the robot course is suitably challenging for the participants' intellectual stage of development.

Self-efficacy is significantly negatively correlated with technical anxiety. The lower the technical anxiety learners have, the stronger their ability to program and manipulate robots. Therefore, in the robotic course based on computational thinking, the difficulty of programming content should be gradual. It is imperative to take the impact of self-efficacy and technical anxiety on behavioral intentions into consideration.

Entertainment perception has a significant positive impact on behavioral intention, perceived usefulness, and perceived ease of use. We should pay attention to the entertainment perception of robot programming courses. The interesting and smart robot courses are more popular than the traditional computer programming courses in primary and secondary school. Hence, robot courses should attach more importance to smart interactivity and entertainment in the future.

In summary, during the instructional design process of robot courses in primary and secondary schools, it is necessary not only to think about the depth and breadth of course content, but also to focus on the important factor of self-efficacy which can enhance students' internal learning motivation and increase the behavior intention of their robot courses. In addition, teachers need to pay attention to the external influence factor of subjective norms because primary school-aged students do not have a strong sense of self-directed learning, and their behavior intentions will be affected by important others such as parents, teachers and classmates. Perceived usefulness and perceived ease of use are the mediators that determine the behavioral intentions related to the robotics courses. They should also be incorporated into the curriculum resource integration and robot teaching process. At the same time, the entertainment perception is positively correlated to the attendance rate of the courses.

VI. RESEARCH LIMITATIONS

First, the sample of this study is mainly concentrated in Jiading District, Shanghai. Samples between different cities in China and different regions of Shanghai have their own characteristics. In particular, this study is the influencing factor of the technical acceptance of robotics courses. The regionality of the samples has a great impact on the research results [10]. Future research can expand the sample and conduct horizontal comparative studies on different areas of technology development, thus improving the universality of research.

Second, the content of the robot course is single. This study is aimed at the training course of the VEX-EDR competition robot. The choice of future courses should be as diverse as possible. Competition-based robotics courses such as VEX-IQ, EDR, and FRC are very different in content from the robotics course based on programming knowledge. The difficulty level and operation processes are different. Factors affecting the student's participation in the curriculum are also different, so future research should take this factor into account.

In summary, despite these limitations, this study links the TAM to the robotic learning behavior of primary and secondary school students. This study uses data modeling to explore the extent to which the seven dimensions of the problem affect their learning behavioral intent. Robot education is an important way for the country to cultivate innovative talents. Teachers should not only teach robot programming knowledge when teaching robots, but also improve students' computational thinking and information literacy. Multidimensional design and thinking will help improve the quality of the course and improve learning efficiency in the robotics course.

REFERENCES

[1] Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340.
[2] Venkatesh, V. (2000). Determinants of perceived ease of use: integrating control, intrinsic motivation, and emotion into the technology acceptance model. Information Systems Research, 11(4), 342-365.
[3] Kandlhofer, M., & Steinbauer, G. (2016). Evaluating the impact of educational robotics on pupils' technical- and social-skills and science related attitudes. Robotics and Autonomous Systems, 75, 679-685.
[4] Venkatesh, V., & Bala, H. (2010). Technology acceptance model 3 and a research agenda on interventions. Decision Sciences, 39(2), 273-315.
[5] Wu Minglong (2010). Structural equation model: The operation and application of AMOS. Chongqing: Chongqing University Press.

[6] Rong Taisheng (2009). AMOS and research methods. Chongqing: Chongqing University Press.
[7] Igbaria, M., Zinatelli, N., & Cragg, P. (1997). Personal computing acceptance factors in small firms: a structural equation model. Mis Quarterly, 21(3), 279-305.
[8] Hui, C., Law, K. S., & Chen, Z. X. (1999). A structural equation model of the effects of negative affectivity, leader-member exchange, and perceived job mobility on in-role and extra-role performance: a Chinese case. Organizational Behavior & Human Decision Processes, 77(1), 3.
[9] Fathema, N., Shannon, D., & Ross, M., (2015). Expanding the Technology Acceptance Model (TAM) to examine faculty use of Learning Management Systems (LMS). Journal of Online Learning and Teaching.11(2),210-233.
[10] Lunceford, Brett. (2009). "Reconsidering Technology Adoption and Resistance: Observations of a Semi-Luddite." Explorations in Media Ecology, 8 (1), 29-47.