Influences of Education App-Assisted Teaching Technology on Learning Efficacy of Learners

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Abstract—This study designed a questionnaire to investigate the influences of education app-assisted teaching technology on learners' learning efficiency. The mediating effect of learning motivation in such influences was analyzed. Research results demonstrate that Cronbach α of the designed questionnaire is 0.833, Kaiser-Meyer-Olkin (KMO) is 0.815, and Bartlett sphericity test is p=0.000<0.001, indicating good reliability and validity of the questionnaire. All four aspects (knowledge architecture (p<0.01), group collaboration (p<0.05), information integration, summary, and assessment) of education app-assisted teaching technology positively affect learning efficacy. Learning motivation has a complete mediating effect on the influence of education app-assisted teaching technology on learning efficacy. The contact duration of learners with education APP-assisted teaching technology influences learning efficacy significantly (p=0.006<0.01). Research conclusions can provide important references to facilitate higher education teachers to integrate teaching content and online teaching deeply, realize multiple assistance effects of information technology to education modes, and promote the organic integration of mobile Internet technology and higher education.

Keywords—education app, assisted teaching technology, learning efficacy, regression analysis, mediating effect

1 Introduction

Education information technology updates quickly in the current 5G age, and more colorful teaching modes have been presented, changing the learning mode of learners and the education thinking mode of people. The ministry of education at all levels in China is taking the initiative in promoting education informationization reform. The number of smart mobile terminal devices in China is increasing yearly, and the number of various educational apps is increasing significantly. The diversified application scenes considerably promote changes in mobile learning mode and provide ample spaces for the personalized learning needs of learners. The education app-assisted teaching of teachers or the personalized learning of students has become important in changing the traditional single teaching mode. Learners have changed from passive knowledge receivers to positive knowledge seekers, thus realizing fundamental

education reform. Supported by education app-assisted teaching technology, university students may be enthusiastic about exploring and learning information, establishing a knowledge system, seeking a balance between learning and life, and finding optimal learning rhythms.

On the one hand, the application of the mobile education apps-assisted teaching mode can recommend the latest teaching resources of teachers to students timely, stimulate their learning motivation, and meet the continuously changing online personalized learning needs of students. On the other hand, the application can create new online informationization learning activities by integrating more ubiquitous high-quality education resources. The education app-assisted teaching mode can connect various social groups, such as schools, parents, students, classmates, and faculties, thus forming a social circle for mutual communication and exchanging teachers, students, and parents. This mode can reflect humanity's care for education and realize personalized education oriented to the ability development of students. The education app-assisted teaching mode can facilitate the construction and perfection of the informationization online education theoretical system so that teachers and learners change from the traditional single teaching-learning mode into the independent study mode of learners. Learners begin to explore their personalized learning mode and facilitate effective improvement of learning efficacy.

2 Theoretical basis and hypotheses development

2.1 Theoretical basis

Problem-based learning (PBL) has become a widely studied and applied teaching mode worldwide. The traditional teaching method orients to subject teaching and focuses on the teaching activity of teachers. The PBL method emphasizes the independent study of students. The PBL method is centered on problem-solving or task fulfillment, in which students deeply explore, construct meaning, and develop knowledge when solving problems. In the PBL method, the learning activity starts with the problem, and all learning contents are derived from it. Education app-assisted teaching technology means that learners interact and communicate with teachers by using apps. Students mainly adopt cooperative groups and independent study, and teachers teach less in classrooms. Students can improve team cooperation through communication and research discussions with group members. They have to finish learning tasks positively, showing their dominant role in the learning activity. Teachers must help students with learning skills and guidance timely and make self-assessment and group evaluations after finishing each course content to evaluate students' learning effects.

2.2 Hypotheses development

With the rapid development of wireless networks and mobile terminals, the app has been used more than the web. Modern education emphasizes training students' ability and consciousness of innovation. The single traditional teaching mode cannot adapt to the needs of modern teaching anymore. It is a new teaching mode to integrate education

