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The Analysis of Digital Maturity of Schools in Croatia

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Abstract—This paper presents results of a large pilot project among Croatian primary and secondary schools focused on digital maturity of schools. It explores relationships between indicators that influence the overall digital maturity level of a school with the main aim to identify the main drivers of digital maturity. It also reveals key steps in the development of the Framework for Digitally Mature Schools in Croatia and the instrument for assessing digital maturity of schools. The instrument evaluation involved 151 primary and secondary schools in Croatia that were assessed against maturity levels. Descriptive statistics is used to identify and explain correlations between 38 indicators of digital maturity of schools. Results obtained from the instrument show that 50 percent of schools in Croatia are in the initial phase of maturity and 43 percent of them are e-enabled which in respect to 5 different maturity levels corresponds to levels 2 and 3 respectively. An on-line system developed for this purpose, besides it features the instrument itself and enables schools to benchmark between themselves, identifies critical indicators for each school that require improvement in order for school to make progress against maturity level.

Keywords—Digital maturity, maturity framework, instrument, e-Schools

1 Introduction

The concept of digital maturity of educational institutions is becoming progressively important due to growing importance of Information and Communication Technologies (ICT) in education. Such claims are supported by the European Commission which indicates the significance of digital maturity and offers support throughout its policies and programmes (see the example [6] or [9]). This was also recognized in Croatia and presented a solid ground for starting the e-Schools project, co-financed from the Structural Funds of the European Union which aims to support the development of digitally mature schools in Croatia. This paper defines digitally mature schools as schools with a high level of ICT integration, and with a systematic approach towards using ICT in school management and educational processes. The above mentioned e-Schools project includes the pilot project, started in 2015 and the major project, which will be implemented from 2019 until 2022 based on the results of the pilot project. The pilot project involves participants from 151 primary and secondary schools, which is about 10% of all schools in Croatia. It is expected that additional 700 schools will be included in the major project.

This paper reveals several major outcomes of the ongoing pilot project. First, it presents the Framework for Digitally Mature Schools (FDMS) developed within the project. The FDMS describes the concept of digitally mature schools and includes the instrument for assessing digital maturity of schools. Next, the assessment results are presented based on the evaluation conducted in 151 schools involved in the pilot project. In respect with the identified digital maturity levels of the involved schools, a deeper analysis was made and the relationships between 38 indicators that describe the digital maturity concept were analyzed.

2 Framework for Digitally Mature Schools in Croatia

In line with the goals of the e-Schools project [4] funded by the European Social Fund and the European Regional Development Fund for the primary and secondary schools in Croatia, we designed the Framework for Digitally Mature Schools (FDMS) as well as the Instrument for self-evaluation and for the external evaluation. Additionally, we developed the software to support the FDMS implementation. The aim of the Framework was to identify the current level of digital maturity of schools in Croatia, to examine possible progress in integration and the efficient use of information and communication technologies (ICT), and to recognize the potential areas for improvement. By our recognition, the FDMS, with the associated instrument and the supporting software, represents a unique and comprehensive tool set created using complex scientific methodology [2].

The development of the FDSM in Croatia underwent several phases with the final goal of developing a framework that contains the evaluation domains and elements of digital maturity which were also recognized in the pre-tertiary education system in Croatia. For the FDMS development we used a complex scientific methodology which includes a set of methods, techniques and instruments such as qualitative analysis and comparability with the 15 internationally recognized digital maturity frameworks that focus on digital technologies or some forms of digital maturity in different sectors; analysis of the existing project documentation, national and international strategies; implementation of semi-structured interviews to gather focused and qualitative data; cards sorting (Q-sorting) method; focus groups analysis and some other methods for defining new framework domains and their elements as well as descriptors related to the maturity levels [2].

Within the analysis of 15 initially recognized digital maturity frameworks, a special attention was paid to the following identified elements: development approach, application area, the existence of accompanying framework, instruments for evaluating the maturity level and for the supporting software and the best practice examples [1]. The analysis revealed DigCompOrg [3] and eLearning Roadmap [8] being two frameworks that best describe the comprehensive field of digital maturity of schools. At later stages, they became the foundation for the construction of a Framework for Digitally Mature Schools in Croatia.

The FDMS is structured into 5 evaluation domains that characterize the pre-tertiary educational institutions in Croatia (1. Planning, Management and Leadership; 2. ICT in Learning and Teaching; 3. Development of Digital Competence; 4. ICT Culture; 5. ICT Infrastructure) divided into 38 elements that are described on five maturity levels in the form of a rubric (see Figure 1). Each evaluation domain relates to different aspects of the ICT use and application. The evaluation domain, as well as the elements are complementary and interrelated, and it could be said that they are forming a unified whole [2].

The main instrument used to measure the digital maturity of a school is a rubric (maturity matrix) that initially had 38 rows (digital maturity elements) and five columns (maturity levels). The maturity levels were identified according to [7]. They are: 1 - Basic, 2 - Initial, 3 - e-Enabled, 4 - e-Confident and 5 - e-Mature. For each of the rows (elements), one of the five levels of maturity (columns) were identified according to the existing school digital maturity position. To connect statements and accurately describe the maturity levels, we used mathematical (propositional) logic with logical operations and quantifiers [1].

The Table 1 presents only one out of ten elements in the ICT Infrastructure evaluation domain which is an integral part of the FDMS. Some terms are additionally described in the Glossary which is also a part of the measuring instrument. A similar description was created for each element in all other domains of FDMS.

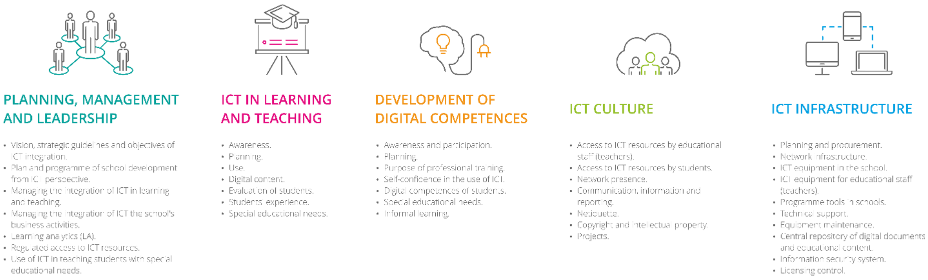

Fig. 1. Overall concept of FDMS

Table 1. Rubric for the element "Software tools in school" in ICT Infrastructure domain

Element	Maturity levels				
	Basic	***Initial***	***e-Enabled***	***e-Confident***	***e-Mature***
Software tools in school	Only operating system (OS) is installed on all computers.	Except OS, less than half of the computer are equipped with Office tools*, and there is no advanced software** on any computer.	More than half of the computers have Office tools installed, and less than half of the computers have other specialized software** installed.	Almost all computers have basic Office tools installed. More than half of the computers have other specialized software installed.	Almost all computers have Office tools and other specialized software installed.

* Office tools include word processor, spreadsheet editor, presentation tools, etc.
** Specialized software: examples of an application include specialized software packages for teaching and learning (Geogebra, AutoCAD, etc.).

Since the descriptors of all elements are complex, the rubric itself is also complex. This was a reason why we simplified the measuring instrument in a way that we developed the new supporting instrument in a form of questionnaire. The questions or answers within the questionnaire are predefined to clearly place the school on a certain level of digital maturity of a particular element in the rubric. So, by combining a few questions and answers, we obtained the maturity level of each element in the rubric.

3 Results of self-evaluation and external evaluation of school's digital maturity

The FDMS, along with the instrument and the associated software, has been successfully applied in the process of self-evaluation and external evaluation of 151 primary and secondary schools in Croatia.

The self-evaluation of schools was carried out during June and July 2016, and the role of the evaluators was assigned to principals and teachers from the involved primary and secondary schools, while the external evaluation was conducted by the external evaluators (experts from Faculty of Organization and Informatics, UniZg and The Croatian Academic and Research Network, CARNet) during October 2016. It is important to notice that for the successful self-evaluation, it is always crucial to have a good preparation of the respondents. However, the results of self-evaluation in the schools have shown that the level of implementation awareness and the goals of self-evaluation in Croatia were not satisfactory and that the results were not reflecting the real levels of their digital maturity. Therefore, the external evaluation was the essential post action tool due to the complexity of the instrument itself, but also due to the more objective approach by evaluators based on evidence and established criteria for evaluation as a part of their training. [2].

The evaluation results of 151 schools in Croatia, show that there is a visible difference between the results obtained by self-evaluation and external evaluation (see Figure 2). According to the results of self-evaluation, 1 school was rated as digitally mature (level 5), 6 schools are on the "e-confident" digital maturity level (level 3), 68 schools are estimated to be "e-enabled" (level 3), 76 schools are on the "initial" level (level 2) and there were no schools on the first level ("Basic"). The results of the external evaluation showed that the external evaluators did not evaluate a single school as digitally confident or digitally mature (levels 4 and 5), 27 schools were evaluated as digitally enabled (level 3), 124 schools were estimated to be on the initial level and there were no schools on the first level (basic).

When researching the deviations in the process of self-evaluation and external evaluation of the observed domains, it was noticed that the major deviations occurred in the evaluation domain titled Planning, Management and Leadership because schools were not aware of the comprehensiveness of the strategic documents they were required to have and therefore have faulty reported their current status. Based on current practice, by adapting the strategic documents, and upgrading the existing school documents with ICT strategy, schools could affect their level of maturity.

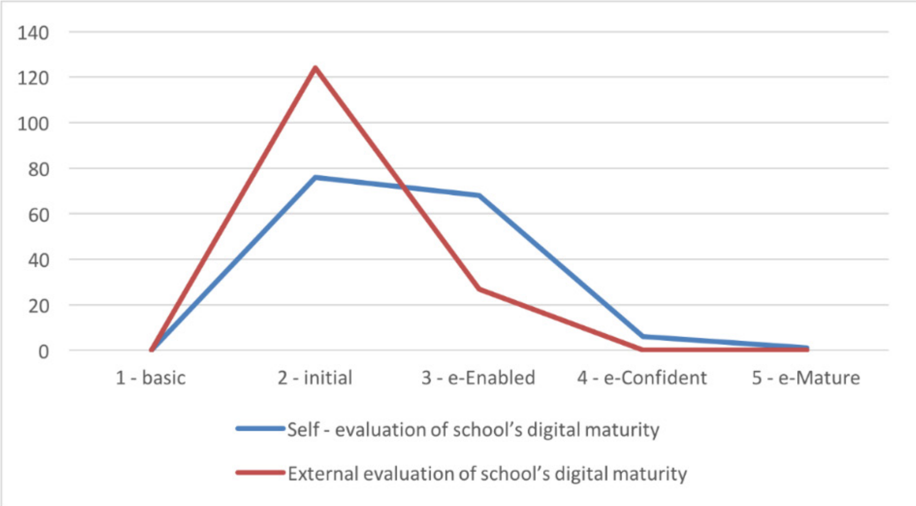

Fig. 2. Summary results of self-evaluation and external evaluation

4 Relationship between digital maturity indicators

As already mentioned, the performed evaluation involved 151 primary and secondary schools in Croatia, that all underwent two rounds of evaluation that included self-evaluation and external evaluation. In this section, we will focus only on the data gathered by the external evaluation conducted as the second round of the evaluation.

The main aim of the external evaluation was to find: (1) Correlations between indicators within the main domains of the Framework, and (2) Indicators that directly influence the overall digital maturity levels.

4.1 Relationship within domains

We started the research by analyzing the correlation matrix for each domain separately where we identified weak and moderate correlations between indicators. The Spearman's correlation coefficient was used to evaluate the relationships? between indicators since all indicators fall into one of the 5 different maturity levels which represents ordinal variables. In this paper, we will focus only on the correlation coefficients around and above 0.3 in respect to [5] who suggest that the correlations sizes below 0.3 indicate negligible connections. However, these are rather arbitrary limits which is the reason why we did not omit the values very near to 0.3 from further interpretation. Therefore, in the following tables (Table 2), the bolded values represent the correlations which are taken into further consideration. Table 2 shows the correlation matrix for the 1st domain - Planning, Management and Leadership.

Within this domain, we found weak correlations between the Vision, strategic guidelines and objectives of ICT integration (PML1) and the Plan and programme of school development from ICT perspective (PML2) (r_s =.299, $p < 0.01$). We can also note that the Plan and programme of school development from ICT perspective (PML2) is obviously a very important indicator because it correlates with almost all other indicators within the domain. Consequently, we found that the Plan and programme of school development from ICT perspective (PML2) weakly correlates with the Management of the ICT integration into school's business activities (PML4) (r_s=.317, $p < 0.01$), the Learning analytics (PML5) (r_s =..391, $p < 0.01$), and with the Use of ICT in teaching students with special educational needs (PML7) (r_s =..293, $p < 0.01$). Moderate correlation is found with the Management of the ICT integration into learning and teaching (PML3) (r_s =.485, $p < 0.01$).

In the second domain (ICT in Learning and Teaching) we noticed that three indicators are closely interconnected (see Table 3). The Awareness (ICTTL1) weakly correlates with the Planning (ICTTL2) (r_s=.396, $p<0.01$) and the Use (ICTTL3) (r_s=.312, $p<0.01$), while the Planning (ICTTL2) correlates with the Use (ICTTL3) (r_s=.309, $p<0.01$).

Table 2. Spearman's rho for the Planning, Management and Leadership

Indicators		PML1	PML2	PML3	PML4	PML5	PML6	PML7
PML1	Vision, strategic guidelines and objectives of ICT integration.	1,000						
PML2	Plan and programme of school development from ICT perspective.	**.299****	1,000					
PML3	Managing the integration of ICT in learning and teaching.	.244**	**.485****	1,000				
PML4	Managing the integration of ICT the school's business activities.	,052	**.317****	.210**	1,000			
PML5	Learning analytics (LA).	,158	**.391****	.214**	.218**	1,000		
PML6	Regulated access to ICT resources.	-,018	.272**	,033	,114	.270**	1,000	
PML7	Use of ICT in teaching students with special educational needs.	,144	**.293****	.207*	,121	,120	.239**	1,000

**. Correlation is significant on the 0.01 level (2-tailed).
*. Correlation is significant on the 0.05 level (2-tailed).

Table 3. Spearman's rho for ICT in Learning and Teaching

Indicators		ICTTL1	ICTTL2	ICTTL3	ICTTL4	ICTTL5	ICTTL6	ICTTL7
ICTTL1	Awareness.	1,000						
ICTTL2	Planning.	**.396****	1,000					
ICTTL3	Use.	**.373****	**.309****	1,000				
ICTTL4	Digital content.	**.312****	.215**	**.353****	1,000			
ICTTL5	Evaluation of students.	,109	.240**	**.374****	.164*	1,000		
ICTTL6	Students' experience.	,044	.176*	,053	,156	.225**	1,000	
ICTTL7	Special educational needs.	.269**	**.311****	.273**	.261**	,116	,077	1,000

*. Correlation is significant on the 0.05 level (2-tailed).
**. Correlation is significant on the 0.01 level (2-tailed).

Except between the first three indicators, we also found some other weak correlations. The Awareness (ICTTL1) correlates with the Digital content (ICTTL4) (r_s=.312, p<0.01), the Planning (ICTTL2) with the Special educational needs (ICTTL7) (r_s=.311, p<0.01), and the Use (ICTTL3) with the Digital content (ICTTL4) and the Evaluation of students (ICTTL5) (r_s=.374, p<0.01).

The largest number of correlations between indicators is found within domain the Development of Digital Competence (see Table 4). The Awareness and participation (DDC1) was identified as the most important indicator in the domain due to its moderate correlation with the Purpose of professional training (DDC3) (r_s=.502, p<0.01) and its weak correlations with the Self-confidence in the use of ICT (r_s=.408, p<0.01), the Digital competences of students (DDC5) (r_s=.300, p<0.01) and the Informal learning (DDC7) (r_s=.315, p<0.01).

Table 4. Spearman's rho for Development of Digital Competence

Indicators		DDC1	DDC2	DDC3	DDC4	DDC5	DDC6	DDC7
DDC1	Awareness and participation.	1,000						
DDC2	Planning.	.267**	1,000					
DDC3	Purpose of professional training.	**.502****	**.395****	1,000				
DDC4	Self-confidence in the use of ICT.	**.408****	.174*	.304**	1,000			
DDC5	Digital competences of students.	**.300****	**.291****	**.389****	**.314****	1,000		
DDC6	Special educational needs.	,128	.274**	.219**	.227**	.162*	1,000	
DDC7	Informal learning.	**.315****	**.301****	**.465****	**.309****	**.307****	,089	1,000

**. Correlation is significant on the 0.01 level (2-tailed).
*. Correlation is significant on the 0.05 level (2-tailed).

The Planning (DDC2) is weakly connected with the Purpose of professional training (DDC3) (r_s=.395, p<0.01), the Digital competences of students (DDC5) (r_s=.291, p<0.01) and the Informal learning (DDC7) (r_s=.301, p<0.01). The Purpose of professional training (DDC3) weakly correlates with the Digital competences of students (DDC5) (r_s=.389, p<0.01), but shows tendency towards moderate relationship with the Informal learning (DDC7). Finally, the Digital competences of students (DDC5) weakly correlates with the Informal learning (DDC7) (r_s=.307, p<0.01).

Table 5 presents correlation coefficients for the domain the ICT culture. Here we found one moderate correlation between the Access to ICT resources by educational staff (teachers) (ICTC1) and the Access to ICT resources by students (ICTC2) (rs=.522, p<0.01). Next, we found that the Communication, information and reporting (ICTC4) is a central indicator of this domain because it has the largest number of correlations with other indicators. In this respect, it correlates with the Access to ICT resources by educational staff (teachers) (ICTC1) (r_s=.414, p<0.01), the Access to ICT resources by students (ICTC2) (r_s=.326, p<0.01) and with the Netiquette (ICTC5) (r_s=.406, p<0.01). Within this domain we also found weak correlation between the Netiquette (ICTC5) and the Projects (ICTC7) (r_s=.336, p<0.01).

Within the last domain we found several weak correlations presented in Table 6. The Network infrastructure (ICTI2) correlates with the Planning and procurement (ICTC1) (r_s=.358, p<0.01) and with the ICT equipment for educational staff (teachers) (ICTI4) (r_s=.291, p<0.01). The ICT equipment in the school (ICTI3) correlates with the ICT equipment for educational staff (teachers) (ICTI4) (r_s=.309, p<0.01) and with the Software tools in schools (ICTI5) (r_s=.347, p<0.01). The last correlation is found between the Information security system (ICTI9) and the Licensing control (ICTI19) (r_s=.423, p<0.01).

Table 5. Spearman's rho for ICT Culture

Indicators		ICTC1	ICTC2	ICTC3	ICTC4	ICTC5	ICTC6	ICTC7
ICTC1	Access to ICT resources by educational staff (teachers).	1,000						
ICTC2	Access to ICT resources by students.	**.522****	1,000					
ICTC3	Internet presence.	.263**	.164*	1,000				
ICTC4	Communication, information and reporting.	**.414****	**.326****	,145	1,000			
ICTC5	Netiquette.	.162*	,138	,089	**.406****	1,000		
ICTC6	Copyright and intellectual property.	-,100	-,016	,012	,052	,106	1,000	
ICTC7	Projects.	.219**	.282**	.259**	.183*	**.336****	,147	1,000

**. Correlation is significant on the 0.01 level (2-tailed).
*. Correlation is significant on the 0.05 level (2-tailed).

Table 6. Spearman's rho for ICT Infrastructure

Indicators		ICTI1	ICTI2	ICTI3	ICTI4	ICTI5	ICTI6	ICTI7	ICTI8	ICTI9	ICTI10
ICTI1	Planning and procurement.	1,000									
ICTI2	Network infrastructure.	**.358****	1,000								
ICTI3	ICT equipment in the school.	,133	.203*	1,000							
ICTI4	ICT equipment for educational staff (teachers).	.210**	**.291****	**.309****	1,000						
ICTI5	Software tools in schools.	,145	.245**	**.347****	,145	1,000					
ICTI6	Technical support.	,095	,123	.203*	.201*	,119	1,000				
ICTI7	Equipment maintenance.	-,052	,019	,142	.172*	,053	.243**	1,000			
ICTI8	Central repository of digital documents and educational content.	.195*	,153	.183*	.182*	,123	,120	-,088	1,000		
ICTI9	Information security system.	,019	,087	.220**	.208*	.273**	.236**	,139	.212**	1,000	
ICTI10	Licensing control.	,040	-,069	,134	,127	.174*	,120	-,045	,157	**.423****	1,000

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

4.2 Relationship between indicators and maturity levels

The next step in our analysis was to research the correlations between maturity indicators and maturity levels in order to identify possible dependencies and maturity indicators that directly influence the final maturity level of a school.

We analyzed the correlation matrix with all indicators and calculated the maturity levels for 151 schools. The total of 21 indicators were found to influence the maturity level of a school with significance level of $p<0.01$ and are listed below by domains:

1. **Planning, Management and Leadership:** Plan and programme of school development from ICT perspective (PML2) (r_s=.407); Managing the integration of ICT in learning and teaching (PML3) (r_s=.441); Learning analytics (LA) (PML5) (r_s=.383); Regulated access to ICT resources (PML6) (r_s=.298); Use of ICT in teaching students with special educational needs (PML7) (r_s=.388).
2. **ICT in Learning and Teaching:** Awareness (ICTTL1) (r_s=.372), Use (ICTTL3) (r_s=.432); Digital content (ICTTL4) (r_s=.390).
3. **Development of Digital Competence:** Awareness and participation (DDC1) (r_s=.389); Planning (DDC2) (r_s=.342); Purpose of professional training (DDC3) (r_s=.381); Self-confidence in the use of ICT (DDC4) (r_s=.350); Informal Learning (DDC7) (r_s=.453).
4. **ICT Culture:** Access to ICT resources by educational staff (teachers) (ICTC1) (r_s=.364); Access to ICT resources by students (ICTC2) (r_s=.468); Communication, information and reporting (ICTC4) (r_s=.331); Projects (ICTC7) (r_s=.463).
5. **ICT Infrastructure:** Planning and procurement (ICTI1) (r_s=.330); Network infrastructure (ICTI2) (r_s=.311); ICT equipment in the school (ICTI3) (r_s=.431); ICT equipment for educational staff (teachers) (ICTI4) (r_s=.334).

5 Discussion

According to the above presented correlation analysis, it is evident that some indicators play an important role within their domains. We showed that the Plan and programme of school development from ICT perspective plays very important role in the first domain because it positively affects many other indicators and that it also affects the overall maturity level of a school. This, somehow, justifies the purpose of such document which is to set a solid ground for all activities that involve ICT. Without a proper plan, it would not be possible to implement and utilize the ICT in teaching and learning. Furthermore, it needs to be noted that this indicator is also connected with the Management of ICT integration into teaching and learning indicating once again that the Plan is indeed a backbone of the ICT implementation and usage primarily in teaching and learning.

In the second domain, we identified the Awareness indicator being the trigger for others. This can be justified by the meaning of the indicator itself. Namely, if there is no awareness of the potentials of the ICT in teaching and learning, all other activities such as planning, usage of the ICT, etc. would probably be very restricted or would not occur at all.

The third domain elicits once again the Awareness and participation as the prerequisites for the development of digital competences. It was shown that, in a broad sense, the mentioned indicator helps to recognize the purpose of the professional training, as well to become more self-confident user of the ICT. Next, the same indicator, if present, will enhance and support the development of digital competences of students, as well as the informal learning, which needs to be encouraged and recognized in a formal schooling system.

The fourth domain did not reveal any key indicator. However, it showed that the Access to the ICT resources for students and for teachers are very related, meaning that if a school sets up the ICT resources, most of them will be available to both, students and teachers, or that at least, if a new equipment is installed for students, a part of that equipment will be available to teachers as well.

The last domain also did not reveal any key indicators, but showed that the network infrastructure greatly depends on the planning procedures, and that the equipment for teachers is purchased taking into account the network infrastructure specifications. This could mean that if a wireless network is present, there is a high probability that teachers will be equipped with laptops and tablets, while it is rarely the case where the wireless network is not present throughout the school. One interesting finding is that a school will pay more attention to licensing control if some kind of information security procedures are developed.

Finally, it needs to be noted that the school management plays very important role in the digital maturity of a school. It was shown that a well written and balanced plan for school development from the ICT perspective, along with the good management of ICT integration in teaching and learning, present a solid ground for digitally mature schools. Most of the "Awareness" indicators are based on a good planning being the triggers for other activities in their domains. Also, the planning within other domains refers to a general plan established in the first domain.

6 Conclusion

This paper presented the Framework for Digitally Mature Schools which serves to identify the domains and elements that contribute to the digital maturity of schools, and the supporting instrument designed to assess the level of digital maturity of schools and to identify the areas of possible improvements in the context of the school's digital maturity. Because of the generic characteristics, the developed Framework, together with the instrument and the software, can be adapted to similar systems in other countries in order to determine the digital maturity of schools.

The results of the external evaluation revealed the fact that the majority of the evaluated schools in Croatia are on levels 2 or 3 which means that there is a room from their progress. A dozens of indicators were revealed that are more or less interconnected and dependent and that influence the overall digital maturity level of a school. Based on the results, it is evident that some indicators play an important role within their domains so the schools should aim to raise the maturity of these indicators first which will reflect in raising the maturity of the domain and in the end, in the general maturity level of a school.

In the next period, all involved schools will receive support in terms of equipment and will be involved in the workshops on how to write strategic documents, i.e. Plan and programme of school development from ICT perspective, and a dozen of education programmes developed with the aim to raise the awareness of school management and teachers about possible implications of ICT in teaching and learning. At the end of the project, the additional round of evaluation will be performed in order to find out if the planned activities were implemented and if they resulted in overall improvement of the digital maturity level of the involved schools.

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Development of WebGL-based Virtual Teaching Platform for Mold Design

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Abstract—As an outcome of the further development of modern simulation technology, virtual technology has been widely used under the support of computer technology and multimedia technology and provides more interactivity and perceptibility. However, in the past, the design of virtual teaching system was mainly based on theoretical analysis, resulting in low practicability. The appearance of WebGL standard simplifies the procedure of developing web-specific rendering plug-ins, contributing to more seamless 3D scenes and models. This study constructed the theory from several aspects including multimedia teaching effect under cognitive theory, WebGL architecture, design of virtual teaching curriculum based on WebGL, and built a WebGL-based virtual teaching platform for mole design through designing the overall framework and constructing the three-dimensional teaching environment. Practice has proved that the platform makes it convenient for users to create teaching scenarios and engage in interactions, and strengthens students' understanding of theoretical knowledge and skill practice.

Keywords—WebGL; Mould Design; Multi-media technology; Virtual teaching course

1 Introduction

Virtual technology as a new type technology based on multiple computer technologies and multimedia technology can simulate and virtualize the real world or objects so as to satisfy people's demands by adjusting self-variation according to surrounding environment changes. Virtual technology based on people's own sense organs can establish 3D images according to direct sensory feeling, so it has high facticity [1]. Advanced virtual technology can combine virtual space with realistic environment to realize system-human interaction by obtaining surrounding and human real-time data. In addition, virtual technology can perceive through vision, as well as sense of hearing and touching. The more lifelike of the simulation experience, the stronger of the interactivity and perceptibility can be provided.

With the increasing maturity of virtual technology, people have simulated the real world in several fields such as commodity display, game development, and military training [2] with preliminary progress achieved. In teaching field, especially medical, PE, and design major teaching have high requirements for practical ability [3]. But problems such as substandard teaching procedures and great practice difficulties prevail. Take Mould Design course as the example. On one hand, traditional teaching environment is greatly different with enterprise actual production environment. On the other hand, mould design is very dangerous. So it is very urgent to introduce virtual technology and virtual teaching system to mould design teaching.

Virtual teaching system achieved complete simulation to a large degree by means of making the teaching course into animation with virtual technology and adding more interactivity and facticity on this basis. Current well-designed virtual teaching system has been widely used in medical experiments, engineering drawing and relevant fields, which has great significance for improving practical teaching effect. This paper conducted irtual “Mould Design” teaching course development based on WebGL technology for the purpose of compensating hardware facility deficiency in universities, and improving students’ learning interest by virtue of the interactivity and creativity of virtual technology so as to achieve better teaching effect.

2 State of the art

Under the background of virtual technology rapid development, domestic and overseas teachers and scholars have realized the necessity of introducing virtual technology into course teaching. With Mould Design and Manufacturing course as the example, Bao, et al. [4] proposed the feasibility of applying 3D VR technology to classroom teaching based on analyzing shortcomings of traditional mould teaching and combining with characteristics of mould main curriculum. Based on theoretical analysis, the scholar also specifically designed the application process of virtual simulation technology with mould design and manufacturing as the principal line. Sun, et al. [5]analyzed the realistic predicament of practical teaching, proposed the construction elements of virtual-real synthesis mould design manufacturing practical teaching system and its improving effect on practical teaching based on virtual simulation technology, computer network technology and multimedia technology. Although people generally agree that virtual technology will bring great change to traditional teaching mode, virtual technology application in educational field is in start stage. There still exist a lot of barriers for the combination of virtual technology and teaching practice.

In recent years, some scholars noticed the standardization of WebGL, the 3D graphics protocol, and tried to introduce it into virtual teaching system development. Burdea, et al. [6] proposed virtual mould rehabilitation technology. The casting process of the hollow turbine blade is simulated by means of the software ProCAST, and the displacement field of the blade is calculated with a finite element model, based on which the mold cavity is optimized by the anti-deformation virtual mold-repair method. As testified by a simulation of the revised mold cavity and identified by a mold cavity model, satisfactory results of mold repair are achieved by this method. This method achieved satisfied effect for mould rehabilitation with product qualification ratio increased by 20%. Technology, et al. [7] conducted modelling of the engineering drawing combination with AutoCAD as modeling tool, and realized the analytical reading of model data file, shader programming, and addition of interactive processing program with WebGL technology through analyzing the export file of its STL format, researched and developed engineering drawing model base operating in browsers, and provided thoughts for virtual model base R&D. Alexiadis, et al. [8] based on WebGL technology, a virtual lab on multimedia systems for telecommunications, medical, and remote sensing applications is presented; consisting of 20 graphical user interfaces, it can support teaching activities for various DSP concepts. The virtual lab developed was used as a teaching companion for a post-graduate course on multimedia content management, to enhancing student comprehension of the material taught; it has been made freely available for similar educational or research purposes. Kun, et al. [9] designed and implemented medical virtual experiment system needed by Chinese medical college education and teaching. The implementation of the system will play an important role of improving medical education technology, improving teaching experiment environment, optimizing teaching process, cultivating talents with innovative awareness and ability, reducing teachin cost. Sun, et al. [10] developed and completed casting virtual experiment teaching system based on WebGL. In this virtual teaching system which is available for students' direct interaction with teaching contents through browser in any devices can realize students' immersive learning any time anywhere. It provided good reference for this paper design.

To sum up, course teaching represented by medicine, design majors are in urged demand of virtual teaching system. But there are some defects such as theoretical analysis oriented and low practicability [11]. In addition, most universities use profession 3D software for scene drawing, which requires for a large amount of professional knowledge and long construction period. And the model built is different with the display effect during actual operation with low efficiency and high complexity. Virtual teaching course based on WebGL in this design is obviously different with traditional teaching mode and previous virtual teaching systems. Introduction of WebGL technology standard can effectively solve current problems in Web interactive 3D animation, and realize Web interaction 3D animation production with HTML script itself, and realize graphic rendering through uniform, standard and cross-platform OpenGL interface. In addition, this design constructed 3D teaching environment based on completing WebGL virtual teaching course for providing multiple 3D scenarios and interactive behaviors, and innovatively built a new 3D teaching environment system for users to rapidly create their own teaching scenarios and required interactive behaviors so as to establish direct and highly interactive teaching scenario.

3 Theoretical construction of virtual technology based on WebGL

3.1 Cognitive Theory of Multimedia Learning

Multimedia teaching is a teaching mode with text, audio, video and simulation method to present teaching contents. According to learner cognitive theory, multimedia teaching has characteristics such as strong expressive force, high interactivity and shareability, and has significant support for students to absorb teaching contents. Multi-media technology and tools can concretize original abstract concept so as to reduce teaching difficulty. Cognitive theory is a learning theory studying how changes occur due to experience. It emphasizes human body's understanding of current scenario with consistent perceptual power with the learning motivation principle, makes cognition specific and concrete [12]. Due to the difference of brain nerve system structure with evolution, human beings and animals have different degrees of comprehension. Cognitive theory which is essential for the interactive effect between learners and the learning environment can directly influence the teaching effect. Factors influencing teaching effect are shown in fig. 1:

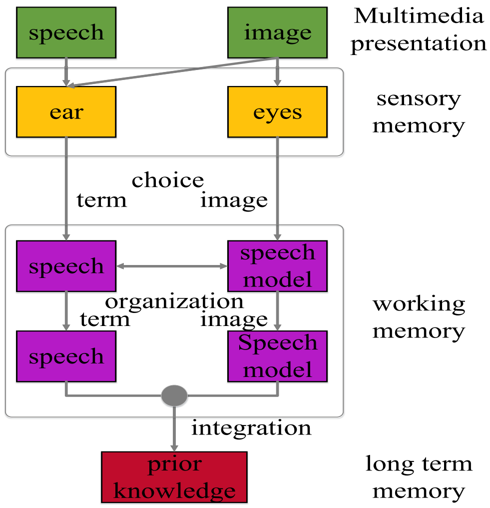

Fig. 1. Diagrammatic figure of multimedia learning cognitive theory

In multi-media environment, students can enjoy rich information media resources and get into learning contents by direct conclusion and new forms. Specific to above two elements, multimedia technology in various forms can display knowledge context and frame clearly. Meanwhile, multimedia teaching can conduct purposeful arrangement of teaching contents with very obvious function of strengthening teaching effect.

3.2 WebGL

WebGL as a free open 3D graphics protocol allows to combine JavaScript with OpenGL ES 2.0, and adds a JavaScript binding to provide accelerated hardware 3D rendering for HTML5 Canvas so as to smfoothly display 3D scenario and model in browsers, and to create complicated navigation and data visualization. WebGL with characteristics of availability in multi-platform environment with no need to develop website specialized rendering plug-in is widely applied in 3D structured web page building. General framework of WebGL application is shown in fig. 2:

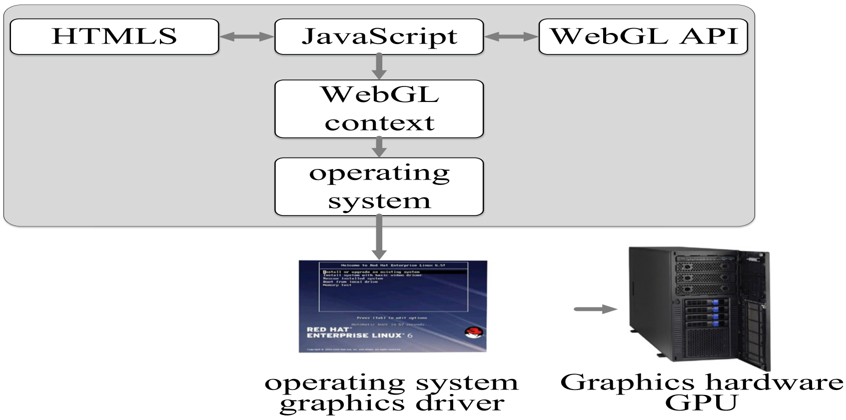

Fig. 2. WebGL application framework diagram

During the using process, WebGL can link with other 3D context webpage contents for base layer rendering call through GLSL ES. As a part of HTML5 standard, each browser is implementing and supporting WebGL so that WebGL is becoming an ideal tool of developing dynamic 3D webpage. By applying WebGL technology, people can directly process graphics contents in B/S mode in the network end, and perfectly solve the previous Web interactive 3D problem.

3.3 Virtual teaching course design based on WebGL

Framework design. Virtual teaching course based on WebGL applies B/S framework for design containing two parts: browser with WebGL analytical ability and Web server. Browser client end software further generates the client end of virtual teaching course including UI interface module and Ajax framework. Web server is constituted by model layer, presentation layer and control layer. The framework design is as follows: model layer design requires to create two XML files, Shape.xml and material.xml. Shape. Xml is for creating the basic shape of object; material. Xml is for storing texture data and surface color. The material.xml contains illumination, text, visual effect and animation XML file.

XML analysis. In framework design procedure, data structure of the whole scene object is obtained by the integration of model layer, illumination and control layer. So data structure of the whole scene can be obtained by analyzing site.xml file.

Rendering processing. WebGL can support Open GL. So WebGL rendering processing can be conducted by referring to Open GL rendering process. The schematic diagram of pipeline is shown in fig.3. In WebGL, a canvas member is added into HTML 5 for 3D graphic rendering. OpenGL graphic can be flexibly used according to the context for scene rendering.

Interactive processing. To achieve the interaction with users, it is possible to implant DOM Events in WEB page during virtual teaching course. DOM Events can be implemented by registering event sound monitor for interactive processing of mouse, keyboard and user's operation events.

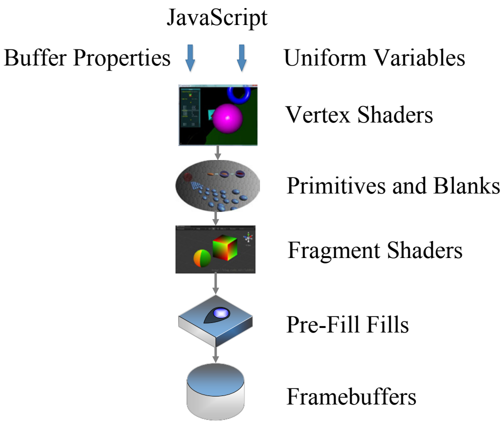

Fig. 3. Flow diagram of virtual teaching rendering processing based on WebGL

4 Virtual "Mould Design" teaching course based on WebGL

4.1 Virtual "Mould Design" teaching course development

Based on completing theoretical construction, this paper conducted R&D of virtual teaching course based on WebGL from two aspects, overall framework design and 3D teaching environment building.

Overall framework design. Overall implementation flow of virtual teaching course based on WebGL is shown in figure 4.

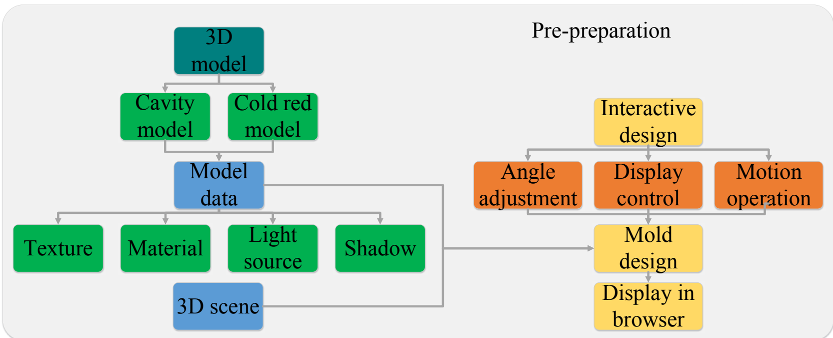

Fig. 4. Overall implementation flow chart of virtual teaching course based on WebGL

Virtual teaching course contains text, form, graphic, audio, animation and rich multi-media resources. Text information can be used in Word for direct input or can be obtained through scanning. The inserted text information can be realized in hyper-text form; most tables are in scanning form to avoid editing errors; graphic editing is also in scanning way. Or map-making software automatic generation can be used for high-precision requirement. Audio is mainly background music.

Animation generation is the key of virtual teaching course research and development, as well as the difficulty of mould design teaching. Generally, standard framework is used in moulds for production use with small appearance difference and different interior structure. The difficulty of mould design learning is the movement mode of each component. 3DS MAX is common animation production software which can vividly display the object appearance and texture with good overall effect and wide application in mould design. But previous mould animation designed by 3DS MAX had problems of compact structure, low recognition, and serious interference of eyesight. This paper used the improved 3DS MAX for mould animation generation, i.e. independent generation of each component. Based on this, conducted dynamic assembly and generated EXE file after rendering for demonstration. The interface of virtual "Mould Design" teaching course based on WebGL is shown in figure 5-7:

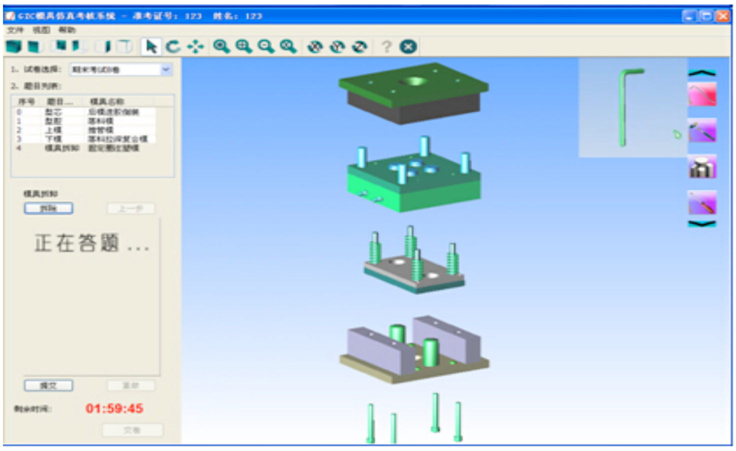

Fig. 5. Interface 1 of virtual "Mould Design" teaching course based on WebGL

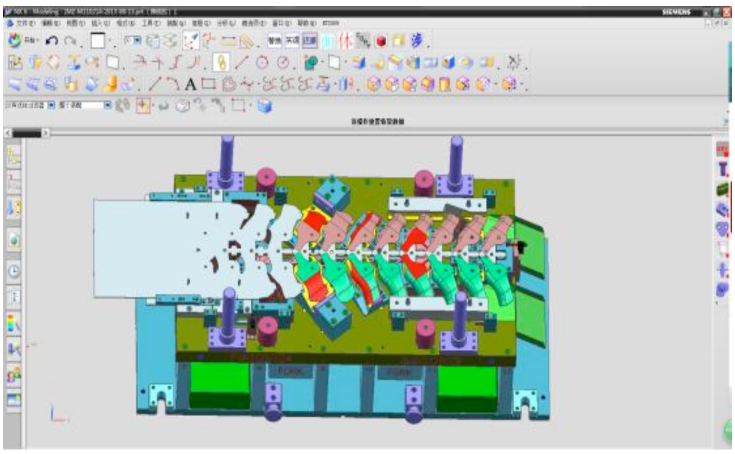

Fig. 6. Interface 2 of virtual "Mould Design" teaching course based on WebGL

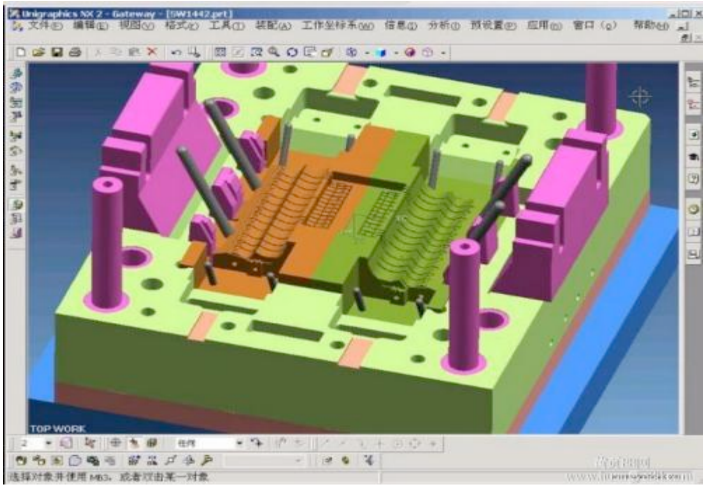

Fig. 7. Interface 3 of virtual "Mould Design" teaching course based on WebGL

3D teaching environment building based on WebGL. Virtual teaching course based on WebGL is suitable for 3D teaching environment. But current 3D teaching environment with high professional requirements can complete model design after long-time construction period. In practical application, there exists model distortion problem which makes user experience in low level for a long time. So this paper conducted 3D teaching environment building to solve the problems of complicated construction and inflexible application of current 3D teaching environment.