APP-assisted teaching technology into university teaching activities and create interactive teaching that conforms to university students' learning styles and characteristics. Some scholars have studied how education app-assisted teaching technology influences learning efficacy, academic performance, or learning outcomes of learners. Seow, P. S et al. [1] believed that education apps could combine mobile and game-based learning and stimulate the interests and motivation of digital native language learners. According to the survey results of students, most people have good evaluations of education apps, indicating their satisfaction. Cummiskey, M [2] provided a free app and allowed students to bring smartphones to every class. Results showed that using smartphones in health and PE classes can improve learning enthusiasm. Wang, L et al. [3] investigated the effect of STEM programs in promoting the learning effect. STEM helps students correct their learning attitude and improve skills significantly, winning high student evaluations. Papadakis, S et al. [4] believed app inventors could improve learners' interest in programming. Tavares, R et al. [5] pointed out that science education can be improved by using technologies, that is, education software. Scientific ability development and independent learning of students could be improved through education app-assisted teaching. Kuhnel, M et al. [6] carried out an online survey of 105 respondents and tested an app. Results showed that students evaluated the idea and navigation of the app positively. Weng, P. L [7] evaluated nine commercial iPad apps designed for disabled students and found that using the iPad and its apps in special education can encourage disabled students to improve learning efficacy. Dore, R. A et al. [8] conducted a contrast experiment and analyzed that the game-based teaching mode promotes children to learn vocabulary. Children with moderate and slightly poor classroom performances learned new vocabularies from interactive mobile games. Hsueh, W. D et al. [9] studied the influences of a medical knowledge app on the education of resident doctors in the Otolaryngology and Head and Neck Surgery Department. Research results show that the app provided valuable perspectives on medical information and was a good tool for testing clinical and medical knowledge. This app increased the sharing and discussion of medical knowledge. The learning mode based on the app may improve the knowledge-based academic performances of medical students. Yang, Y et al. [10] pointed out that an education app regulated the correlation of performance expectations and habitats that intend to use apps. Game-related characteristics regulate the correlation between entertainment motivation and intention to use. Petko, D et al. [11] developed the app "Metapholio" and applied it to teaching practice. Results showed that the app supported teachers to collect moments worthy of attention during class through the individual and cooperative notebook function, which effectively stimulated trainers to participate in reflection dialogue. Campbell, A et al. [12] realized the education process through a social work education and practice app. This education app provided information about the use level according to geographic location, download information, and time spent in each part of the app. It could help social educators to accept online education and practice at any place and time. Keeley, K et al. [13] believed that apps could provide technology to students before they engage in special fields and offer them freedom other than the typical classroom environment, making preview and review of knowledge convenient at any time. Zhang, S [14] evaluated the advantages of mobile apps in education by choosing apps designed exclusively for users to practice oral English. Results demonstrated that the convenience and flexibility of apps

for English learning could stimulate learning interest, train independent study, realize personalized learning, and improve the English learning performance of students. Kohnke, L et al. [15] pointed out that respondents who learned English vocabulary using internal mobile apps acquire more vocabulary at middle and high levels than at the primary level. Relevant apps could facilitate and support learners in understanding vocabulary acquisition. Voshaar, J et al. [16] analyzed the influences of game-based mobile learning apps on the Introduction to Accounting exam. Results showed that using apps has a positive influence on the academic performances of learners. Existing studies have shown that education informationization reform has been a key concern of education reform in countries worldwide. Education app-assisted teaching technology is the application mode of education software and practice teaching technologies. In particular, various education apps have been used more and more in teaching activities to respond to the rapid development of mobile media device technologies. Most literature supports that education apps can effectively stimulate students' learning interests and efficacy. Furthermore, students can make fragmented online learning by using education apps. The learning opportunities for students increase, making independent study activities easier. The design, research, and development of mobile education apps provide new learning platforms and resources to traditional classroom teaching activities. Thus, some hypotheses about the influences of education app-assisted teaching technology on the learning efficacy of learners were proposed (Figure 1).

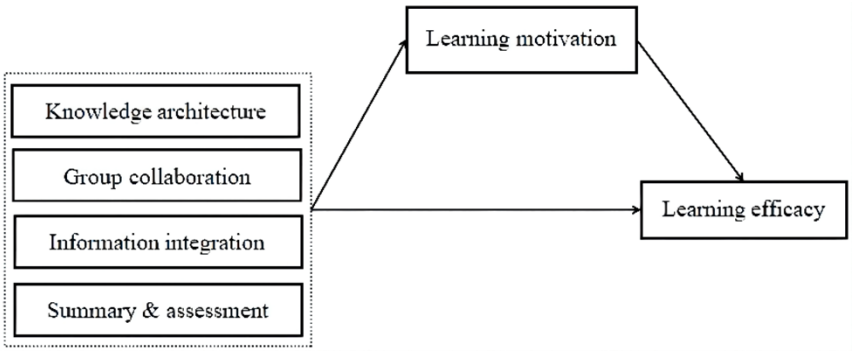

Fig. 1. Research hypotheses

3 Methodology

3.1 Questionnaire design

This study designed a questionnaire on the Influences of Education App-assisted Teaching Technology on Learning Efficacy of Learners. This questionnaire has four parts. Part I investigates the general information of respondents, including gender, grade, major, and duration of the education app-assisted teaching mode. Part II measures the education app-assisted teaching technology. Specifically, four, four, three, and four questions were set to measure knowledge architecture, group collaboration,