3D teaching environment built by this paper firstly displays scene set and object set. Then user selects and sets the position. Next, object graphics and scene graphics can be displayed together through rendering and graphics integration. In this 3D teaching environment, users can choose scene and object properties for setting, or edit files necessarily, modify environment parameters as required, and also modify object interaction properties so that objects in the scene have rich properties of moving, being clicked and opened. After modification, users can save the operation and send the file to client end for demonstration. Flow of 3D teaching environment generation based on WebGL is shown in fig.8.

It can be known from fig.8 that users after logging in the system can see a lot of pre-set 3D scenes and objects. Next, they can adjust the position of scenes and objects according to their demands. Users can keep changing the properties of objects in the scene after setting 3D scenes and objects, and can further make interactive design of objects. After clicking the object to be designed, users can choose interaction content and form in the pop-up window. After designing, the system will record the user's design data, and save the scene information, objective information and interaction information together in this file. 3D teaching environment designed by this paper with low user requirement and fast design speed has great significance for improving user design efficiency and reducing user's cost of creating 3D scenes. Specific to the function modules, 3D teaching environment designed by this paper contains following modules, see fig.9.

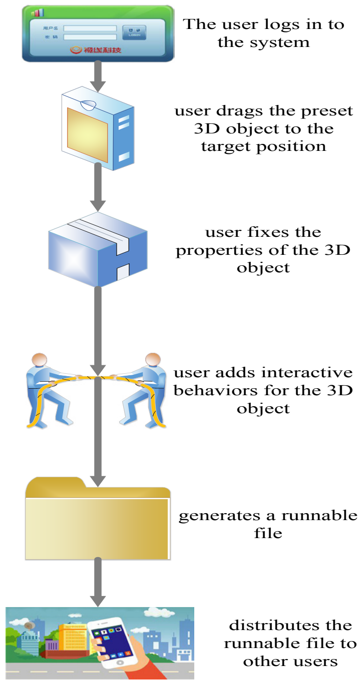

Fig. 8. Flow chart of 3D teaching environment generation based on WebGL

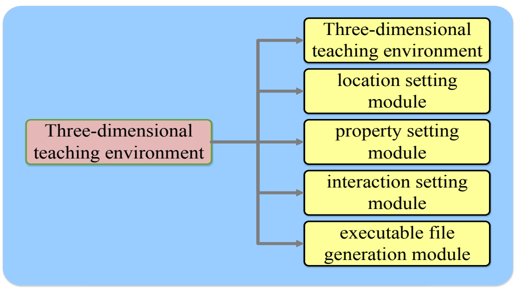

Fig. 9. Module diagram of 3D teaching environment based on WebGL

Display module is used for displaying 3D scenes set and 3D object set; position setting module is for receiving the position setting, object selection and other information of the 3D scene to generate 3D teaching environment file; property setting module is responsible for modifying relevant information of 3D teaching environment file; interaction setting module is for receiving user's 3D object selection information and interaction setting information; executable file generation module is for generating 3D teaching environment executable file. Users can complete 3D scene and interactive behavior demonstration by using the 3D teaching system designed by this paper. Scene graph of 3D teaching environment generation based on WebGL is shown in figure 10.

Fig. 10. Scene graph of 3D teaching environment generation based on WebGL

4.2 Teaching effect

60 students in two class grade 2016 of module design and manufacturing major of a university were selected as the research object of this paper, 30 students in each class including 45 boys and 15 girls. Two classes were respectively used as experiment group and control group to participate in the experiment. Students in experiment group studied with the support of virtual "Mould Design" teaching course based on WebGL, and carried out teaching and training in 3D teaching environment. Teachers and students cooperated to complete the setting of 3D teaching environment. Previous multimedia teaching system was used in control group for assisted instruction.

After the class period, final examination and questionnaire survey were used for teaching effect assessment. The ratio of theory and practice in the final examination was 50%, with Excellent (>90), good (80-90), fair (60-79) and poor (<60) for segmentation. The questionnaire survey mainly emphasized students' evaluation of teaching environment ad was conducted once after the class hour at site. The recovery rate was 100%. Table 1 shows the statistics of students' final examination scores.

It can be seen from table 1 that in experiment group 27 students obtained Excellent, 23 students obtained Good, with Excellent-Good ratio of up to 83.3%, obviously higher than the ratio in control group. The number of student obtaining Poor in experiment was 0, obviously different with control group. On a whole, students in experiment group performed better than control group, which indicated good practical effect of virtual "Mould Design" teaching course based on WebGL Table 2 shows students' evaluation of teaching environment from the questionnaire survey.

It can be seen from table 2 that students in experiment group had obviously higher evaluation of teaching environment than control group. Virtual "Mould Design" teaching course based on WebGL played a more important role in stimulating learning interest, strengthening operational ability, increasing class activity and deepening practice participation.

Table 1. Students' final examination scores

Group	Student number	Excellent	Good	Fair	Poor	Excellent-Good ratio (%)
Experimental group	30	14	11	5	0	83.3
Control group	30	10	8	11	1	60.0

Table 2. Students' evaluation of teaching environment

Group	Stimulate learning interest	Strengthen operational ability	Increase class activity	Deepen practice participation
Experimental group (n=30)	28	26	28	29
Control group (n=30)	20	21	22	18

As a whole, mould design major teaching efficiency was higher in 3D teaching environment. Students obviously strengthened learning activity in highly interactive teaching scene. Self-built 3D teaching scene was more consistent with the teaching practice. Internet education requires to improve trainees' real immersive feeling and their real experience. Constructing virtual teaching environment can improve trainees' real experience and their learning activity. With the maturity of 3D display technology, establishing 3D teaching environment with 3D display technology further improved the real sense of teaching environment. Regarding teaching effect, virtual teaching course based on WebGL can obviously improve students' academic scores. Meanwhile, students are more satisfied with the teaching environment of this virtual teaching course. Analyzing the reasons, firstly, using this virtual teaching course can help students to clarify their personal study plan. The topic and knowledge key points of process mould design course can be vividly and truly presented in virtue of virtual technology so as to impress students profoundly and strengthen their learning effect. Secondly, the virtual teaching course can stimulate students' thirst for knowledge. This teaching course massively applied virtual technology for supporting multimedia teaching including audio, image, animation, audio and video products to stimulate students' visual and hearing sense comprehensively. This avoided the singleness of traditional teaching mode. The novelty and diversity of different hi-tech teaching modes stimulated students' interest and sense of participation. Teachers could also instruct discipline frontier development trend related to classroom contents, scientific historiette including interesting science stories by using network information to mobilize students' classroom activity. More importantly, this virtual teaching course based on WebGL in this design achieved graphic rendering through uniform, standard and cross-platform OpenGL interface, and 3D teaching environment built by this paper could help teachers and students to rapidly create their own teaching scenes and desired interactive behaviors so as to establish vivid and highly interactive scenes. In this case, it could further strengthen students' profound love and enthusiasm for mould design major.

5 Conclusions

Virtual teaching course based on WebGL gave new meaning to "Mould Design" major teaching. The vivid 3D virtual model can strengthen students' overall cognition and understanding of mould design, effectively relieve the unsound infrastructure problem of university design major teaching, and help students to participate in practice with more activity and devote into study with greater passion. Further perfection and development of Virtual teaching course based on WebGL will provide new thoughts for improving traditional teaching system, and gradually construct a 3D virtual teaching system with higher teaching efficiency and stronger teacher-student interaction.

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Improved Adaptive Genetic Algorithm for Course Scheduling in Colleges and Universities

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Abstract—Traditional artificial intelligence and computer-aided course scheduling schemes can no longer meet the increasing demands caused by the informatization of teaching management in colleges and universities. To address this problem, this study designed an improved adaptive genetic algorithm that is based on hard and soft constraints for course scheduling. First, the mathematical model of the genetic algorithm was established. The combination of time, teacher, and course number was regarded as the gene coding. The weekly course schedule of each class was a chromosome, and the course schedule of the entire school was the initial population. The fitness was designed according to the priority of each class, curriculum dispersion, and teacher satisfaction. Local columns between individuals were selected through the roulette principle for a variation of crossover and random columns. Iterative calculation was implemented on the basis of the default mutation and crossover rates to study the optimal course scheduling scheme. Experimental results demonstrate that the improved adaptive genetic algorithm is superior to the original genetic algorithm. When the number of iterations is 150, population evolution is optimal and the fitness does not increase. When the population size is 150 classes, the average scheduling time is the shortest. The basic, adaptive, and improved adaptive genetic algorithms are compared in terms of the number of average iterations required for convergence, maximum individual fitness, and average individual fitness. Comparison results show that the improved adaptive genetic algorithm is superior to the two other algorithms. This study provides references for the model building and evaluation of course scheduling in colleges and universities.

Keywords—course scheduling, mathematical model, improved adaptive genetic algorithm

1 Introduction

Course times and places and teachers should be arranged every semester in colleges and universities according to the teaching plan and curriculum structure. Many rules are observed in course scheduling, which should consider such factors as the times and places of instruction and the teachers. The reasonable allocation of these factors forms a multi-constraint professional resource optimization problem. Course scheduling in most colleges and universities is presently manually implemented by teaching staff, who encounter numerous difficulties because of the large number of courses and teachers, required instruction places, and multiple constraints[1][2].

To address the general requirements of colleges and universities, this work regards each factor in the course scheduling problem as inputs into a genetic algorithm, which is a multi-objective optimization problem with constraints. Many constraints and combination factors are used in course scheduling, thereby increasing its complexity. A genetic algorithm is a parallel random search optimization algorithm that simulates natural and biological genetic and biological evolution. The algorithm establishes a model of biological evolution and implements the relevant calculation. The genetic algorithm can realize global optimization and parallel processing to optimize the configuration of various resources[3][4].

This study first establishes a mathematical model of course scheduling in colleges and universities. The improved adaptive genetic algorithm corresponds to the problems of college scheduling individually, and the optimal solution is searched by simulating natural evolutionary processes. The course scheduling in colleges and universities is designed and optimized. Finally, the NP-hard combinatorial problem is solved effectively[5].

2 State of art

After the 1990s, Arabinda Tripathy of the School of Management, Vastuper University, India, proposed course scheduling that is based on individuals and solved conflicts in course scheduling through the multi-class group method. Jean Aubin of Montreal University, Canada decomposed the problem of course scheduling into timetable and grouping[6][7]. The course scheduling decision support system was developed according to these two issues and includes modules of data processing, automatic optimization, and interactive optimization. Several scholars realized course scheduling and scheduling decision support systems through Lagrange relaxation technique-based branch and bound techniques[8][9]. In 1991, D. Whitey proposed a crossover operator that is based on domain crossover, which represents the individual crossover of genes through serial numbers, and applied the operator to the knapsack problem. D. H. Ackley et al. proposed an iterative genetic algorithm with hill-climbing methods of a complex probability election mechanism. The method determines the value of a new individual through m “voters” [10][11]. Experimental results indicated that the solution speed of the random iterative genetic algorithm with hill-climbing methods was higher than that of genetic algorithm, simulated annealing algorithm, tabu search, and a combination of several intelligent algorithms. Colomi et al. applied a matrix representation scheme with crossover and mutation operators to course scheduling in high schools in Milan. Since 2002, Lalescu has been devoted to studying the application of genetic algorithms in course scheduling systems and developed the software FET. However, the rules and conditions of course scheduling in foreign countries differ from those in China[12][13].

Although domestic scholars began studying course scheduling relatively late, scheduling algorithms are now being studied by many colleges and universities. In

1984, Lin Zhangxi and Lin Yaorui of Tsinghua University conducted an experimental research and designed a timetable scheduling system called TISER（Tmaetable Schedul ER）. The university timetable scheduling system of the Nanjing Institute of Technology and the intelligent teaching organization management and curriculum scheduling system of the Dalian Institute of Technology use artificial intelligence expert systems and decision support systems to simulate artificial course scheduling. Southwest Jiaotong University proposed a course scheduling algorithm that uses the calculation of the class element and the candidate space–time slice of the course element as the core. Yanbian University developed an automatic course scheduling algorithm with a computer-based data structure[14][15]. In 2002, Dai Xiaoming et al. presented the parallel evolution of multi-population heredity; different mutation operators search a variable space, various populations use different genetic strategies, and genetic information is exchanged through a population migration operator to address the convergence of classical genetic algorithms to local optima[14][15]. In 2004, Zhao Hongli et al. proposed a parallel genetic algorithm for gene block coding considering the low search efficiency of a Simple Genetic Algorithm (SGA) in large-scale combinatorial optimization problems. In 2005, Jiang Lei et al. used the parallel genetic algorithm to solve the knapsack problem and attempted to maintain the diversity of the population through an elastic strategy; the authors obtained good experiment results; the algorithm crossed the obstacle of local convergence and evolved in the direction of global optimization. On the basis of analyzing and summarizing the experience of the original course arrangement, Shanxi University presented a formal description to solve the problem of course scheduling and realized an automatic course scheduling system that is based on the knowledge reasoning of this idea. Liu Hong et al. proposed the principle of artificial intelligence to realize the course scheduling of colleges and universities. In recent years, greedy and backtracking algorithms have been used to address the problem of course scheduling in China. However, the greedy algorithm is not necessarily the optimal solution, and the backtracking algorithm should be used with other algorithms because of high time complexity[16][17]. Therefore, complex course scheduling, which involves considerable calculation, should not only rely on pure mathematical methods but also plan and solve the problem step by step by drawing lessons from operational research.

The course scheduling schemes in the abovementioned studies are based on the curriculum characteristics and teaching resources of the corresponding colleges and universities and thus cannot be popularized on a large scale. Each university has its own characteristics of teaching and operation. Courses should be scheduled according to the curriculum characteristics and teaching resources of schools. In the meantime, the following problems also occur. (1) As in the case of combined classes, the constraints considered are not comprehensive enough. (2) The objective function considers only the number of times the constraint is violated and not the importance of various courses and the different teaching effects in varying periods. (3) Each university should consider its actual teaching implementation when formulating a teaching plan. In view of these shortcomings, an improved method is proposed.

3 Methodology

3.1 Constraints on course scheduling

The rules in course scheduling are divided into hard and soft rules. Hard rules are immutable and must be executed in accordance with plans, talent programs, and teaching objectives. Soft rules are satisfied as much as possible if conditions permit, thereby improving the feasibility of the scheme[3]. The hard and soft rules of the proposed method are as follows.

The hard rules are the following. (1) The number of courses offered and the corresponding hours are fixed according to the teaching plan and talent training objective. (2) Each course can be offered in only one class at the same time. (3) Each teacher can teach only one course at the same time. (4) A course can be offered in only one classroom at the same time for several classes together. (5) The capacity of a classroom must be greater than the number of students in a class.

The soft rules are the following. (1) Teachers who have requirements for class scheduling should be considered. (2) PE classes should not be the first or second class in the morning. (3) Public courses take precedence over professional courses. (4) Teachers' course schedules should be as concentrated as possible to allow them to rest or have spare time for studying and preparing lessons. (5) Courses with many periods should be prioritized. (6) The schedules of theoretical and practical courses should be considered in certain majors and courses. (7) Teaching times of the same course should be determined such that hectic schedules are avoided.

Every university can formulate soft rules according to their own situation. On the basis of fulfilling the hard conditions, this study aims to arrange a course schedule in accordance with the soft rules without serious conflict or error to improve the working efficiency of teaching staff.

3.2 Course scheduling through genetic algorithm

To correspond course scheduling with SGA, the definition of the genetic algorithm should be considered. The most important factors in genetic algorithm are the coding, fitness function, initial population, population size, crossover rate, operator, mutation rate, and abort condition[18][19]. Each course has a course number, teaching time, and teacher, and the combination of these three objects is considered a gene. A chromosome is a combination of genes; that is, the combination of course scheduling or the solution of the problem. Initial population refers to a variety of scheduling programs. Individuals select operators through roulette selection. The selection probability of an individual is distributed on a roulette. The greater the fitness, the larger the probability of being selected as a parent individual[20][21].

Population establishment and conflict detection. A genetic algorithm needs to create an initial population composed of character strings. The initial population comprises individuals, which are composed of chromosomes. The chromosomes are made up of genes. The gene coding is as follows. The coding of teaching task can be written as the time + teacher number + course number. First, the teaching tasks are written into the course schedule individually. The course schedule is a two-dimensional table. The columns indicate the time (Monday–Friday), and the lines indicate the number of courses every day (1–6). T1–T2 represent the first and second classes on Monday. If a time is occupied, a new period will be generated. Finally, the substitute teacher numbers are placed in Course schedule 2 without repetition, thereby forming a class schedule. This scheduling method meets Constraints 1, 3, and 4. Course schedules are arranged for N classes via the same operation, thereby obtaining N chromosomes that are individuals. The weekly schedules of N classes form a two-dimensional weekly schedule of classes and teaching times, as shown in Table 1. Meanwhile, the weekly teaching tasks in Table 2 generate the initial population. The population size is defined as 15, thereby resulting in 15 schedules.

Table 1. Initial population table

Time	Class 1	Class 2	Class ….	Class n
T1–T2	24	16	15	12
T3–T4	6		7	4
T5–T6	9	13	9	
T7–T8	16	24	21	
T9–T0				
….	….	….	….	….

Table 2. Course schedule for Class 1

Time	Monday	Tuesday	Wednesday	Thursday	Friday
T1–T2	24	16	14	11	
T3–T4	6			17	19
T5–T6	9	8	12		

Conflict should be checked once the initial population is established. The teacher number on the first column on the first row in Table 1 (1, 1) should be checked and compared with that on the second column on the first row. The chromosome coding values are compared if the numbers are the same. The teacher is teaching in a combined class if the coding values are the same. Errors exist in course scheduling, and a random number i is generated if the code systems of other bits in the chromosomes are different. Cells (1, 1) and (1, i) in Table 1 are exchanged for recomparison. Data comparison in the first line is completed. Subsequently, Table 1 (2, 1) should be checked, and the above steps should be repeated until the end. Consequently, the conflict in which the same teacher teaches multiple courses at the same time is solved; that is, Constraint 2 is satisfied. Courses are allocated at the same time period in Table 1 that require m language laboratories, n machine rooms, 1 small classroom, and x large multimedia classrooms, which are distributed according to the number of available classrooms. Consequently, Constraint 5 is satisfied.

Fitness function. Fitness affects the iterative direction and convergence speed of a genetic algorithm and thus reflects the advantages and disadvantages of the course schedule.

Weight of course interval. In general, teaching in the morning is more effective than that in the afternoon because students are more focused in the morning. The expected priority value of each class is obtained according to years of teaching experience. Separate expected values are required for special courses, such as PE. The priority weight distribution for each class is shown in Table 3.

Weight of course interval. The weights of different time intervals of the same course within one week are also different. The weight distribution of the theoretical course interval is shown in Table 4.

The fitness function is defined as Fit = k1*w1+k2*w2+punish. k1 and k2 are the weights for each class priority and class combination priority, respectively, where k1+k2 =1. "Punish" indicates teacher satisfaction. Before course scheduling, the priority for each teacher's teaching time should be established. Teachers select the time they prefer to schedule classes according to their requirements, as shown in Table 5.

Table 5 indicates the time that teachers do not want to schedule classes. Teachers aim to concentrate their courses because the campus is far from urban areas. Therefore, this work uses the punish weight value, teachers like +5, do not like −5, dislike −10, and do not know 0.

Table 3. Priority weight distribution for each class

Number of courses	1, 5, 9, 13, 17	2, 6, 7, 11, 14, 18	3, 8, 10, 15, 19	4, 12, 16, 20
Expected value	0.8	0.6	0.4	0.1

Table 4. Weight of course interval

Time difference	1, 2, 3, 19, 18	4, 5, 15, 16, 17	6, 7, 11, 12, 13	8, 9, 10, 14
Expected value	0.2	0.4	0.6	0.8

Table 5. Teachers' satisfactory scheduling time

Time	Monday	Tuesday	Wednesday	Thursday	Friday
T1–T2	−1			−1	
T3–T4			−1		
T5–T6	−1				

Selection, crossover, and compilation. Selection is based on the roulette method, and the probability that chromosomes are selected is proportional to fitness. This method cannot guarantee the selection of a chromosome with a high fitness value, but the possibility is relatively large. This study adopts the single-point crossover method, and the probability of individual destruction is relatively small. The predetermined crossover probability is compared with a random value n. Crossover exists if n<PC. A cross point is randomly selected. A column, namely, the course schedule of a class, is selected from Table 1 and exchanged with the same column of another individual. Teaching time is constant during the exchange. For example, Parents 1 and 2 cross to generate the next-generation Individuals 1 and 2, as shown in Tables 6, 7, 8, and 9.

Table 6. Parent 1

Time	Class 1	Class 2	Class 3	Class….	Class n
T1–T2	21	12	3		
T3–T4	3	0	5		
T5–T6	0	9	11		
T7–T8	5	7	8		
T9–T10	8	11	22		
….	….	….	….	….	….

Table 7. Parent 2

Time	Class 1	Class 2	Class 3	….	Class n
T1–T2	21	7	4	….	
T3–T4	8	0	5	….	
T5–T6	0	12	11	….	
T7–T8	7	11	8	….	
T9–T10	9	12	23	….	
….	….	….	….	….	….

Table 8. Individual 1

Time	Class 1	Class 2	Class 3	….	Class n
T1–T2	21	7	3		
T3–T4	3	0	5		
T5–T6	0	12	11		
T7–T8	5	11	8		
T9–T10	8	12	22		
….	….	….	….	….	….

Table 9. Individual 2

Time	Class 1	Class 2	Class 3	….	Class n
T1–T2	21	12	4		
T3–T4	8	0	5		
T5–T6	0	9	11		
T7–T8	7	7	8		
T9–T10	9	11	23		
….	….	….	….	….	….

The probability of mutation is generally small enough to avoid the destruction of the optimal solution. Schaffer recommended that the optimal mutation rate is 0.001–0.05. On the basis of the mutation principle, one or more bits are selected to reverse the bit string of an individual in the population in mutation probability. The mutation that corresponds to course scheduling refers to the random position of several column exchanges with the code of another random position in the same column to ensure that the teaching task of the mutation class is invariable. Mutation is implemented if $r<pm$. The mutation of Individual 2 into Individual x yields Tables 10 and 11.

Table 10. Individual 2

Time	Class 1	Class 2	Class 3	….	Class n
T1–T2		12			
T3–T4		0			
T5–T6		9			
T7–T8		7			
T9–T10		11			
….	….	….	….	….	….

Table 11. Individual x

Time	Class 1	Class 2	Class 3		Class n
T1–T2		12			
T3–T4		0			
T5–T6		11			
T7–T8		7			
T9–T10		9			
….	….	….	….	….	….

3.3 Course scheduling based on improved adaptive genetic algorithm

The course scheduling algorithm based on the improved genetic algorithm is implemented as follows.

1. The course task is coded according to the characteristics of the course scheduling.
2. The population is initialized according to the teaching task and outline, and the constraint condition is satisfied. The hard rules are first satisfied, and the soft rules are subsequently fulfilled.
3. The weight value, reward, and punishment right values are set according to the curriculum combination, time combination, curriculum characteristics, and teacher satisfaction, and individual fitness is calculated on the basis of weight.
4. Fitness is selected using the roulette principle. If no fitness is selected, then Operation (3) is implemented again. If several fitnesses are selected, then cross mutation is applied to generate filial generation and Operation (3) is performed again.
5. When the number of iterations reaches the requirement, the output results are obtained and the algorithm ends.

Courses should be scheduled according to the teaching tasks. Therefore, the condition for terminating the algorithm is the iteration time reaching a. The values of p_c and p_m, which directly influence the convergence, should be set. The new generation of breeding will be fast and the fitness will be disturbed if p_c is extremely high. The progeny reproduction will be slow if p_c is extremely small. The algorithm will be destroyed if p_m is large. A new individual will not be generated if p_m is small, which is unsuitable for the generation of the next generation of outstanding individuals[22][23]. The adaptive genetic algorithm adopts the following formula of p_c and p_m, which was proposed by Schaffer.

$$p_c = \frac{p_{c2}\left(f_m - f^{'}\right)}{f_m - f_a} \qquad \left(f^{'} \ge f_a\right) \tag{1}$$

$$p_c = p_{c_1} \qquad \left(f^{'} < f_a\right) \tag{2}$$

$$p_m = \frac{p_{m2}\left(f_m - f\right)}{f_m - f_a} \qquad \left(f \ge f_a\right) \tag{3}$$

$$p_m = p_{m1} \qquad \left(f < f_a\right) \tag{4}$$

where f_m is the individual with the largest fitness in a population; f_a is the average fitness in a population; $f^{'}$ is the individual with the largest fitness in a cross operation; f is the fitness of variant individuals; p_{c1}, p_{c2}, p_{m1}, and p_{m2} are the values of [0, 1], which are obtained through Formulas (1), (2), (3), and (4). The closer f_m is to f, the smaller the crossover and mutation rates. If f_m and f are equal to the maximum fitness, then the crossover and mutation rates are zero. If the better individual is in an unchanged state, then the solution is not necessarily global optimization. Therefore, this method is unsuitable for population evolution in the early stage. The algorithm is improved. Thus, the crossover and mutation rates of individuals with the largest fitness values in the population will not be zero, and p_m and p_c can be increased. The formula is rewritten as:

$$p_c = p_{c1} - \frac{\left(p_{c1} - p_{c2}\right)\left(f^{'} - f_a\right)}{f_m - f_a} \qquad \left(f^{'} \ge f_a\right) \tag{5}$$

$$p_c = p_{c1} \qquad \left(f^{'} < f_a\right) \tag{6}$$

$$p_m = p_{m1} - \frac{\left(p_{m1} - p_{m2}\right)\left(f - f_a\right)}{f_m - f_a} \qquad \left(f \ge f_a\right) \tag{7}$$

$$p_m = p_{m1} \qquad \left(f < f_a\right) \tag{8}$$

where $p_{c1} = 0.9$, $p_{c2} = 0.6$, $p_{m1} = 0.1$, and $p_{m2} = 0.001$.

4 Result analysis and discussion

In addition to the crossover and mutation rates, the population size and the number of iterations in the genetic algorithm affect the experimental results. The iteration number parameters, namely, T = 30, T = 50, T = 100, T = 150, and T = 300, are tested in the experiment. The maximum fitness for different iterations is calculated when the mutation and crossover probabilities are constant, and the test results are shown in Table 12.

Table 12 shows that the improved adaptive genetic algorithm is closely related to the convergence of the algorithm. The population evolution approaches the optimal and the fitness does not increase when the number of iterations reaches 150. Corresponding tests are conducted when the population sizes are M = 40, M = 90, M = 120, and M = 150. The algorithm converges, and the test results are shown in Table 13. The iteration number is 50. As shown in Table 13, the time consumption for course scheduling is the shortest when M = 150 classes.

The average time is the shortest when population M<=150 and T<=300. However, the optimal course schedule in accordance with the constraints is obtained. The algorithm is compared with the adaptive genetic algorithm in terms of the number of convergent iterations, number of local convergences, maximum individual fitness, and average individual fitness. The improved experimental data are shown in Table 14.

Table 12. Relationship between iteration number and maximum fitness

Group number	Iteration number	Maximum fitness
1	30	1456
2	50	1678
3	100	2109
4	150	2208
5	300	2207

Table 13. Relationship between population scale and maximum fitness

Group number	M = 40 Time (s)	M = 90 Time (s)	M = 120 Time (s)	M = 150 Time (s)
1	4456	4567	3478	1231
2	4678	3473	2789	1345
3	4109	3109	2990	1675
4	4208	3401	2763	1873
Average time	4362.75	3637.5	3005	1531

As shown in Table 14, the number of average iterations for convergence of the improved adaptive genetic algorithm is 50 times fewer than the that of the adaptive genetic algorithm and the maximum individual and average individual fitnesses are significantly increased. The relationships between the number of iterations and the maximum fitness and between the population size and the maximum fitness show that the optimal course scheduling scheme can be obtained when M<=150. Meanwhile, a comparison of the improved algorithm and the adaptive genetic algorithm shows that the average convergence of the former is 50 higher than that of the latter. The maximum and average fitnesses are also increased by 5454 and 6164, respectively.

Meanwhile, the experiment evaluates the quality of course scheduling from five perspectives, namely, the maximum fitness value of the individual in the population, the priority of each class in course scheduling, course dispersion, teacher satisfaction, and operation time. The experimental results are shown in Table 15.

Table 15 is converted to Figure 1, and they show that although the operation time of the improved adaptive genetic algorithm is longer than that of the basic and genetic algorithms, the course arrangement, course dispersion, and teacher satisfaction of the improved algorithm is better than those of the two others. Therefore, the improved genetic algorithm is the best of the three.

Table 14. Results of Experiment 1

Algorithms	Number of average iterations for convergence	Maximum individual fitness	Average individual fitness
Basic genetic algorithm (GA)	Cannot realize convergence		
Adaptive genetic algorithm (GA1)	212	17689	13876
Improved adaptive genetic algorithm (GA2)	162	23143	20010

Table 15. Results of Experiment 2

Evaluation	GA	GA1	GA2
Maximum fitness value		16789	24560
Priority of each class in course scheduling	7890	8890	9980
Course dispersion	5698	7760	8678
Teacher satisfaction	3990	6789	6909
Operating time (seconds)	3490	5990	6785

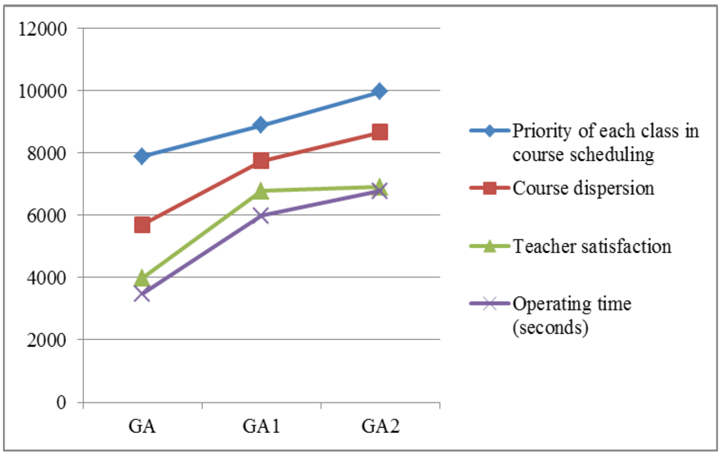

Fig. 1. Comparison of experimental results of three algorithms

5 Conclusions

On the basis of the actual situation of colleges and universities, the improved adaptive genetic algorithm was applied to course scheduling, and the daily goodness of fit, course combination degree, and teacher satisfaction were set through the fitness function. A scheme with high fitness satisfied the course scheduling requirements and reduces the time of manual scheduling. Therefore, applying the improved genetic algorithm to course scheduling was scientific and feasible. The following conclusions could be drawn.

1. The average scheduling time is the shortest when population size is 150 classes.
2. The adaptive genetic algorithm and the improved adaptive algorithm are compared using the same parameters. The experimental analysis shows that the improved genetic algorithm converges faster than the adaptive genetic algorithm, and the effect of course scheduling is good.
3. The improved adaptive algorithm is superior to the adaptive genetic algorithm in terms of the number of convergent iterations, local convergence time, maximum individual fitness, and average individual fitness.
4. The average number of iterations for convergence, maximum individual fitness, and average individual fitness show that the improved adaptive genetic algorithm is superior to the genetic and adaptive genetic algorithms.

This study discusses the application of the genetic algorithm in college course scheduling and proposes a new method, which adopts certain references from the research of college scheduling. However, several problems, such as alternate week class scheduling and decrease in calculation rate caused by the increase in population size, are found. Course scheduling is a complex combinatorial optimization process. Additional factors should be considered in future study and research, and new algorithms should be tested to provide enhanced course scheduling methods.

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MOOC Teaching Mode of News Transmission Based on Network Audio Data Decoding Technology

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Abstract—MOOC, an online classroom development mode, has gradually developed due to its unique advantages under the background of big data. However, most online audio data of MOOC are acquired through the application software on PCs, which has limitations in the support of audio format. In the meanwhile, there are still some shortcomings in the existing research on the application and integration of the core technology of MOOC. Therefore, this study constructs the News Transmission MOOC course based on the network audio data decoding technology. Moreover, the course is applied to the actual teaching process to test the teaching effect and realize the organic integration of the core technology of computer and the teaching idea of MOOC. The practical teaching results show that the MOOC course not only improves the teaching effect, but also has significance and value for improving students' ability and learning interest.

Keywords—Network audio data decoding technology; MOOC; multimedia; big data

1 Introduction

The third revolution of science and technology in western countries, namely, the revolution of information technology, has swept the world for several decades, exerting profound influence on various industries. As the information technology revolution develops to a new stage, artificial intelligence, cloud computing and big data have made great breakthroughs, which have greatly changed our life, work and learning styles [1]. Particularly, the frontier information technology represented by big data has been extensively used in all walks of life due to its excellent data analysis and data mining capabilities. MOOC is the abbreviation of Massive Open Online Course. MOOC [2] refers to a teaching and learning approach which rapidly grows with the fast development of computer technology and Internet technology with the characteristics of openness and online. Course providers publish the courses on Internet server and thus learners can access the course resources through the Internet at anytime and anywhere to complete the study. In other words, the learners can break through the limits of time and space to learn courses based on MOOC. Due to the advantages of spanning time and space, MOOC has made great progress in recent years. At present, numerous famous universities at home and abroad begin to publish MOOC courses on the Internet, covering mathematics, computer science and other natural sciences [3], as well as multiple disciplines such as engineering, social science and humanities [4].

Instructors' audio data which is the core content of MOOC, are continuously transmitted to learners in the progress of MOOC course. The audio information generated by instructors is analog signal, while the computer and the Internet transmit digital signal. Therefore, it is necessary to sample and code audio information using technical means before it is published in MOOC course. Learners' client must decode the information into audio analog signal and then obtain the contents published by instructors. To guarantee that the audio information of instructors can be timely and accurately transmitted to learners, the network audio data decoding technology contained in MOOC should be both real-time and correct. Due to the limitation of time and space, the traditional teaching form can hardly meet the learning needs of various groups. Therefore, MOOC with high freedom degree can break the restrictions of time and space, which has become the inevitable choice of news transmission related courses.

2 State of the art

With the development of mobile Internet and the popularity of smart phones, the way of news transmission has changed dramatically. The rapid development of social media and internet media has altered the news transmission way dominated by the traditional media such as TV and newspapers. In the meanwhile, the emerging self-media, as an important form of newsTransmission, has great advantages over transmission speed and transmission scope compared with the traditional media. Under the dramatical changes, the teaching methods of journalism and language related majors can hardly meet the requirements of the news transmission industry. At the same time, the traditional multimedia teaching method has some defects in participation and interaction, requiring changes to adapt to the changes. Therefore, domestic and foreign scholars have carried out extensive and in-depth research on the teaching of journalism and language majors. Barak [5] applied MOOC teaching to English and Arabic language courses, concluding that both the intrinsic motivation and learning autonomy of MOOC participants are improved. Zhuhadar et al [6] envisioned a new generation of MOOCs which support formal semantics interpretability through online social networks and SemanticWeb. Compared with the existing platforms of MOOCs, semantic technology supports more flexible management of information. The experimental results demonstrate that MOOCs teaching is conductive to promoting students' understanding and learning. Recently, a large number of open online courses have emerged in Spain, which have been proved to be an effective way of foreign language teaching and learning. The course conducted by Chacón-Beltrán [7] is an experience in a large student group with MOOC as a learning tool of Spanish English. The experience course aims to enable learners to quickly learn the meaning of the most common 1,000 words in English and begin to read short sentences. According to the experimental results, the teaching effects of MOOC have been recognized by both teachers and students. In China, Li Liang et al. [8] deeply discussed the problems existing in the teaching of news transmission under the trend of media convergence as well as the improvement strategies. Besides, they believed that the optimization of curriculum system and the integration of teaching mode should be the core contents of teaching improvement. A research team [9] focused on the teaching reform strategy of writing, the core course in the teaching of journalism and transmission, and deeply studied the theoretical basis and advantages of introducing audiovisual resources into the curriculum to assist teaching. Briefly, MOOC has realized the scale and globalization of the audience of high-level university teaching resources through the standardized online course teaching, expanding the knowledge imparting chain of the traditional higher education [10]. However, there still remain some problems in teaching practice and technology implementation of MOOC. Firstly, in most cases, MOOC acquires network audio data based on application software on PCs, which has limitations on the support of audio format [11]. Secondly, the existing research still has some shortcomings in the application and integration of the core technology, which only focuses on the construction of curriculum framework. The integration of core technology, especially the decoding of network audio data, is of significant importance to curriculum construction. It undertakes the task of accurately and timely transferring the course resources provided by instructors to learners. Moreover, compared with the traditional open distance education system, MOOC is only at the level of course, which lacks digital teaching resource database as well as data exchange and sharing with other teaching and management platforms. This is far from the requirements of UNESCO for the standards of open education resources.

The innovation of this study is mainly reflected in the following two perspective: Firstly, MOOC is organically combined with News Transmission course to construct a complete computer teaching mode of News Transmission , thus providing a highly efficient teaching environment for the course development. Secondly, network audio data decoding technology is integrated into the construction of the teaching mode of MOOC, which offers a solid technical guarantee for the timely and accurate transfer of course resources to learners. Besides, the implementation of MMS protocol on the embedded ARM platform is completed. MMS protocol is a private streaming media protocol of Microsoft, and its specification is confidential. In addition, some open source software deduces the content of MMS protocol by fetching the received and sent packets when MMS streaming media data is played by WMP (Windows Media Player). According to the specific content of MMS protocol, the MMS function is successfully realized on ARM platform using C language. The computer teaching model based on the teaching environment of MOOC constructed in this study provides a new teaching mode for the corresponding teaching.

3 Theoretical construction

3.1 Application of motivation theory in MOOC

This study mainly introduces motivation theory to MOOC. Motivation theory [12] holds that the learning process can truly achieve the desired effect only if the learners fully possess the learning motivation and develop the meaning of learning knowledge. This can effectively stimulate learners' creative consciousness in the learning process, which further improves the learning effect. In the teaching environment of MOOC, learners can independently control the learning process according to their needs and learning conditions and can also make use of the functions provided by the teaching model so as to communicate with other learners on the course content in real time, thus strengthening the learning effect. Figure 1 shows the structure of motivation learning theory.

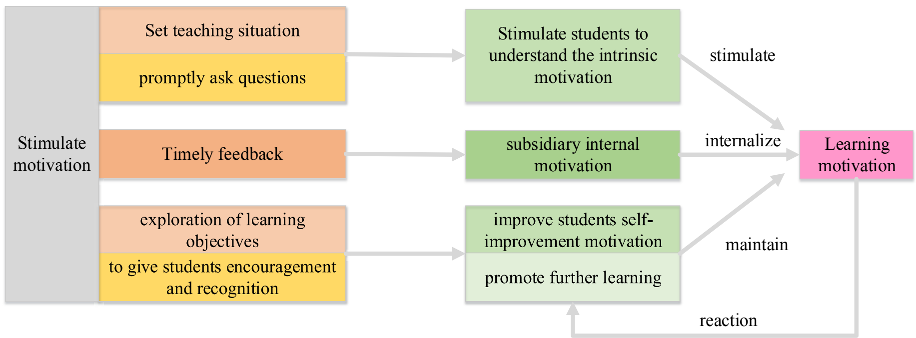

Fig. 1. Structure of motivation learning theory

3.2 Application of MMS Protocol in MOOC

MMS is a private streaming protocol of Microsoft, which transmits a series of real-time multimedia broadcasts, videos, audio tracks and live data on the internet. The users can receive real-time video or audio through a computer or a dedicated receiving terminal. The media files on the MMS multimedia server exist in the form of ASF (Advanced Streaming format) or WMA. Besides, MMS protocol sends relevant data to users from multimedia server to their computers in the form of data packets and data blocks. The client-side flow chart of MMS is presented in Figure 2.

3.3 Application of network audio data decoding technology in MOOC

Current;u, most audio data on the Internet are stored and transmitted in MP3 audio format characterized by high compressibility and low distortion. In the meanwhile, it can adjust the bit rate according to the bandwidth of the transmission channel. Consequemtly, it is suitable for audio data transmission in computer network environment.

After the Huffman encoding data and the relevant coding parameters are read from the MP3 data frame, the audio data decoding process can be carried out to output the audio signal. The decoding of audio data consists of three processes, respectively, inverse quantization of Huffman coding data, inverse cosine transform, windowing operation as well as frequency inversion and synthesis multi-term filtering. The network audio data decoding process is shown in Figure 3.