information integration, and summary and assessment, respectively. Part III measures learning efficacy. This study also designed five questions based on the research conclusions of Duncan, T. G et al. [17]. Part IV measures the mediating variable (learning motivation). According to the research results of Garcia, T et al. [18], four questions were applied. All questions in the questionnaire were estimated using a 5-point Likert scale.

3.2 Respondents

Hubei Province is an important province where universities concentrate in China. It takes the leading role in education informationization reform. The education informationization level of many universities and the information-based teaching level of teachers are relatively high. Furthermore, the basis for students to learn with apps is relatively good. This study chose undergraduates in 6 universities of China from the School of Computer at Wuhan University, Huazhong University of Science and Technology, Wuchang Institute of Technology, Wuhan University of Technology, Wuhan University of Science and Technology, and Hubei Engineering University as respondents. In the questionnaire survey, a QR code designed by the research team was sent online, and respondents retrieved the questions using their smartphones through the QR code and then answered them on their phones. A total of 351 questionnaires were sent, and 275 valid ones were collected, showing an effective recovery rate of 78.35%. The descriptive statistical results are shown in Table 1.

Table 1. Descriptive statistical results

Name	Options	Frequency	Percentage (%)
Gender	Male	136	49.45
	Female	139	50.55
Grade	Freshman	50	18.18
	Sophomore	78	28.36
	Junior	127	46.18
	Senior	20	7.27
Major	Software engineering	32	11.64
	Communication engineering	66	24
	Computer application technology	40	14.55
	Electronic information engineering	67	24.36
	E-commerce	45	16.36
	Electronic engineering	25	9.09
Duration	<0.5 year	16	5.82
	0.5–1 year	13	4.73
	1–2 years	99	36
	2–3 years	93	33.82
	>3 years	54	19.64

4 Results analysis and discussion

4.1 Reliability and validity test

The reliability of a questionnaire refers to the consistency or stability between survey results and practical situations. In other words, reliability is an indicator that reflects the reality of respondents. After questionnaires were collected, the original data was inputted to test the reliability of the questionnaire by using SPSS26.0. In this study, Cronbach α was used to measure the reliability of the questionnaire.

Table 2. Reliability test results

Type of Variables	Name of Variables	Number of Questions	Cronbach α	Cronbach α
Independent variables	Knowledge architecture	4	0.864	0.833
	Group collaboration	4	0.862	
	Information integration	3	0.858	
	Summary and assessment	4	0.843	
Mediating variable	Learning motivation	4	0.850	
Dependent variable	Learning efficacy	5	0.762	

Table 2 shows that the overall Cronbach α of the questionnaire is 0.833, and the reliability coefficient of research data is over 0.8, indicating the high reliability and quality of data. The whole questionnaire has good reliability.

4.2 Validity test

Validity refers to the measuring precision of objects by tools or means.

Table 3. KMO and Bartlett tests

KMO value		0.815
Bartlett sphericity test	Approximate Chi-square	2903.72
	df	276
	P value	0

Table 3 shows that KMO value is 0.815 and the Bartlett sphericity test is p=0.000<0.001, indicating that the data can be used in factor analysis.

Table 4. Results of AVE and CR

Factor	Average Variance Extraction (AVE)	Combined Reliability (CR)
Knowledge architecture	0.616	0.865
Group collaboration	0.61	0.862
Information integration	0.67	0.859
Summary and assessment	0.582	0.846
Learning motivation	0.586	0.85
Learning efficacy	0.402	0.765

Table 4 shows that the CR values of six factors are higher than 0.7, but one AVE is lower than 0.5. The questionnaire generally has good validity.

Table 5. Discriminant validity

	Knowledge Architecture	Group Collaboration	Information Integration	Summary and Assessment	Learning Motivation	Learning Efficacy
Knowledge architecture	0.785	–	–	–	–	–
Group collaboration	0.324	0.781	–	–	–	–
Information integration	0.172	0.223	0.818	–	–	–
Summary and assessment	0.203	0.294	0.135	0.763	–	–
Learning motivation	0.204	0.053	0.124	0.072	0.766	–
Learning efficacy	0.086	0.028	0.027	0.109	0.451	0.634

Table 5 shows that the square root of AVE of knowledge architecture is 0.785, which is higher than the maximum absolute correlation factor among factors (0.324), implying that the questionnaire has good discriminant validity.