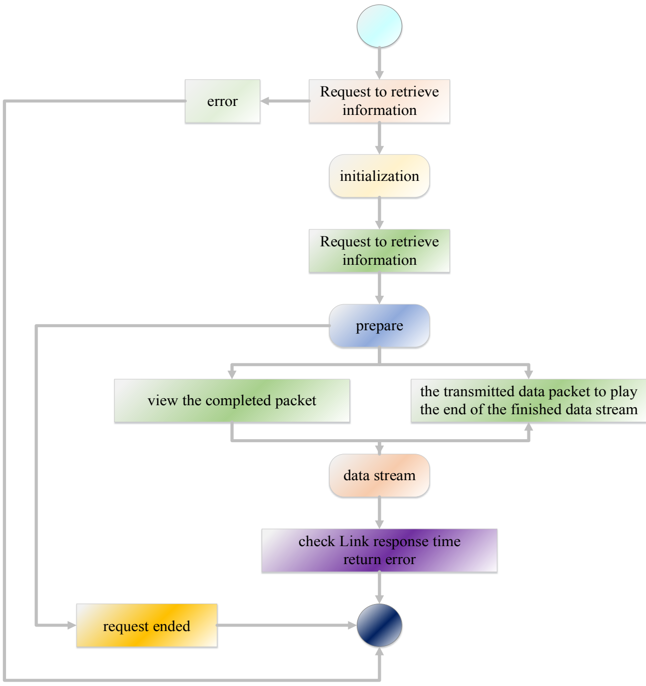

Fig. 2. Client-side flow chart of MMS

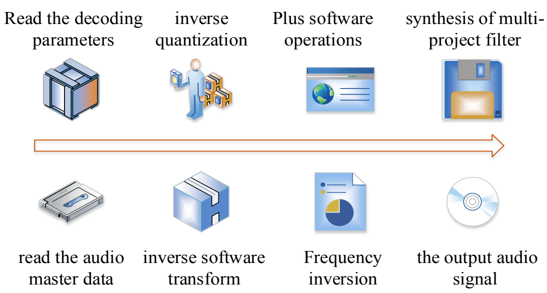

Fig. 3. Network audio data decoding process

Inverse quantization. x_i is the received Huffman coding data. y_i is the results obtained by inverse quantization. Inverse quantization is achieved using formula (1) - formula (3):

$$y_i = sign(x_i)\ \ abs(x_i)^{(4/3)} 2^{u1} / 2^{u2} \tag{1}$$

$$\text{u1} = \frac{1}{4}(global_{gain[gr][ch]} - 210) \tag{2}$$

$$\text{u2=scalefac\_multiplier-(scalefac}_1\text{ [gr][ch][sfb]+preflag[gr][ch] pretab[sfb]} \tag{3}$$

Inverse cosine transform. After completing the inverse quantization of Huffman coding data, the obtained data is conducted with inverse cosine transform, and the transform formula is shown in formula (4):

$$\text{X}_i = \sum_{k=0}^{\frac{n}{2}-1} X_k \cos(\frac{\pi}{2n}(2i+1+\frac{n}{2})(2k+1)...i = 0,1,2,...,n-1 \tag{4}$$

Windowing Operation. After the inverse cosine transform, the output results need to be windowed in accordance with different window types of MP3 data frames. Different window functions are required for various types of blocks. The block type parameters exist in the header of the MP3 data frame. Based on the block types, the window function is shown as below:

When the block type is 0 (normal frame):

$$\text{Z}_\text{i}\text{=x}_\text{i}\ \sin(\frac{\pi}{36}(i+\frac{1}{2})).....0 \le i < 35 \tag{5}$$

When the block type is 1 (start frame):

$$Z_i = \begin{cases} \text{x}_\text{i}\ \sin(\frac{\pi}{36}(i+\frac{1}{2}))............0 \le i < 18 \\ \text{x}_\text{i}....................................18 \le i < 24 \\ \text{x}_\text{i}\ \sin(\frac{\pi}{12}(i-18+\frac{1}{2})).....24 \le i < 30 \\ 0.....................................30 \le i < 36 \end{cases} \tag{6}$$

When the block type is 3 (end frame):

$$Z_i = \begin{cases} 0.....................................0 \le i < 6 \\ \text{x}_\text{i}\ \sin(\frac{\pi}{12}(i-6+\frac{1}{2})).......6 \le i < 12 \\ \text{x}_\text{i}\ ....12 \le i < 18 \\ \text{x}_\text{i}\ \sin(\frac{\pi}{36}(i+\frac{1}{2}))............18 \le i < 36 \end{cases} \tag{7}$$

Frequency inversion and synthesis multi-term filtering. After conducting the windowing operation, the obtained data are processed with frequency inversion and synthesis multi-term filtering. Frequency inversion aims to compensate coding and improve the efficiency of cosine transform. The synthesis multi-term filtering synthesizes the data obtained after frequency inversion and outputs the final audio signal.

4 MOOC of News Transmission based on network audio data decoding technology

4.1 Teaching example

Construction of teaching mode. In this study, MOOC course of News Transmission based on network audio data decoding technology is constructed through modularization. That is to say, the realization of MOOC is divided into different modules according to the functions. After the implementation of all functional modules, they can be integrated into a complete course by linking each other. This construction method mainly has two advantages. Firstly, by dividing a large and complex system into smaller and easier functional modules, the whole system is realized through the integration of modules, which can effectively reduce the difficulty of implementation and also improve the platform building efficiency and robustness. Secondly, when system operation occurs problems, the modular construction method can quickly locate the specific module and implement the corresponding repair scheme, thus effectively improving the stability of the system.

The whole teaching mode construction process includes three steps including decomposition and definition of modules, realization of modules, and integration and construction of MOOC courses. MOOC is a new educational technology based on the development of computer technology and Internet technology. The main form is that the course provider publishes the course content in the network server. Then, learners can obtain the data of the course content through the Internet and present the complete curriculum environment after processing the local program. On the whole, MOOC course is constructed on the basis of server-client structure. At the same time, it can provide the statistical data generated by learners during the learning process to the course providers so as to improve the course content, which is a main characteristic of MOOC. Therefore, the corresponding modules should be provided in the construction of MOOC course to support this property.

Based on the above analysis, News Transmisson MOOC course based on the decoding technology of network audio data mainly includes the following parts: (1) MOOC course content server: this component is used to store all the course resources needed in the course and upload the course resources produced by the course provider to the content server. (2) Data statistic device: as one of the core components, this module provides the corresponding support to the collection and analysis of the teaching and learning data in MOOC course. (3) Network router: this module is a network component connecting the background module and the foreground module, exerting the function of data transmission. (4) Data access component: this module receives the course data of the MOOC course server from the network router and reversely sends learners' statistic data in learning. (5) Teaching client-side: the module is a client-side program for learners to receive MOOC course. (6) Data storage device: the module temporarily stores the course resource data sent by the course server in order to avoid the impact of network fluctuation on learning. (7) Teaching peripheral equipment: this equipment is set to assist students in their learning process. (8) Network audio data decoding component: this module decodes the network audio data transmitted by the MOOC course server to convert it into audio signals.

The MOOC course content server adopts the structure of Windows platform and MySQL database is used to support the persistence layer in the course content data storage. In the application layer of course content server, Java programming language is adopted to realize the interface of course content acquisition. Client program can obtain course content data from the server through this interface. Data statistic device module and data storage device mainly store students' learning data and course content data obtained by the client. This study adopts MySQL database to store the data. Besides, Java programming language is used in data access module and teaching client module. Data transmission among these modules is implemented using Socket network data transmission mode.

In the current work, network audio data decoding technology is one of the core components of MOOC course constructed. The basic decoding principle and flow have been explained in the section of theoretical basis. In this study, the object-oriented programming technology is used to implement the network audio data decoding tool class, which realizes the concrete function of each link in the decoding process and the decoding of network audio data.

After the realization of each specific module, these modules are integrated through a certain structure to form a complete MOOC course platform. To be specific, the MOOC course content server is connected to the data statistics device, and the data statistics device is linked to the network router. Besides the other end of the network router is connected to the data access component of MOOC client program. The data access component is connected with the network audio data decoding component. Then, the audio data is decoded and transferred to the MOOC client. To provide the functions of data storage and auxiliary function service, data storage devices and teaching peripheral equipment are connected to teaching client. The structure of each module in the system is shown in Figure 4.

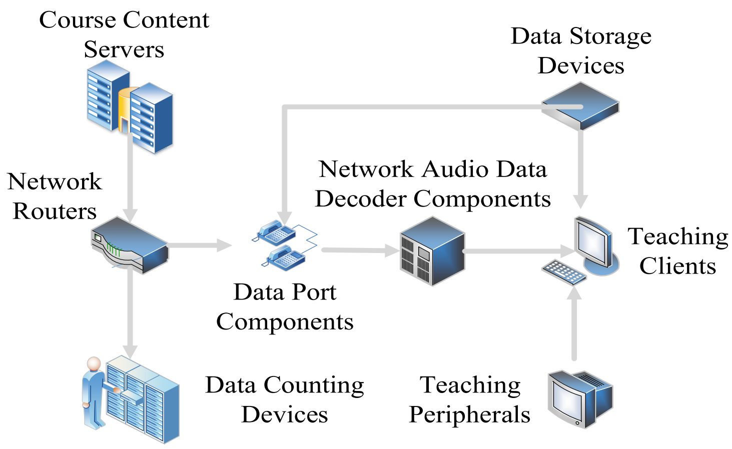

Fig. 4. Structure of News Transmission MOOC course based on network audio data decoding technology

Practice of teaching mode. Figure 4 and Figure 5 show the construction results of News Transmission MOOC course based on network audio data decoding technology. Figure 5 presents the login interface of MOOC course. Learners can enter the course system by entering the user name and login password. Figure 6 shows the tablet use step of MOOC course. In this interface, learners can not only study the relevant course resources, but also communicate with other learners. In the meanwhile, compared with the traditional teaching methods, learners can control their learning schedule according to their time arrangement. After they log off the system, the previous learning schedule will be automatically connected in next login,

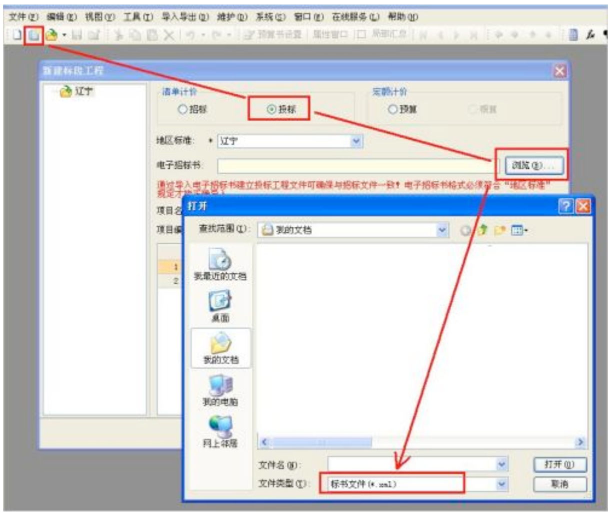

Fig. 5. Login interface I of News Transmission MOOC course based on network audio data decoding technology

Fig. 6. Login interface II of News Transmission MOOC course based on network audio data decoding technology

4.2 Teaching effect

In order to test the teaching effects of MOOC course constructed in this paper, the course was given to 90 undergraduate in two classes of journalism major in 2016.

The 45 students in one class were taught through the traditional teaching method as a control class. The 45 students in the other class received MOOC course in the learning of News Transmission. To minimize the uncertainty caused by the other factors, the course contents were arranged and taught by the same teacher and corresponding test questions were designed to test the learning effect of the two classes of students.

The test questions are the same for both groups, and the test scores are listed in Table 1. Obviously, the score distribution of the class receiving the Moo course is better than that of the class using the traditional teaching.

In addition to testing the teaching effect using test paper, a survey on the teaching satisfaction of MOOC course among the students was carried out through questionnaire. The questionnaire includes 6 questions, each of which contains three dimensions of approval, general and disapproval. The results of the questionnaire survey are shown in Table 2. Most students believe that MOOC course can effectively improve their autonomous learning ability, self-management ability, Transmission skills and teamwork ability. Additionally, MOOC course has also been recognized by most students in terms of stimulating learning interest and enhancing the knowledge mastery degree.

Table 1. Comparison of test results between the traditional teaching class and MOOC teaching class

Group	Average scores	＜60	60-69	70-79	80-89	≥90
Control group (n=45)	75.4	7	14	12	9	3
Experimental group (n=45)	81.5	2	4	15	16	8

Table 2. Investigation results on the teaching satisfaction of MOOC course

Questions	Agree	Normal	Disagree
Improving autonomous learning ability	41(91.11%)	3(6.67%)	1(2.22%)
Improving self-management ability	39(86.67%)	3(6.67%)	3(6.67%)
Develop Transmission skills	42(93.33%)	1(2.22%)	2(4.44%)
Developing teamwork ability	40(88.89%)	3(6.67%)	2(4.44%)
Stimulating learning interest	38(84.44%)	2(4.44%)	5(11.11%)
Enhancing the mastery degree of knowledge	39(86.67%)	4(8.89%)	2(4.44%)

It can be seen that News Transmission MOOC course based on the network audio data decoding technology can not only improve students' academic achievement, but also enhance their learning ability, consequently achieving good teaching effects. It has the following advantages: Firstly, compared with the traditional teaching method, MOOC course has a strong degree of freedom, and learners can decide whether to learn or not, as well as the learning time and place. As a result, MOOC can prevent learners from wasting precious time in meaningless learning and apply their time to meaningful learning so as to improve the learning results. Secondly, dramatical changes have taken place in the positions of teachers and learners. The learning process is controlled by learners instead of teachers, and learners have higher initiative and freedom degree in the learning process. Most importantly, the subjects of this study are students majoring in journalism. As journalists, they must have excellent critical thinking and discrimination ability, which is formed based on the understanding of all kinds of knowledge and culture. This teaching mode can realize cross-specialty and cross-school cooperation and resource sharing through MOOC platform. Therefore, students majoring in journalism and transmission can receive courses in other colleges and specialties to expand their knowledge.

As a whole, students in experiment group have high recognition of 3D multimedia teaching platform. Most students can accept the new teaching mode and obtain improvement of learning interest and improve their attainment of professional courses. Through 3D multimedia teaching platform, students in architecture specialty have in-depth understanding of urban-rural master plan, and they can directly know relevant architecture distribution and characteristics. Meanwhile after class, students and teachers can maintain communication conveniently through 3D multimedia teaching platform. Students can download relevant materials, propose questions, browse question records, and complete content extension through the system. Teachers can know students' real-time dynamic, adjust teaching objective constantly so as to obtain better teaching effect. 3D multimedia teaching platform is suitable for different stages and different subjects. Using 3D model generated by 3D virtual technology can bring more direct feeling to students and achieve the objective of teaching mode reform and teaching quality improvement.

5 Conclusions

In the Internet era, MOOC has become a kind of teaching method with broad development prospects. Various courses are gradually offered to learners in the form of MOOC. The practice results show that the News Transmission MOOC course based on the network audio data decoding technology can not only improve students' academic achievement, but also enhance their learning ability, thus achieving good teaching effects. The following are its advantages:

1. Compared with the traditional teaching method, MOOC course has a strong degree of freedom, and learners can decide whether to learn or not as well as the learning time and place. Therefore, MOOC can prevent learners from wasting precious time in meaningless learning and apply their time to meaningful learning so as to improve the learning results.
2. Under this condition, great changes have taken place in the positions of teachers and learners. The learning process is controlled by learners instead of teachers, and learners have higher initiative and freedom degree in the learning process.
3. Most importantly, the objects in this study are the students majoring in journalism. As journalists, they must have excellent critical thinking and discrimination ability, which is formed based on the understanding of various aspects of knowledge and

culture. Moreover, this teaching mode can realize cross-specialty and cross-school cooperation and resource sharing through MOOC platform, so that students majoring in journalism and transmission can receive courses in other colleges and other specialties to expand their knowledge.

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Information Communication Technology Use among Students in Inclusive Classrooms

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Abstract—Inclusion has brought diversity into 21st-century classrooms and introduced challenges for teachers who must adapt their teaching to diverse groups of children. Related research findings indicate that information and communication technology (ICT) can be used to provide personalized learning and support inclusion. Our research compared the school- and leisure-related computer use of students in inclusive classrooms. The frequency of computer use, types of ICT-supported activities, and attitudes toward computer use were examined. Consistent with those of previous studies, our findings show that students with special needs (SN) and their peers use computers more frequently for leisure activities than for school activities. Compared with their peers, students with SN use computers less frequently and are more resistant to computer use. No correlation was found between the presence of SN and a student's desire to use a computer or a student's opinion on whether computer use improves learning success. A comparison of male and female students revealed that boys use computers more frequently, and have a stronger belief that computer use improves learning success. This study discusses ICT integration in inclusive classrooms for personalized learning in all domains of learning, the cognitive, affective–social, and psychomotor domains. The main conclusions derived from the study inform teachers in planning their ICT integration for cognitive, social and emotional scaffolding of students in inclusive classrooms.

Keywords—information and communication technology (ICT), inclusive class, students with special needs

1 Introduction

The use of information and communication technology (ICT) has proliferated in education and learning design; the classrooms of the 21st century are undergoing rapid transformations resulting in innovative learning environments that are connected, flexible, and collaborative [1].

Another important change is the shift toward inclusive education, which aims to educate all children regardless of their learning differences or other characteristics [2]. The proportion of children with special needs (SN) enrolled in regular primary schools in Slovenia is increasing, and in the school year 2017/2018, it has reached 6.18% of all primary school students [3]. Inclusive classes are therefore becoming a rule rather than an exception.

Inclusive classes pose several challenges for teachers and school staff worldwide [4]. Teachers must use different teaching methods to best reach students with varying learning abilities and facilitate their learning progress.

ICT can be a good tool for adapting teaching to children with different abilities and characteristics [5]; this has been demonstrated in previous research proving that the use of ICT benefits cognitive development [6] and motivation [7] in students with SN and their peers, as well as improves the literacy [8], communication [5], [9] and social skills [10], [11], [12], [13] of students with different types of SN. Research findings indicate progress in the cognitive and affective–social domain and correlate it with motivation, collaboration, flexible time management, diversity of learning methods, and autonomy in learning.

2 Student's ICT use in school and leisure activities

ICT integration is examined in terms of enhancing the quality of education [14] and contributing to the cognitive, affective–social, and psychomotor domains of learning [15]. The requirements in these domains as also expected motivational effects [16] have encouraged the more systematic use of ICT in school-related activities. Students have therefore increasingly utilized ICT, which was previously limited to leisure and home use (for example, as a social media tool), in school settings, as well.

The use of technology in school settings might not be equally effective for all students, depending on their learning and technology preference [17], as well as their attitudes toward technology use; the latter are related to the extent to which they perceive the computer as a learning tool [18].

Male and female students seem to differ in their learning preference [19] and in the technology they prefer to use [20], [21]. However, data on gender differences are not conclusive because of changes in the attitudes toward ICT as a result of increased ICT universality in society [22]. An important aspect that should be considered in inclusive education is the characteristics of students with different SN and the factors requirements that affect their ICT use. Therefore, special attention is required when choosing the appropriate ICT tools to support the learning of different groups of students with SN [23], as certain particularities can directly affect the ICT use (e.g., poor vision, hearing, language understanding).

School- and leisure-related activities both affect students' ICT experience and knowledge, emotions, competencies, and attitudes related to ICT use. These aspects are important to consider when planning ICT-supported teaching.

2.1 Gender and ICT use

Researchers studying the differences between ICT use of male and female students have focused on the impact of gender on attitudes related to ICT use [24], [25], [26], resistance to ICT use [22], [27], frequency of ICT use [22], [28], and types of activities using ICT [29].

Differences between male and female students' learning preferences [19], types of ICT-supported activities [28], and ICT attitudes and opinions [24], [27] are reported. Male students are more often interested in ICT use [25], and use the computer more often for leisure activities [28]. They consequently hold more positive beliefs about their digital skills [26]. By contrast, female students are found to be less skilled in ICT use than males are [26].

Gender differences were also found in school-related ICT activities, in which males exhibit a more positive attitude than females do [24]. Similarly, Conti-Ramsden et al. [27] found that females exhibit greater fear and discomfort in ICT use. Nevertheless, some authors emphasized that gender differences in ICT use decrease with time and that male and female students do not significantly differ in their attitudes toward computers, amount of time spent using computers, or degree of self-reported computer anxiety [22].

2.2 Importance of the characteristics of students' ICT use in inclusive classrooms

Inclusive classrooms, in which children with SN attend school with their peers, bring benefits to all students but pose challenges for teachers who need to be flexible and adaptable in recognizing the needs of students and in tailoring the learning process to these students' learning abilities. ICT use was found to benefit students with learning disabilities [30], [31], [32], [33], dyslexia [6], [34], [35], Down syndrome [36], autism [9], [11], [12], [13], mental disorders, and cerebral palsy [4]. ICT has a great potential that can be adequately exploited in education only with appropriate awareness and consideration of the individual characteristics of children in terms of ICT use [21].

Previous research on students' ICT use in inclusive classrooms has investigated different areas, such as the following:

- frequency of ICT use [29],
- types of activities using ICT [29], [37],
- home access to computers and/or the internet of students with SN and their peers [28], [33],
- reluctance to use ICT [27].

Most students have access to computers [28], [38] and the internet at home [38]. However, the majority of students with SN have greater home access to [33] and use computers at home more than their peers do; their peers tend to be more engaged in other free-time activities [29]. ICT use by students with SN improves their interactions with their peers [29].

The belief that learning with computers is more interesting and enables better learning conditions is shared by both students with SN [27], [37] and their peers [24]. However, the belief that ICT improves educational conditions and personal development is more pronounced in students with SN, although they experience more ICT-related anxiety than their peers do [27].

Gender [17], [21], [24], [27] and the presence of SN [27] may influence differences in students' attitudes, experiences, and preferences in ICT and should be considered when using ICT to facilitate differentiation and individualization [21]. This study aims to explore the differences between the ICT use of students in an inclusive classroom. In particular, the following three research hypotheses are explored:

H1: Frequency of computer use is gender specific and varies depending on SN status.

H2: Gender and presence of SN influence differences in the types of ICT-supported activities of students.

H3: Attitude toward computer use is gender specific and varies depending on SN status.

3 Methods

3.1 Research design

A quantitative survey was conducted in an inclusive classroom to examine the school- and leisure-related computer use of students with and without SN.

3.2 Participants

In recruiting the participants, 47 Slovenian elementary schools were randomly selected by choosing 10% of the schools in each of the 12 Slovenian regions. Next, 1,880 students who are attending inclusive classes in the third part of their elementary education (grades 7 through 9) were selected from the participating schools. Of the selected students, 602 (32% response rate) completed the questionnaire. The participants included 116 (19.3%) students with SN and 486 students without SN. Of the participating students with SN, 79 (68.1%) were males and 37 (31.9%) were females. Of the participating students without SN, 216 (44.4%) were males and 270 (55.6%) were females. For more detailed data on the participants and their classes, see Table 1.

Table 1. Students with SN and their peers by grade

		Students with SN		Peers		Total	
		N	*%*	*N*	*%*	*N*	*%*
Grade	Grade 7	50	43.1	172	35.3	222	36.8
	Grade 8	32	27.6	128	26.3	160	26.5
	Grade 9	34	29.3	187	38.4	221	36.7
Total		116	100	486	100	602	100

3.3 Data analysis

Univariate, bivariate, and multivariate analyses were conducted to investigate the computer use of students with SN and their peers. The data analysis used descriptive statistics relating to frequency distributions, percentages, Spearman rank correlation coefficients, the Mann-Whitney U test, and factor analyses. All data processing was conducted using the SPSS statistical package.

3.4 Instrument

Data were collected through a questionnaire with nine questions. The first question collected information on demographic variables, whereas the other eight questions explored computer access, frequency of ICT use, and school- and leisure-related computer activities. The eighth question comprised 18 statements with Likert-type scales to assess the students' attitudes toward ICT use. Some of these statements were derived from the Computer Attitude Questionnaire [39]. The ninth question collected information on the students' free-time activities and comprised a list of yes–no sub-questions.

Both the validity and the reliability of the questionnaire were evaluated. Reliability was confirmed by calculating the Cronbach's alpha (which, at 0.74 for students' opinions that computer use improves learning progress, 0.86 for resistance to computer use, and 0.67 for the desire to use computers in school, indicated good internal reliability). Construct validity was confirmed with a factor analysis. Specifically, the following four factors were extracted with variables related to Table 2: students' opinions that computer use improves learning progress, students' fear of using computers, students' well-being when using computers, and students' desire to use computers in school. The first factor explained more than 20% of the variance.

Factors 3 and 4 were merged, and the reverse-scored items were re-coded. These adjustments yielded the following three dimensions that were measured in relation to computer use:

- students' opinions that computer use improves learning success (variables 1, 2, 3, 4, 5, 6, 7, and 8);
- students' resistance to computer use (variables 9, 10, 11, 12, 13, 14, 15, and 16);
- students' desire to use computers in school (variables 17 and 18).

The content validity of the instrument was ensured by formulating the questions in a comprehensive and understandable way. The questionnaire used clear expressions; simple questions; and clear, unambiguous, and concrete instructions.

Objectivity was ensured through closed-ended questions and clear, unambiguous written instructions. The researchers were not present during the completion of the questionnaires, so they had no subjective influence on the respondents' responses.

Table 2. Rotated factor matrix for students' attitudes toward IT use

	Variables	Factor			
		1	*2*	*3*	*4*
1	If I learn using a computer, I get a better grade.	.761			
2	Computers can improve my learning.	.740			
3	If I use my computer, I can learn more.	.721			
4	When I can use a computer for learning, I try harder.	.672			
5	I would learn more if I could use a computer.	.661			
6	I can learn more easily with a computer.	.581			
7	When I use a computer, learning is more interesting.	.542			
8	I can learn more from books than from a computer.	-.435			
9	Using a computer is very difficult for me.		.600		
10	Computers are difficult to use.		.568		
11	I am not interested in computers.		.527		
12	Using computers makes me nervous.		.523		
13	I am tired of using computers.		.399		
14	Computers enable me to learn new things.			.497	
15	I like to use computers.			.462	
16	I am not afraid to use computers.			.435	
17	The more often a teacher uses a computer, the more I enjoy the class.				.626
18	I would like to use computers in school more often.				.565

Note: Extraction method: principal axis factoring; rotation method: Varimax with Kaiser normalization.

4 Results

Data on the students' home access to computers and the internet are presented in Table 3. The results show that a very high percentage of all students (98.8%) have computers at home and that slightly more students with SN (99.1%) (98.8%) have access to computers at home. A high percentage of all participants (96.2%) were also found to have home internet access, although students with SN are slightly less likely to have internet access (93.1%) than their peers are (96.9%).

With regard to time spent in front of a computer, the majority of the students (38.3%) reported using computers between one and four hours per week. Some students (2.6%) replied that they do not spend any time in front of computers, whereas 22.2% reported spending more than 10 hours per week in front of a computer. Students with SN reported spending less time than their peers did in front of a computer.

Table 5 shows the students' most common ICT-supported activities. The data indicate that children with and without SN have the same popular and unpopular ICT-supported activities. Both groups of children most often browse the internet, listen to music, and chat. The least popular ICT-supported activity for both groups is doing homework.

Table 3. Home access to a computer and the internet

		Students with SN		Peers		Total	
		N	*%*	*N*	*%*	*N*	*%*
Do you have a computer at home?	Yes	115	99.1	481	98.8	596	98.6
	No	1	.9	6	1.2	7	1.2
Do you have internet at home?	Yes	108	93.1	472	96.9	580	96.2
	No	8	6.9	15	3.1	23	3.8

Table 4. Time spent using a computer

		Students with SN		Peers		Total	
		N	*%*	*N*	*%*	*N*	*%*
How many hours per week do you use a computer?	0 hours per week	4	3.5	12	2.5	16	2.7
	1–4 hours per week	63	54.8	167	34.4	23	38.3
	5–10 hours per week	27	23.5	194	40.0	221	36.8
	More than 10 hours per week	21	18.3	112	23.1	133	22.2

Table 5. ICT-supported activities of students with SN and their peers

	Students with SN		Peers		Total	
	N	*%*	*N*	*%*	*N*	*%*
I watch movies on the computer.	75	65.2	391	80.5	466	77.5
I listen to music on the computer.	99	86.1	454	93.2	553	91.9
I download music/movies from the internet.	68	59.1	375	77.0	443	73.6
I surf the internet.	102	87.9	472	97.1	574	95.3
I use webmail.	66	57.4	372	76.4	438	72.8
I look online for information I need in school.	91	78.4	411	84.7	502	83.5
I do my homework with the computer.	62	53.4	305	62.6	367	60.9
I use social networks (e.g., Facebook).	91	78.4	421	86.4	512	84.9
I play computer games.	82	71.3	335	68.8	417	69.3
I chat through the computer (e.g., by email or Facebook).	93	80.2	435	89.3	528	87.6

Each student's attitude toward computer use was determined by assessing the following:

- the student's opinion that computer use helps improve learning success,
- resistance to computer use,
- desire to use computers.

As can be seen in Table 6, a low level of agreement (mean = 3.36) was found for items suggesting that computer use improves learning success. The students agree most with the claim that learning is more interesting when they use computers (mean = 3.36) and that they can learn more from books than from a computer (mean = 3.30). For both items, students with SN show lower levels of agreement than their peers do. Students with SN agree least with the claim that they would get better grades if they learned with a computer (mean = 2.32). Their peers, however, agree least with the assertion that they would learn more if they could use a computer (mean = 2.35).

In general, both groups of students expressed the desire to use computers in school. They agreed (mean = 3.53) that they would like to use computers more often in school. Again, however, students with SN expressed somewhat less agreement (mean = 3.39) than their peers did (mean = 3.49).

Table 6. Attitudes toward computer use

	Students with SN		**Peers**		**Total**	
	M	***SD***	***M***	***SD***	***M***	***SD***
I like to use computers.	4.16	1.18	4.38	1.02	3.94	1.06
Computers give me the chance to learn new things.	3.57	1.30	4.03	1.13	3.94	1.18
I learn more easily with computers.	2.70	1.38	2.86	1.36	2.83	1.37
I would learn more if I could use a computer.	2.83	1.52	2.35	1.43	2.44	1.46
I would like to use computers more often in school.	3.49	1.55	3.54	1.50	3.53	1.51
The more often a teacher uses a computer, the more I enjoy the lesson.	2.92	1.50	3.06	1.47	3.03	1.48
If I am studying with a computer, I get a better grade.	2.32	1.36	2.41	1.34	2.39	1.34
I am not afraid to use computers.	3.82	1.59	4.19	1.30	4.12	1.36
I can learn more when I use computers.	2.90	1.47	2.83	1.32	2.84	1.35
Learning is more interesting when I use computers.	3.24	1.51	3.39	1.41	3.36	1.43
Computers can improve my learning.	2.63	1.38	2.66	1.30	2.65	
When I can learn with a computer, I try harder.	2.69	1.31	2.65	1.42	2.66	1.40
Using a computer with friends is more fun than using it alone.	3.48	1.44	3.83	1.36	3.76	1.38
I am tired of using computers.	1.97	1.33	2.02	1.21	2.01	1.24
I do not use computers when it is not necessary.	2.85	1.55	2.79	1.53	2.80	1.53
I am not interested in computers.	1.46	1.13	1.36	.88	1.38	.93
Using computers makes me nervous.	1.62	1.16	1.58	1.11	1.59	1.12
Computers are difficult to use.	1.49	1.09	1.34	.86	1.36	.91
I can learn more from books than from a computer.	3.09	1.47	3.35	1.37	3.30	1.39
Using a computer is very tiring for me.	1.59	1.08	1.35	.86	1.39	.91
Those who often use computers have fewer friends.	2.06	1.38	2.05	1.34	2.05	1.35

The responses concerning resistance to computer use show that neither students with SN nor their peers are averse to computer use. Both disagreed with claims that computer use is difficult, causes nervousness, and is uninteresting. Both also expressed feeling neither tired nor scared of using computers. However, although both groups expressed similar opinions, students with SN had higher scores, meaning that they experience more effort, nervousness, and fear when using computers.

The results suggest that students like to use computers in school, find learning with computers interesting, and are unafraid of using computers. Nevertheless, students do not consider computer use to be important for learning success.

Table 7 presents the results related to students' free-time activities. Most of the students with SN reported watching television (90.5%), listening to music (90.5%), and socializing with friends (87.9%) during their free time. Their peers most often socialize with friends (91.6%), listen to music (95.1%), and watch television (91.6%). The less-frequent activities were also similar for both groups. Children with SN and their peers were least likely to dance in a dance group, play an instrument, or engage in fine art. In all of the mentioned activities, students with SN had lower scores than their peers had.

Table 7. Leisure activities of students with SN and their peers

	Students with SN		Peers		Total	
	N	*%*	*N*	*%*	*N*	*%*
I watch television.	105	90.5	446	91.6	551	91.4
I listen to music.	105	90.5	463	95.1	568	94.2
I hang out with friends.	102	87.9	470	96.5	572	94.9
I do my homework and study.	87	75.7	391	80.6	478	79.7
I read books or magazines.	59	50.9	318	65.3	377	62.5
I do sports.	81	69.8	394	81.1	475	78.9
I do housework.	78	67.2	389	80.7	467	78.1
I draw or create art.	44	37.9	198	40.7	242	40.2
I take care of animals.	93	80.2	332	68.3	425	70.6
I play an instrument.	27	23.3	147	30.2	174	28.9
I dance in a dance group.	11	9.5	74	15.2	85	14.1

4.1 Frequency of computer use, types of ICT activities, and attitudes toward computer use in relation to gender

Two new indices that combine questions measuring the same phenomena were created to examine the correlations between frequency of computer use, types of ICT activities, and attitudes toward computer use and gender. The leisure activities index comprised the following variables: "I watch movies on the computer," "I listen to music on the computer," "I download music/movies from the internet," "I surf the internet," "I use webmail," and "I use social networks." The school activities index comprised "I look online for information I need in school" and "I do my homework with the computer."

Table 8 shows that on average, students use ICT more for leisure activities (M = 6.51) than for school activities (M = 1.44).

Table 8. Characteristics of students' leisure and school activity indices

	Leisure activities using ICT	School activities using ICT
N	603	603
Mean	6.519	1.441
Median	7.000	2.000
Modus	8.000	2.000
SD	1.677	.658
Asymmetry	-1.500	-.765
Kurtosis	2.352	-.496
Minimum	.000	.000
Maximum	8.000	2.000

The variables measuring students' attitudes toward computer use were found to include the following four dimensions:

- the opinion that computer use improves learning progress,
- fear of using computers,
- well-being when using computers,
- desire to use computers in school.

The variables fear of using computers and well-being when using computers were grouped into one index, the resistance to computer use index, to further analyze computer use. Table 9 presents the characteristics of the three created indices. The data show that students do not feel resistant toward computer use (M = 1.67) and are neutral concerning the benefits of computer use for learning success (M = 2.73) and their desire to use a computer in school (M = 3.28).

Table 9. Attitudes toward computer use

	Opinion that computer use improves learning success	Resistance to computer use	Desire to use computers in school
N	603	603	603
Missing	0	0	0
M	2.732	1.669	3.282
Median	2.750	1.500	3.500
Modus	3.0	1.0	5.0
SD	.9774	.6168	1.2934
Asymmetry	.238	1.278	-.243
Kurtosis	-.601	1.762	-1.102
Minimum	1.0	1.0	1.0
Maximum	5.0	4.4	5.0

As the distribution deviated from the norm, gender differences were calculated using the Mann-Whitney U test (Table 10). The results show the following:

- Males use computers for more hours per week (U = 38968.5, p = 0.003).

- Males use computers for more leisure activities (U = 39734.5, p = 0.007).
- Females use computers for more school activities (U = 39465.5, p = 0.002).
- Males believe more strongly that using a computer improves their learning achievement (U = 38440, p = 0.001).
- Males have a greater desire to use computers in school (U = 40308.5, p = 0.019).

No statistically significant differences were found between males' and females' resistance to using computers. The data confirm that frequency of computer use, types of ICT-supported activities, and attitudes toward ICT use are all gender specific.

Table 10. Relationships between computer use frequency, types of ICT activities, and attitudes toward computer use and gender

	Mann-Whitney U	Z	P	Average ranks	
				Males	*Females*
Time spent per week using computers	38968.5	-2.951	.003	319.90	280.69
Leisure activities using ICT	39734.5	-2.695	.007	320.31	283.43
School activities using ICT	39465.5	-3.057	.002	281.78	320.45
The opinion that computer use improves learning success	38440.0	-3.210	.001	324.69	279.21
Resistance to computer use	42694.5	-1.218	.223	292.73	309.93
The desire to use computers in school	40308.5	-2.350	.019	318.36	285.30

4.2 Frequency of computer use, types of ICT activities, and attitudes toward computer use in relation to the presence of SN

Spearman's correlation coefficient was used to calculate the correlations between computer use frequency, types of ICT activities, and attitudes toward ICT use and the presence of SN in students (Table 11). The results show that compared with their peers, students with SN

- spend less time using computers (rs = -0.132, p = 0.001);
- use computers in fewer leisure (rs = -0.209, p <0.001) and school activities (rs = -0.086, p = 0.034); and
- have greater resistance to computer use (rs = 0.124, p = 0.002).

No statistically significant differences were found between students with SN and their peers with respect to the opinion that computer use improves learning success or the desire to use a computer.

Students with SN and their peers differed in ICT use. Specifically, students with SN spent less time in front of computers, used ICT for fewer activities, and exhibited more resistance to ICT use than their peers did. However, the two groups of students share a similar desire to use computers and similar opinions on whether computer use improves learning success.

Table 11. Relationships between computer use frequency, types of ICT activities, and attitudes toward computer use and the presence of SN in students

	Presence of SN
Time spent per week using computers	-.132**
Leisure activities using ICT	-.209**
School activities using ICT	-.086*
The opinion that computer use improves learning success	.025
Resistance to computer use	.124**
The desire to use computers in school	-.056

* $p < 0.05$, ** $p < 0.01$

5 Discussion

This study examined the use of computers in the leisure and school activities of seventh- to ninth-grade students enrolled in inclusive elementary school classrooms in Slovenia. The impacts of gender and the presence of SN on computer use frequency, types of ICT-supported activities, and attitudes toward ICT use were investigated.

The availability of a computer and internet at home affects students' ICT use and was therefore examined. Our data show the very high accessibility of computers and internet to both SN students and their peers. Of the students with SN, 99.1% have home access to a computer, and 93.1% have internet access. Similarly, 98.8% of their peers have a computer at home, and 96.9% have internet access. The accessibility reported by other authors is lower. Hakkarainen and colleagues [28] found that 82.9% of all students in their study have home access to a computer, and more than half have internet access at home. An even lower percentage (69.2%) was reported by Vekiri and Chronaki [38]. Between the two tested groups, no significant differences in home access to a computer and internet were found in the current study. By contrast, Eden and Heiman [33] found that all students with SN in their study, compared with only 38.9% of their peers, have access to computers at home. Hakkarainen and colleagues [28] suggested that home internet and computer access depends on schools' promotion of ICT-supported activities. Our study reveals a very high home computer and internet access among Slovenian students (SN and non-SN) in inclusive classrooms. We suggest that this finding is due partially to ICT use in schools and mainly to students' ICT-supported leisure activities.

In this part, we summarize the results of the current study in relation to the three research hypotheses. The first hypothesis states gender- and SN status-related differences in the frequency of computer use. The students with SN included in our study reported spending between one and four hours per week in front of a computer. Their peers reported a much higher computer use, which exceeded 10 hours per week. However, a minority of the respondents (3.5% of the students with SN and 2.5% of their peers) also reported no computer usage at home. Our findings show a different trend in the frequency of computer use among pupils with SN and their peers and suggest that children with SN use computers less often than their peers do. Ari and Inan [37] reported a higher frequency of computer use among students with SN, with all of them using computers and more than half of them exceeding 5 hours of use per week. Lidström and colleagues [29] found that physically handicapped children use computers at home more often than their peers do because the latter are more engaged in sports and other outdoor activities. Differences in computer use duration were also found between male and female students. Consistent with the findings of previous research [28], we also found that male students use computers for a longer time per week than females do. Hakkarainen et al. [28] suggested that male students use computers more because of their generally better computer knowledge and, consequently, their higher motivation to use computers.

The second research hypothesis explores students' engagement in ICT-supported activities focusing on the influence of gender and SN. Consistent with the findings of previous studies [28], we found that Slovenian students with SN and their peers are more likely to use computers for leisure activities than for school activities. Possibly, students do not usually have schoolwork requiring computer use, so they are not sufficiently motivated to use ICT for school-related activities. The comparison of school- and leisure ICT-supported activities suggests that most students use computers to browse the internet and listen to music. Similarly, Ari and Inan [37] found that most children with SN watch movies and browse the internet on computers. Lidström and colleagues [29] reported that most Swedish students with SN and their peers chat online and play computer games to connect with friends. We can conclude that students with SN and their peers in Sweden use ICT more for developing and establishing social contacts than do Slovenian students, who typically use ICT for individual activities at home. Concerning the use of ICT for social purposes, our data show that in Slovenia, students without SN use social networks and webmail more often than students with SN do. Therefore, Slovene students without SN likely have more social contacts than Slovene students with SN have. This assumption is confirmed by the analysis of other common ICT-supported activities, as most respondents with SN reported watching television and listening to music in their free time, whereas most of their peers hang out with friends (a finding supported by other studies [29]).

Insights into students' resistance to computer use, desire to use computers in school, and opinions that computer use improves learning success were obtained to explore the third research hypothesis. This hypothesis indicates the influence of gender and SN on attitudes related to computer use.

According to our data, students are not resistant to computer use. Consistent with the findings of previous studies [27], fear of computer use was found to be more common among students with SN than their peers. Ari and Inan [37] suggested that a possible reason could be a lack of ICT skills among students with SN. Students with SN are generally less skilled and less confident, so they tend to feel more afraid of using things that they have not fully mastered [37]. In the future, this fear of ICT use among students with SN should be reduced through better preparation.