4.3 Regression analysis

Table 6. Regression results

Variables	Normalization Coefficient	*t*	*p*	VIF	R^2	Adjusted R^2	*F*
Constants	–	7.866	0.000**	–	0.228	0.217	(4,270) = 19.971, p = 0.000
Knowledge architecture	0.430	7.939	0.000**	1.026			
Group collaboration	0.129	2.296	0.022*	1.112			
Information integration	0.042	0.759	0.449	1.061			
Summary and assessment	0.037	0.664	0.507	1.090			

Notes: D-W value:1.839;*p<0.05 **p<0.01.

Table 6 reveals the following:

(1) Knowledge architecture has significantly positive effects on learning efficacy. Education app-assisted teaching mode can encourage learners to enter into the navigation module of the education app to choose courses and chapters they want to learn. It can be either new courses or a review of previous courses. Education apps provide students with learning ideas, and students can search and access more information quickly. It helps students to expand their knowledge and understanding, leading to the development of different subjects. Furthermore, learners are more likely to discuss their problems to seek answers with others, further strengthening the interaction frequency and helping learners establish the knowledge system and master key and difficult knowledge points. In the network environment, education app-assisted teaching mode can help learners eliminate spatiotemporal constraints, use the fragmented time to learn small knowledge contents, enrich their knowledge structure through accumulation, and deepen systematic memory of knowledge. Through the effective integration of fragmented knowledge, learners can review knowledge points using the high-order thinking ability according to internal logic, establish a personalized learning framework for independent inquiry learning, classify and summarize knowledge, and improve learning efficacy.

(2) Group collaboration has significantly positive effects on learning efficacy. By using the education app skillfully, teachers help students establish the knowledge system and content framework and broaden their horizons of knowledge. In mobile learning, students can form groups to conduct task-oriented learning and complete group learning tasks. To complete group-based common learning objectives, students can discuss problems through more diversified forms (e.g., private and group chat in the app). The cooperative activities of students during learning are more beneficial for their high-order thinking and information communication. Meanwhile, students can effectively respond to others' problems and discuss them positively. During app-assisted mobile learning, the app-assisted teaching technology can also improve students' imitation learning ability, prompt them to form scientific critical thinking,

increase innovative thinking, and strengthen their learning interests and motivation. Group collaboration promotes students' understanding and digestion of knowledge and deepens their comprehension and application of content.

(3) Information integration positively affects learning efficacy, but the regression coefficient is insignificant. When learners inquire about learning with the assistance of education apps, teachers carefully observe the dynamics of group learning and discussions, prepare to provide learning guidance and answer questions at any time, and supervise their learning progress throughout the class to assure the learning effect. Teachers can recommend supplementary learning materials to students in linkages or videos through education apps according to their knowledge and needs. However, teachers must design lessons by centering on students during online learning based on apps. The teaching mode shall be adjusted considering subjectivity, initiatives, and personalization of students. However, students are not good at information integration and cannot integrate it scientifically. Thus, teachers shall systematically design learning tasks and schedules following students' personalized needs considering their knowledge level, academic performances, and learning interests so they can become independent subjects in this process. Thus, students' learning initiatives and creativity are played to the maximum extent in app-assisted learning processes, and their learning efficacy is improved.

(4) Summary and assessment positively affect learning efficacy, but the regression coefficient is insignificant. After learners complete learning tasks, they communicate, share learning outcomes in groups, and make mutual assessments. Teachers offer more objective scientific evaluations of the learning outcomes of students. Students consolidate and deepen their comprehension of knowledge by summarizing course contents. After learning status, participation in discussion and contributed knowledge content of students are known using education apps, learners easily feel fatigued and do not make summaries and assessments carefully. Therefore, inter-group mutual assessments and student-student mutual assessments are mostly invalid, hindering the learning progress and ability improvement of learners. As a result, the learning efficacy of learners shows no significantly continuous increase.