Our results show neutral opinions of students on the use of computers in school. The desire to use computers in school was found to be more common among male students than among female students, a result that is consistent with those of previous studies [24]. The reason may be the better computer skills of male students and, thus, their greater motivation to use computers. Volman and colleagues [40] reported a greater desire of computer use in school, expressed by 68.1% of the students in their study. Our findings may indicate that ICT is no longer a significant motivator for Slovenian students.

The students in our research did not attribute particular importance to computer use in schools and expressed neutral opinions on the impact of computer use on improved learning. Approximately half (50.8%) of them fully or partially agreed that learning with a computer is more interesting than learning without one; among these children, the majority were without SN. Hakkarainen and colleagues [28] made a similar observation; they found that only 34.6% of the students in their research agreed that computers can improve learning. On the other hand, Kubiatko and Haláková [24] reported a higher percentage of students (82%) who believed that learning with a computer is more interesting than learning without one. The authors concluded that learning with a computer is more interesting and more motivating for adolescents [24]. Basing on the results of the current study, we conclude that ICT is not a significant motivator for learning among Slovenian children.

No correlation was found between students' opinions that computer use improves learning success or their desire to use computers in schools and the presence of SN. All students expressed neutral opinions on computer use in school and do not consider it important for learning success.

Slovene teachers have been found to have neutral attitudes toward ICT use in inclusive education and to believe that they lack sufficient competence in ICT-supported learning and assistive technologies [41]. Our research provides useful information on ICT integration in inclusive classrooms for personalized learning. It helps teachers in planning their ICT use for cognitive scaffolding and for social and emotional scaffolding. However, the data presented in this study should be interpreted with caution because all students with SN in this study were combined in a single group. The results may be different from those of a study that includes only those children with SN for whom ICT is an essential learning tool.

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Construction of Real-time Interactive Mode-based Online Course Live Broadcast Teaching Platform for Physical Training

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Abstract—As a new teaching mode, online courses have become one of the most important teaching methods in higher education. At present, there are still some shortcomings in online course live broadcast teaching platform including insufficient hardware support, low flexibility and weak interactivity. Meanwhile, during the entire online course teaching process, teachers do not know the overall learning effect of students in real time to determine the next teaching plan. This study presented a real-time interactive technology to enhance the interactive of the entire online course broadcast teaching platform. At the same time, it combined a monitoring method for online course terminals, servers and learning process to demonstrate students' learning effect in the whole online course learning process, and finally built the online course broadcast teaching platform. The practice test in teaching shows that the online course broadcast teaching platform can improve the teaching effect among students, which is of great significance for the improvement of teaching quality.

Keywords—Real-time interaction mode; Physical Training teaching; Network course

1 Introduction

The emergency of internet at the end of the 20th century has brought the development of information technology. With the development of information technology, the functions provided by internet become more and more. Online multimedia technology, also called network course technology, can effectively serve for coursed teaching [1]. Its difference with multimedia technology in routine teaching work is that, offline multimedia technology conducts corresponding teaching presentation through multimedia system in teaching work, and corresponding teaching tasks can be completed through real-time display on the computer. Carrying out corresponding teaching task through multimedia technology is called single offline teaching. With the development of information technology, more and more teaching functions can be achieved through internet. So, network course live broadcast teaching platform as a new online course teaching platform suitable for internet development requirements was born.

In the whole network course operation, the interaction between teachers and students is the most important factor. Network course live broadcast teaching platform proposed in this paper takes Physical Training network course as the main object of study. This course aims to serve as the training foundation of different physical training, enhance basic skills of physical trainers and correct students' postures in physical training. Based on the teaching objective of Physical Training, real-time information exchange between teachers and students is required, which is also the basis of interaction mode of this network course live broadcast teaching platform. Only with such interaction mode, the whole network teaching platform can improve students' learning efficiency and effect. Meanwhile, the users of network course platform can really learn corresponding course knowledge, and the talents with professional knowledge can be provided for the society.

2 State of the art

From 1980s (before the birth of internet), some large IT companies in science and technology powers such as US, Japan and Europe started to conduct online multimedia teaching. The final idea of these internet companies was to form an online multimedia platform with rich information resources by which users could communicate with each other [2]. Based on the researches of these companies, they first invested and established LAN-based multimedia communication systems which could implement speech communication within certain network scope. The most mature system was Etherphone communication system of American Xerox Company [3]. With the research on online multimedia teaching, small-scale LAN gradually developed into internet in 1990s. World Wide Web greatly promoted the research on network multimedia platform. American VocalTec Company first launched IP phone software called Internet Phone. Such IP phone software as the earliest online multimedia communication platform has become the earliest exploration of these internet companies [4].

Except the demand for online multimedia voice communication, people are not satisfied with pure online voice communication, with the gradual development of internet and continuous improvement of internet functions. People further need face-to-face video communication. The software which can online transmit audio/video information such as videophone and video conference gradually emerged. With the emergency of such software, hardware industry of network multimedia technology has gained corresponding development: Toshiba Corporation took the lead to develop MPEG-4 coding and decoding chips, which laid a foundation for the development of light and mobile multimedia equipment [5]. Motorola also applied the chip in mobile phone. Corresponding film resources could be watched in real time on the phone launched by Motorola. This is also the prototype of network broadcast. The network course live broadcast also referred to it.

In foreign countries, live broadcast teaching system becomes the research emphasis of distance classroom education institutions, because of the development of distance education technology. As continuous researches, the researches on network course live broadcast teaching gradually developed to intelligence, modularization, automation and virtualization. Network course live broadcast teaching system gained great development in US. At present, all states in US have established corresponding live broadcast teaching system. Western Virginia real-time teaching application platform (WVVS) has been established to make education free from the restriction of school scale, time and space and offer rich and complete course education for students anytime and anywhere [6]. Colombi [7] applied network live broadcast course in dance teaching, and constructed a virtual discussion zone for students on the basis of Blackboard online course. The result shows that the network course could enhance students' learning effect. Freguia [7] applied network live broadcast course in engineering course and environmental protection teaching and found that students held positive attitude to webcasts: the proportion of students viewing the webcast in advance was 80% -92% over the five weeks of the intervention. Enhanced engagement brought increasing attendance (85-92%), and prominent active participation in class (half of observed teams (~80%) were active). Sato [9] surveyed the experiences of PE teachers in online adapted physical education (APE) postgraduate courses and the final theme assessment experiences, and depicted the process in which the participants learned knowledge and skills through online courses about assessment and evaluation. The result indicates that the course contributes to teaching and can be further promoted and applied.

Numerous internet companies developed network education products, and online education products synthesizing real-time teaching and online interaction functions sprang up, such as MPEG2 network teaching live broadcast and VOD scheme [10]. The network teaching live broadcast and VOD scheme aims to meet teaching demand of platform users. MPEG-2 video technology is used to transmit corresponding courses in real time. Students can view course live broadcast and rebroadcast through campus LAN. However, due to the insufficient amount of video compression, the data size is too large in each course, and the course could not transmitted on internet in real time. Streaming media technology has become the mainstream of network video live broadcast technology. The technology can effectively save storage space and reach corresponding continuous transmission. At present, streaming media technology has been fully utilized on network live broadcast platform. Chinese educational institutions such as New Oriental and Sailing have applied streaming media technology to establish network course live broadcast teaching platform with thorough functions [11].

With the development of information technology, network course live broadcast teaching platform still has the defect of insufficient interactivity. In the whole teaching process, there are only a few teachers. However, since the scope of audiences is very large, teachers cannot exchange with every student in real time. Real-time interaction must be supported by corresponding software. It lacks flexibility on the whole, so it is not suitable for large-scale promotion [12]. Moreover, the teacher cannot know students' learning effect in real time so as to confirm the next teaching plan in the operation process of network live broadcast platform, for the teacher and students are in the one-to-more relationship. For the above two problems, this paper, on the one hand, proposes a real-time interaction technique to improve interactivity of network course live broadcast teaching platform. On the other hand, this paper combine a monitoring method used for network course terminal, server and learning process to feedback students' learning effect so as to improve the learning method and enhance learning efficiency. Through network course live broadcast platform, students can learn more knowledge and more network education talents can be provided for the society.

3 Theoretical construction

3.1 Real-time interaction technology

Real-time interaction technology owns multiple interaction modes. The interaction mode used by video capture interaction module is H.263 coding and decoding technology. Audio acquisition and playing adopt G.729 coding and decoding technology. The feature of H.263 coding and decoding technology is that information compression ratio and image quality can improve greatly, and compression efficiency in information transfer process can increase. G.729 coding and decoding technology occupies small bandwidth and can effectively meet the demand of network course live broadcast teaching platform. Voice communication for which common decoding and coding technology is used needs to occupy 64Kbps bandwidth, but G.729 technology only needs 8Kbps bandwidth. Such real-time interaction technology can effectively promote interaction instantaneity, effectively relieve network bandwidth burden of the server and reduce operation cost of the server.

3.2 Monitoring method used for network course terminal, server and learning process

The main purpose of this monitoring method is to monitor user's behavior of browsing online live video for study with low-load server through database method. Multiple modules are included in the whole monitoring method: video browsing module, logging module and information reporting module. Through video browsing module, online video may be accessed, and corresponding video can be displayed on the above network course terminal. Logging module is connected with the above video browsing module to periodically store video linkage accessed by video browsing module and the access time. Information reporting module is connected with logging module to upload video accessed and access time recorded in the logging module to the external server.

The whole external server technology also includes corresponding modules and server technology: video linkage database which is used to store the linkage of specified videos for corresponding network courses; input module which is used to receive linkage and access time of videos sent by external network course terminal; judging module which is connected with input module and video linkage database, and is used to contrast whether the inputted video linkage is consistent with the video linkage in the database, judge whether the video browsing time conforms to time requirement of database and finally confirm whether the learner's study is effective. The structure of system monitoring method is shown in Fig.1.

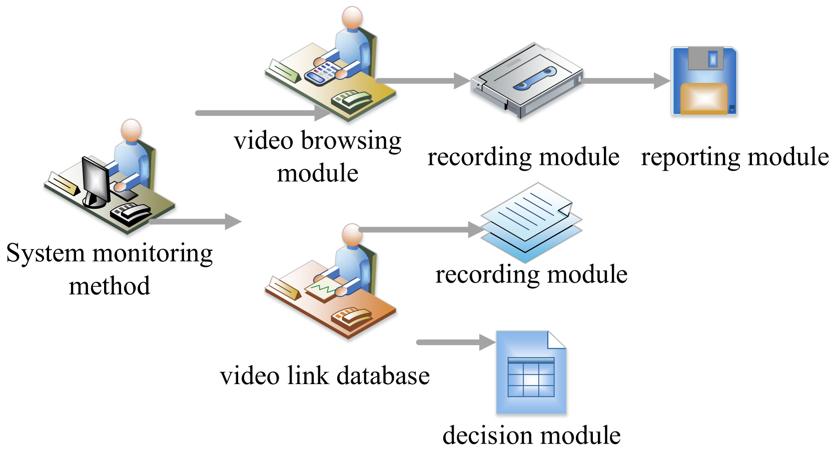

Fig. 1. Structure of system monitoring method

In the monitoring method used for network course terminal, server and learning process, it is most important to confirm whether corresponding time lengthy conforms to server requirements in the whole monitoring process.

4 Physical Training network course live broadcast teaching platform based on real-time interaction mode

4.1 Framework of network course live broadcast teaching platform

Network live broadcast teaching platform in this paper mainly adopts yoga as the teaching course. In the teaching process, yoga practice part is the key. Since the most important factor in yoga practice is the unity of movement, breath and ideology, the teacher and students need to form real-time interaction and exchange in the teaching process, and the teacher should test students' learning situations in real time.

Network live broadcast teaching platform in this paper mainly includes network live broadcast module, real-time interaction module and evaluation module. CSMX technical proposal is chosen for network live broadcast module. Microsoft Visual Studio C++6.0 is used as the development tool. The development language is C++. The feature of CSMX technology is that the whole screen transmission quality is high and transmission data size is small.

Real-time interaction module includes real-time interaction module server and real-time interaction module client. Real-time interaction module server contains:

1. Web server: Visual Studio 2008 is used as the development tool, and the development software is C#.

2. Flash Media Sever: Flash CS3 is used as the development tool, and Flash Media Sever ActionScript is used as the development language.

Real-time interaction module client also uses Flash CS3 and Flash Media Sever ActionScript as the development tool and development language respectively. The playing process of network course live broadcast teaching platform is shown in Fig.2.

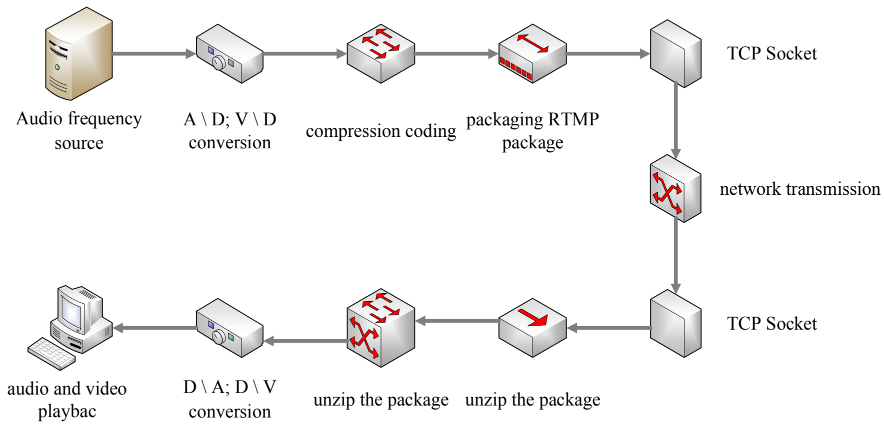

Fig. 2. Process of live broadcast teaching platform system

4.2 Network live broadcast module

Network live broadcast module mainly includes two parts: teaching resource collection and teaching resource playing through CSMX technology.

Teaching resource collection. Teaching resource collection requires collection of audio/video information of teachers and capture of corresponding teaching actions in the teaching process. After corresponding information is gathered, data are compressed and transmitted to network terminal server. The development tool of teaching resource collection is Microsoft Visual Studio C++6.0, and MFC API is also applied.

Screen capture coding module divides the teacher's screen into 16, and the 16 video areas are monitored by Hook technology. As monitoring process proceeds, corresponding video information is gradually sent to the server through two functions: Hookhandle (UINT Message, HWND hWnd, WPARAM wParam, LPARAM lParam), and void EncodeScreen*(DSDATAIRP *screen). Hookhandle (UINT Message, HWND hWnd, WPARAM wParam, LPARAM lParam) stores the collected videos in a structure. The other function takes out corresponding code of vide data from screen.

Audio/video collection coding module calls functions void CaptureVideo(char* buf) and void CaptureAudio(char* buf). The two functions collect teacher's audio/video and stores corresponding parameters in the internal storage specified by buf. Then, the functions call void EncodeVideo(char* buf) and void EncodeAudio(char* buf) and code audio/video data in buf. Teaching resource collection process is shown in Fig.3.

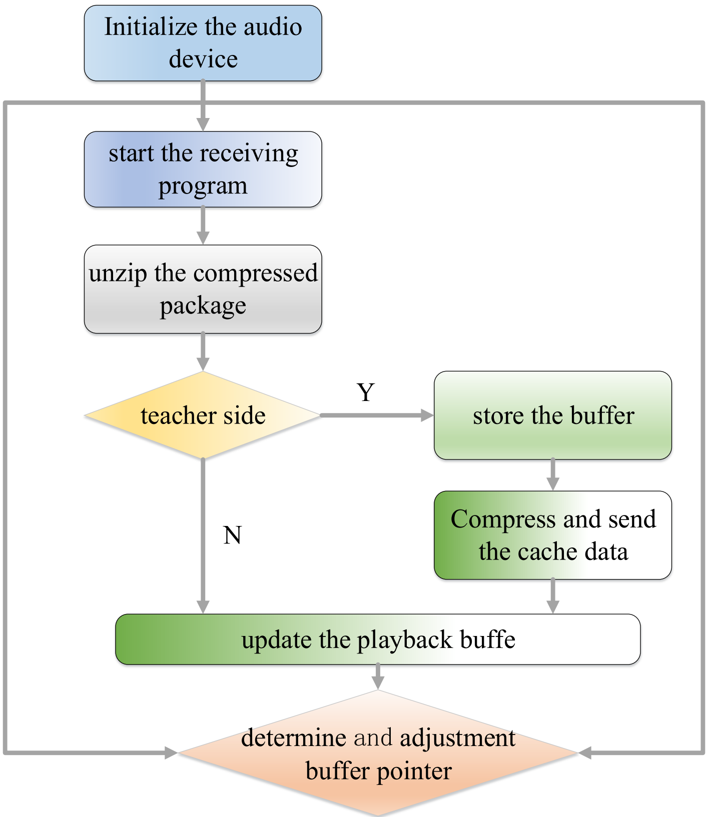

Fig. 3. Teaching resource collection process

Teaching resource playing in CSMX technical proposal. In CSMX technical proposal, teaching resource playing includes audio, video and screen decoding playing. The server transmits the codes of corresponding teaching resources to teaching resource playing module, and the playing module decodes and plays.

In the whole playing process, desynchrony of audio, video and screen needs to be solved. The major solution is as follows: confirm corresponding reference clock for the whole system and confirm corresponding call function as void Play, confirm corresponding time label at the data starting time and ending time. In the whole playing process, the system reads corresponding time label and plays according to the time on the reference clock.

4.3 Real-time interaction module

The corresponding real-time interaction module is introduced in the network course live broadcast teaching platform. The teacher and students can discuss in real time through the module. When students encounter problems, they may propose them through audio-video transmission tools such as microphone and camera. The teacher may carry out corresponding analysis according to the problems or correct students' movements through the video transmitted by the camera in real time. This module can effectively promote students' classroom study participation and contribute to improving learning efficiency.

Audio/video interaction module mainly includes two parts: video decoding part and network transmission part at the client. In the network transmission part, the real-time interaction module achieves corresponding data sending and reception. Audio video resources implement coding and decoding of audio/video resources through Nellymoser coder and On2Vp6 coder respectively. The transmission process of real-time interaction module is shown in Fig.5.

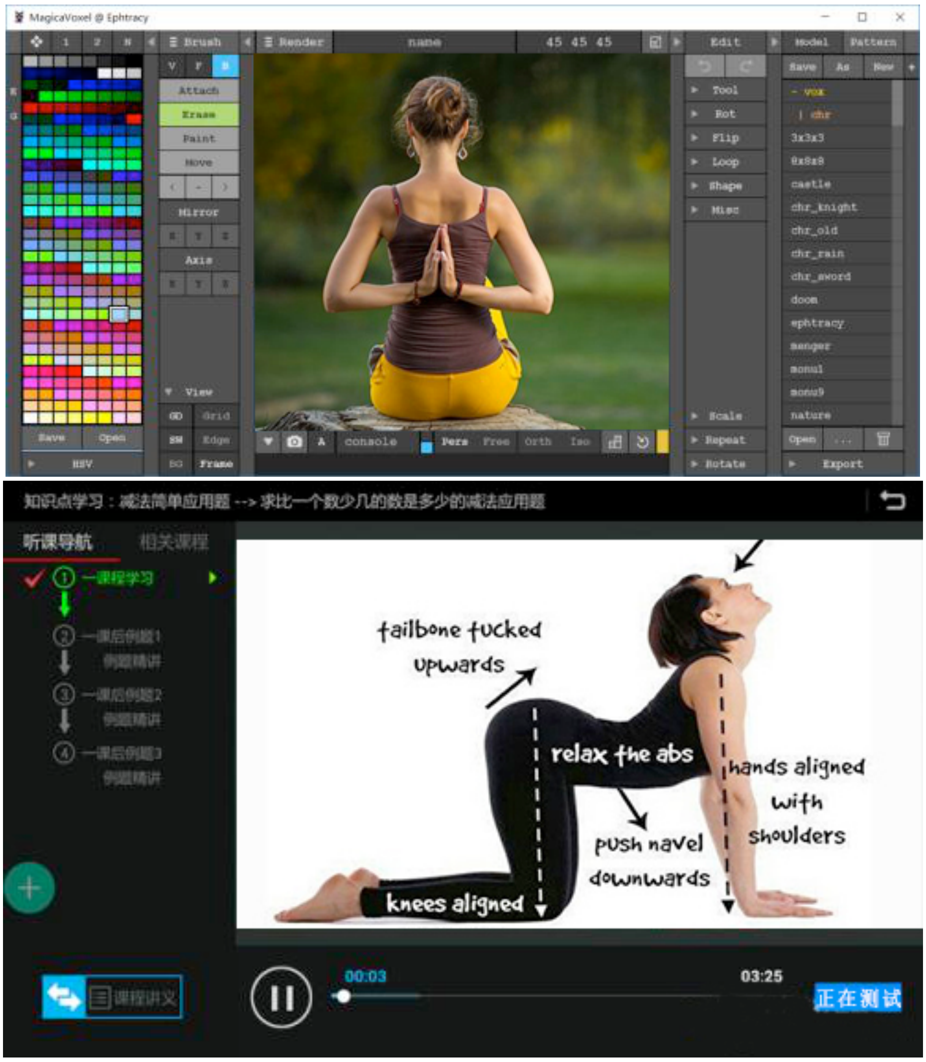

Fig. 4. Learning platform interface

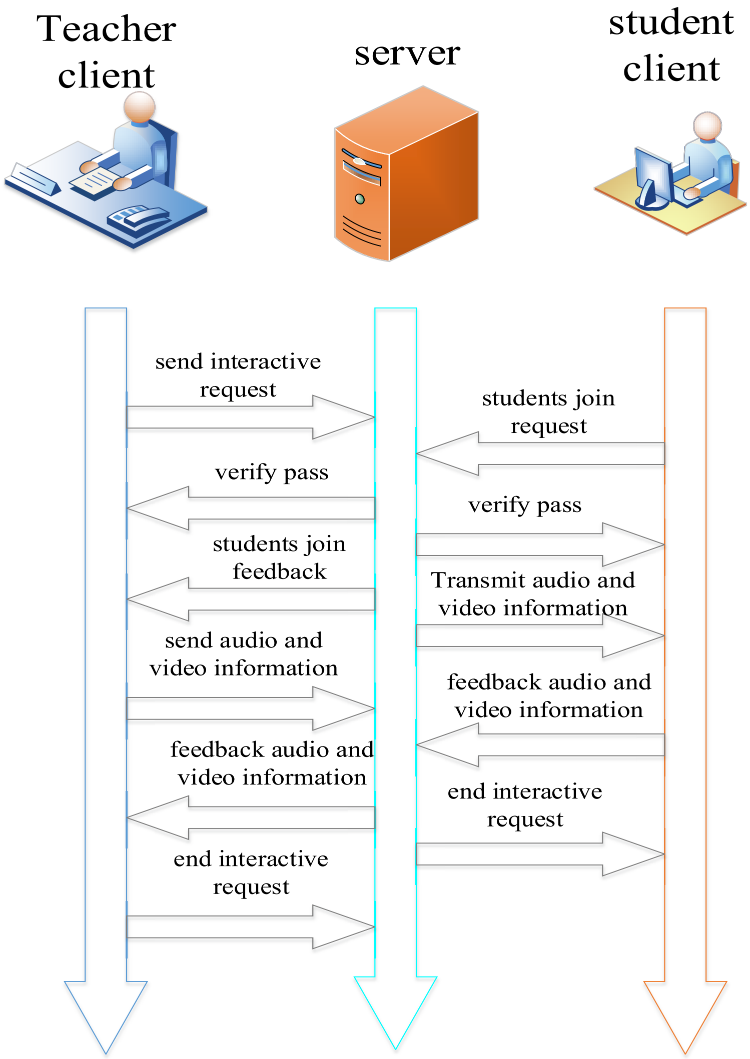

Fig. 5. Transmission process of real-time interaction module

4.4 Evaluation module

Evaluation of students' study us also an important part of network course education. Starting from the monitoring method used for network course terminal, server and learning process, this paper establishes comprehensive evaluation system for the network course students. Students' online school time, video viewing time and interaction frequency with the teacher are used as the comprehensive evaluation indexes of Physical Training. The complete process logging module can more effectively promote students to grasp knowledge, and the teacher can better know students' learning performance. Corresponding module analysis of evaluation module is shown in Fig.6.