4.4 Mediating effect

Table 7. Mediating effect

	Learning Efficacy	**Learning Motivation**	**Learning Efficacy**
Constant	3.961** (22.156)	3.492** (16.336)	2.662** (11.801)
Education app-assisted teaching technology	0.062 (1.435)	0.179** (3.444)	–0.004 (–0.106)
Learning motivation	–	–	0.372** (8.190)
R^2	0.007	0.042	0.204
Adjusted R^2	0.004	0.038	0.198
F value	F (1,273)=2.058, *p*=0.153	F (1,273)=11.860, *p*=0.001	F (2,272)=34.818, *p*=0.000

Table 7 shows that learning motivation completely mediates the influences of education app-assisted teaching technology on the learning efficacy of learners. The reason is that education app-assisted teaching technology uses problem-based learning in classrooms and innovates the problem-based teaching mode. Teachers build real problem scenarios for a teaching topic content to present learning tasks. Students have developed a strong desire and interest in the knowledge they will learn. They have the motivation to gain more knowledge. Besides, students discuss and communicate different learning topics more thoroughly, determine their learning tasks and learning directions, and enter the classroom with questions and knowledge interests. Teachers shall still summarize some problems worthy of further explorations according to course contents, guide students to learn and inquire about course content, and help learners improve their learning efficacy significantly.

4.5 Difference analysis

Table 8. Effects of contact time of learners on learning efficacy

	Contact Time with Education App-Assisted Teaching Technology Median M(P25, P75)					**Kruskal-Wallis Test Statistics**	***P***
	1.0 (n=16)	**2.0 (n=13)**	**3.0 (n=99)**	**4.0 (n=93)**	**5.0 (n=54)**		
Learning efficacy	4.500 (3.3, 5.0)	4.000 (3.0, 5.0)	4.000 (4.0, 5.0)	4.000 (4.0, 5.0)	4.000 (3.0, 4.0)	14.388	0.006**

Note: **p<0.01.

Table 8 shows that Kruskal-Wallis test statistics was used for analysis. The difference in learning efficacy under different contact times of learners with education app-assisted teaching technology is significant at the 0.01 level (p=0.006<0.01). The reason is that this technology occurs in teaching activities gradually with the comprehensive development of information technologies such as 5G. It is a novel teaching technology for teachers and students. If learners accept such teaching technology most of the time, they will become more familiar with the significance and objective of education app-assisted teaching, formulate suitable learning plan better, operate education apps more skillfully and comprehensively, form their own use style, and meet their learning needs, thus improving learning efficacy.

4.6 Discussions

Education app-assisted teaching technology is a new education method that teachers must integrate into university teaching. This study demonstrates that all four aspects (knowledge architecture, group collaboration, information integration, and summary and assessment) of the education app-assisted teaching technology improve learners' cognition, skill, and emotional objectives. Generally, integrating education app-assisted teaching technology into university teaching brings good promotion and assistance in studying students' behaviors. It is superior to the traditional simple and boring classroom teaching modes. Compared with the traditional teaching mode, education app-assisted

teaching technology can promote knowledge memory and migration better and help students master the learning method effectively and use learning strategies flexibly. Furthermore, it can strengthen students' learning interests and increase the frequency and effectiveness of teacher-student and student-student interactions online. Moreover, almost all university students have mobile devices such as mobile phones. Education app-assisted teaching technology is a low-cost and high-efficiency teaching mode. It is an innovative application in classroom teaching and brings some enlightenment to teaching technological reform in higher education. Thus, education app-assisted teaching technology shall attract wide attention from educators.

5 Conclusions

The hardware condition for education informationization has matured because of the continuous development of mobile technology and the continuous perfection of mobile communication networks. In the education informationization field, more learners are willing to accept mobile learning. More and more students have used PCs for personalized learning, which can meet their learning needs anywhere and anytime. Education app-assisted teaching technology becomes important to meet students' independent study needs and change the traditional simple and boring classroom teaching mode. Such education technology can encourage students to discover and review knowledge more positively, highlight the dominant role of students, and rebuild the knowledge system.

Education app-assisted teaching technology is conducive to realizing teacher-student or student-student sharing of education resources. In this study, a questionnaire to investigate the influences of education app-assisted teaching technology on the learning efficacy of learners was designed. The mediating effect of learning motivation in such influences was also analyzed. Results show that Cronbach α of the designed questionnaire is 0.833, KMO is 0.815, and the corresponding P value is lower than 0.001, indicating good reliability and validity of the questionnaire. Education app-assisted teaching technology has a positive effect on the learning efficacy of learners. Learning motivation has a complete mediating effect on such influences. The difference in learning efficacy under different contact times of learners with education app-assisted teaching technology is significant at the 0.01 level. Future research should analyze the influences of education apps on the observation ability of learners and teacher-student interaction by observing classroom videos and following teachers' guidance in learning activities and inquiry cooperation among students through the reasonable use of apps.

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