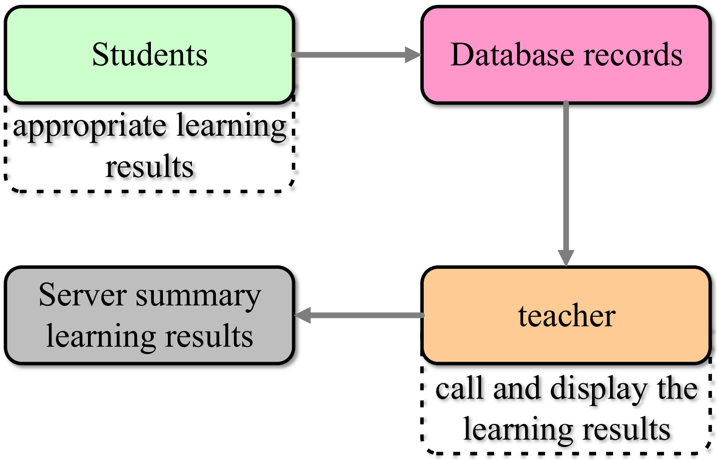

Fig. 6. Structure of evaluation module

4.5 Effect check

Before testing the effect of network course live broadcast teaching platform, the author investigated 56 users. Among them, only 5 students had certain understanding of yoga training video and textbook knowledge. The 56 experimental subjects were classified into two groups at random: experimental group (28 students) and control group (28 students). Traditional offline yoga course teaching mode was used for the control group. The network course live broadcast teaching platform was applied for the experimental group. 56 electronic questionnaires were distributed, and all of them were recovered, with the recovery rate of 100%. There were 56 effective questionnaires, with the effective rate of 100%. The data statistics software SPSS was used to analyze the survey result.

Table 1. Yoga movement mastery of both groups

Group	Excellent of Yoga movement method	Excellent of Essential of Yoga movement
Experimental group (n=28)	24(85.7%)	26(92.8%)
Control group (n=28)	16(57.1%)	19(67.8%)

It can be seen from Tab.1 that, the excellence rates of experimental group in yoga movement method and essential of Yoga movement are 85.7% and 92.8% respectively, significantly higher than the control group (57.1% and 67.8%). This indicates yoga course teaching can effectively improve students' movement method level. Judging from the excellence rates of both groups, the excellence rates of experimental group are 28.6% and 25% higher than that of control group. This proves that network course live broadcast teaching platform has good teaching effect.

Table 2. Comprehensive score of yoga movement in both groups

Scores	Experimental group		Control group	
	Number	*Percent (%)*	*Number*	*Percent (%)*
0-7	3	10.7	15	32.2
8-15	25	89.3	19	67.8
Total	28	100	28	100

After yoga course teaching ended, yoga movement knowledge mastery was tested for both groups. The examination method is that the online teacher uploaded yoga movement video on the learning module, and the offline teacher organized students to view corresponding yoga movement video. According to yoga movement knowledge taught and corrected in the class, 15 wrong movements shown in the yoga movement video were corrected. 1 score was added whenever one wrong movement was found. The proportions of students gaining 0-7 scores and 8-15 scores in the experimental group are 10.7% and 89.3% respectively, while the proportions of control group are 53.6% and 46.4% respectively. The proportion of experimental group (8-15 scores) is 21.5% higher than that of control group. This proves that the learning effect of students using network course live broadcast teaching platform is better than that of students who did not use network course live broadcast teaching platform.

5 Conclusions

This paper designed and implemented Physical Training network course live broadcast teaching platform based on interaction mode as well as explored the applicability of new teaching mode and method for physical training courses. Meanwhile, after analysis of teaching effect of network course live broadcast teaching platform based on interaction mode, such type of network course teaching can indeed enhance students' learning interest and efficiency during learning physical courses. But, the network course live broadcast teaching platform also has defects and needs to be improved from the following aspects:

1. The teacher's teaching level on the network course teaching platform influences students' learning effect to a large degree. How to evaluate teacher's teaching level? A thorough course teaching evaluation system is required.
2. Since the hardware facilities' and software facilities of the network course live broadcast teaching platform are not mature, the collapse of live broadcast teaching platform and other reasons will reduce students' interest and use. Thus, another problem to be solved is to make network course education platform more stable.

In one word, although there are some problems in the construction of network course live broadcast teaching platform, internet-based learning has become the general trend with the rapid development of information. After in-depth research, the scale of network course teaching will become will be larger, and network course teaching will be full of vigor after current problems are overcome.

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Automatic Composition of Instructional Units in Virtual Learning Environments

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Abstract—In this paper, a new approach for automatic composition of instructional units based on a new variant of Harmony Search Algorithm is proposed. The purpose is to solve curriculum sequencing issue by designing and arranging learning content in a suitable sequence. By suitable sequence we mean a learning sequence that fits learner level and presents the content in a way that conveys its structure to learner. Results show that the proposed approach is promising. For instance, individualized courseware plan are generated "on the spot" carefully considering both students characteristics and subject-matter coherence.

Keywords—Curriculum Sequencing Problem, Curriculum Design, CS Problem, Virtual Learning Environment, Evolutionary Computation, Harmony Search Algorithm, Learning Path, e-Learning, Personalized Learning, Adaptive Teaching Learning Sequence.

1 Introduction

Technology changed drastically the teaching learning process. Using technology students benefit from instant access to materials anytime and anywhere. Online learning materials have the potential to captivate student's attention and foster their interest since this generation is digital natives. Many studies pointed out the importance of using technology in the educational settings. For instance, the survey conducted by[1] shows that students are highly motivated to adopt mobile technologies for educational purposes and that they consider mobile learning as a useful and easy to use learning method. Although technology provides a huge boost in flexibility. Still, most virtual learning environments provide students with "One-size-fits-all": the same learning material is presented in the same way and at the same time to all learners. This ignores the fact that learners have different backgrounds, knowledge and goals, they proceed according to their own pace and might be interested in different contents at different stages of the learning process. Another drawback of the "One-size-fits-all" is that, in an online educational environment, learner may get confused when searching for what could fit their level or learning style, leading up to online courses with not balanced learning concepts, or sometimes to cognitive overload.

One of the current challenges of today's educational technology is to provide students with authentic and meaningful learning experience, helping them achieve a standard of performance, and succeed – at their own pace- in a highly competitive environment. However, information overload remains an issue in virtual learning environments where a massive amount of information is presented to learners in a way that not conveys to their level or learning style making them feel frustrated and dissatisfied.

To this end, this paper highlights a new approach for automatic composition of instructional units. More specifically, the focus is on the mechanism of generation of courseware taking into consideration both students characteristics and instructional design point of view. This is a well-known research issue that has been classified by many researchers as an NP hard problem. This has been justified by [2], in order to find an appropriate learning sequence for a subject-matter with N learning concepts, one should explore a large number of possible solutions with a Total of N!. In this case, using an ordinary algorithm to search for suitable learning concepts would take a very long time, and may end up without finding optimal learning sequence. It's important to note that: not only exploring large databases to form suitable learning sequences is time consuming and difficult task, it is also heavily constrained. Some of constraints are related to students' characteristics and others are bound up with domain knowledge.

The reminder of this article is organized as follows: in section 2, related works are reported and discussed. This section is divided into two main parts: first of all, approaches for curriculum design are presented and recent approaches for composition of instructional units are highlighted. In section 3, Automatic Composition of Instructional Units is presented. For instance, we present the proposed approach to solve the problem based on Harmony Search Algorithm followed by experiments and results in section 4. Section 5, summarizes the contribution. Finally, we draw a conclusion and announce our future work.

2 Related works

Creating individualized teaching learning sequence is a research issue commonly known as "Curriculum Sequencing Problem" or "Learning Path Generation" or "Personalized Teaching Learning Sequence". Curriculum is the arrangement of content. It compasses learning content in respect to an educational approach. It should be flexible and responsive to meet students' needs and expectations. Curriculum sequencing problem might be divided into two open problems: (1) curriculum design and (2) curriculum sequencing. Curriculum design entails the process of designing structuring and chunking the content, while curriculum sequencing is the mechanism of gathering learning concepts together such as contents, activities, and exercises to form a unique learning sequence. Curriculum design and curriculum sequencing are critical steps to deliver appropriate learning sequence. In this section, we report and discuss related works.

2.1 Approaches for Instructional Design

As stated by [3] “Curriculum is not a monolithic construct”, it entails the design of learning materials or reuse of existing ones in respect to an educational approach and should be aligned to some standards. Curriculum design approaches could be classified into two main categories: learner-centered curriculum sequencing and concept-related curriculum sequencing.

In one hand, learner-centered curriculum approach puts the emphasis on students' characteristics and their changing states of mastery. It is based on the underlying assumption that learners are in the heart of any educational system and curriculum should be derived from students' characteristics. It replaces traditional way lecturers use to deliver knowledge with a self-directed learning in which student is responsible of learning and is engaged in the process. At this stage, educational technology should be able to pinpoint student's characteristics and knowledge level. It should also help them grow in their understanding moving them from novice to expert status. Many works fall in this category such as [4]who proposed a style-based ant colony system to provide student with suitable learning path in respect to their learning style. Learning style stands for preferred ways to learn (visual, aural, reading/writing and kinesthetic). Chih-Ming Chen[5] postulates that learner ability is an important factor that should be taken into consideration while designing e-learning course. Authors distinguished between learning style and cognitive style. The learning style refers to underlying traits that leads to a learning behavior while cognitive style stands for preferred ways of learning. The same authors propose an adaptive system based on dimensions of Felder-Silverman's learning style. Other researchers put the focus on learner's level, prior knowledge or competency into the design of curriculum.

In the other hand, concept-related curriculum depends on domain knowledge. The focus is on knowledge structure and design instruction to achieve a learning goal. As posited by[6] most approaches focus on the content to be delivered and pedagogical approaches are not incorporated. To deal with this issue, some researchers deal with the depth and breadth of the content to be taught while others are interested in techniques to structure domain knowledge. For instance many techniques are proposed to deal with the instructional design step: graph based presentation of content such as ontology[7] or Bayesian network structure[8], Visual Educational Modeling [9], Using SCORM(Shareable Content Object Reference Model) provided with most learning management systems to create and enable exchange of content[10].

Brusilovsky[11] distinguishes between (1) Active Sequencing and (2) Passive Sequencing. In one hand, Active sequencing is the mechanism of preparing a learning sequence “on the spot” based on learner profile. It's goal-driven and cover the whole subject-matter. The purpose of active sequencing is to build the most suitable individual path to achieve a standard of performance based on the difference between student's current level of knowledge and the target one. For instance, active sequencing uses intelligent techniques in order to search for the best learning objects in a hyperspace. This assumes that the subject-matter is divided into a series of learning objects which are stored in different learning repositories and might be linked so to form a unique individually planned sequence of resources. In the other hand, Passive sequencing - called also remediation or remedial sequencing – addresses the learning difficulties by providing students with relevant items to correct the misunderstandings or overcome the situations that hinder their achievement.

Another popular approach for instructional planning is collaborative filtering used in recommender systems; the purpose is to find appropriate content that suits for a target user. These approaches start with clustering students into homogenous groups called also virtual communities of interests then provide each group with appropriate learning material.

2.2 Approaches for Composition of Instructional Units

Composition of Instructional Unit stands for the operation of populating a sequence with suitable learning concepts. There have been several approaches for composition of instructional units proposed by researchers. For instance, some authors formulate the automatic composition of instructional unit as a Constraint Satisfaction Problem[12]while other researchers formulate the problem as a Multi-Objective Optimization Problem[13]or Permutation problem[14][15].

Many techniques are proposed in order to solve the issue of automatic composition of Instructional Units: evolutionary computation such as GA (Genetic Algorithm)[2][16][17], ACO(Ant Colony Optimization)[18], PSO (Particle Swarm Optimization)[2], Artificial Neural Network(ANN)[19], Bayesian Network(BN)[8], Fuzzy Logic(FL)[20],Case-based Reasoning[21], Semantic Web[22], IRT(Item Response Theory)[23][24] are used. As result, evolutionary computation is increasingly popular in recent years and the literature is divided into two popular categories: Genetic Algorithm, and Particle Swarm Optimization. Both algorithms are applied to solve diverse types of problems related to the e-learning field. However, none of the scientific papers found so far has tested the potential of Harmony Search Algorithm to solve Curriculum Sequencing issue.
The motivation of choosing HSA is as follows:

- GA, PSO and HSA belong to non-deterministic class of algorithms so the solution may vary for each run. The quality of the obtained solution depends on the initial population, and the chosen parameters and operations.
- GA and PSO require a set of configurations. Furthermore, GA needs Chromosome encoding which is different from one problem to another. In the other hand, HSA could directly be implemented, all it needs is setting parameter such as objective function, stopping criterion.
- HSA is based on the principle that each new solution is better than all existing ones stored in a memory called Harmony Memory. Iteration after iteration, the algorithm starts to use candidate solution belonging to known high-quality solutions. HS algorithm generates a new vector after considering all of the existing vectors.
- Finally, HSA returns more than one good solution. It returns N best solutions. N refers to Harmony Memory Size.

3 Automatic Composition of Instructional Units

In what follow Harmony Search Algorithm is presented followed by its application to produce automatic instructional units.

3.1 The proposed Approach

We propose to use Harmony Search Algorithm (HSA) to tackle curriculum sequencing issue. HSA is a population-based metaheuristic algorithm which was first introduced by Zong Woo Geem[25]and has been applied to solve the optimization problem of water distribution networks. As pointed out by [26][27], HSA has gained popularity due to the fast convergence speed. It's an algorithm which attempts to imitate jazz musicians especially those who play music together for the first time. For instance, they use improvisation and notes variations to find good harmony. Each musician in the group should find iteratively and over time the next note; to do so s/he refers to previously played notes and the context of music they are playing. Harmony search Algorithm uses this metaphor to iteratively produce a solution vector.

Our contribution: the process of searching for better harmonies in HSA is replaced by the process of searching for better learning concepts to form an individualized learning sequence, carefully considering both student's needs and content coherence. In the following section, HSA algorithm will be presented and discussed then, its application to automatic composition of instructional units will be illustrated.

3.2 Harmony Search Algorithm

HSA is a novel population-based meta-heuristic algorithm. The basic idea is adjusting the input (pitches) in order to obtain a perfect output (harmony)[28]. For instance, when musicians try to come up with a new harmony, they usually try previous combinations of pitches they remember. This is analogous to the process of finding an optimal learning path by combining different learning objects already stored in different learning repositories. HSA searches for a possible combination of candidate solutions, called also decision variables, the purpose is to minimize or maximize a fitness function, under a set of constraints. Figure 1 depicts the HSA Global Search Strategy.

HSA Global Strategy
Initialize the algorithm and problem parameters *While (Stopping Criteria is not met)* **Improvise a new solution vector** *If (New solution is better than the worst ever stored)* **Update Memory with the new solution** *Endif*

Fig. 1. HAS Global Strategy

The harmony search algorithm works as following:

Step1: Initialize the optimization problem and algorithm Parameters. HSA Algorithm uses a set of abbreviations described below:

- ***X_i***: decision variable.
- ***N:*** Number of decision variables.
- ***HM:*** Harmony Memory, a memory system in form of a matrix; it contains the best solution vectors found within the search process.
- ***HMS:*** The number of solution vectors in HM.
- ***HMCR:*** Harmony Memory Consideration Rate explained in rule (1).
- ***PAR***: Pitch Adjusting Rate, explained in rule (3).
- ***Ni:*** Number of iterations, it's the basis for terminating the optimization process.

The output of the initialization step is a HM Matrix with random decision variables. Each solution vector of the Harmony Memory is judged based on a cost function f(x) that the algorithm tries to recursively optimize. Obtained value of f(x) is stored in the last column of the Matrix.

$$\mathbf{HM} = \left[\begin{array}{cccc|c} x_1^1 & x_2^1 & \cdots & x_n^1 & f(\mathbf{x}^1) \\ x_1^2 & x_2^2 & \cdots & x_n^2 & f(\mathbf{x}^2) \\ \vdots & \cdots & \cdots & \cdots & \vdots \\ x_1^{HMS} & x_2^{HMS} & \cdots & x_n^{HMS} & f(\mathbf{x}^{HMS}) \end{array}\right]$$

The improvisation step: Generate a new possible solution. A new solution vector X'= (X'$_1$, X'$_2$, X'$_3$, X'$_4$, ..X'$_N$) is generated based on three rules HMCR, Random Selection and PAR explained bellow, which decide on the value that will be assigned to each decision variable in the new solution vector. The generation of new solution vector is called improvisation.

Rules of selecting new candidate solutions are:

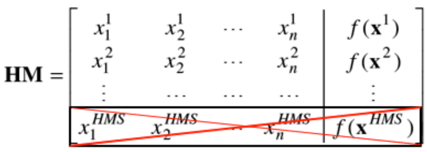
Rule 1: select candidate solution based on HMCR (Harmony Memory Consideration Rate): it refers to the probability that a specific candidate solution would come from existing Matrix HM, since it contains the best solutions found so far. The value of HMCR (0<=HMCR<=1) but usually greater than 0.5.

Rule 2: select a candidate solution based on Random selection: it refers to the process of random Selection of a solution candidate with a probability of (1 – HMCR).

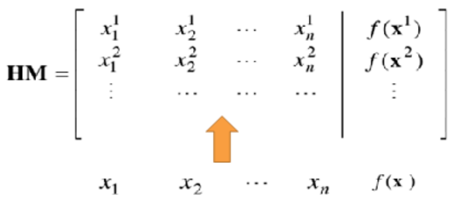
$$x_i' \leftarrow \begin{cases} x_i' \in \{x_i^1, x_i^2, \ldots, x_i^{\mathrm{HMS}}\} & \text{with probability HMCR} \\ x_i' \in X_i & \text{with probability (1 - HMCR).} \end{cases}$$

Rule 3: select candidate solution based on PAR (Pitch Adjustment Rate) the probability that a specific candidate solution in the new vector would be replaced by a new one assigned randomly within the bounds of the problem.

Harmony memory update. Once the new solution vector (Harmony) is obtained using the above rules (1) (2) and (3). The goodness of the new generated solution is calculated. The goodness of a solution vector function is calculated using a function *f(x)* that recursively calculate the cost of solution vector, each of which is a possible learning sequence. If the new solution is better than the worst solution stored in the HM, then the worst solution so far is excluded and replaced with the new one with less violated constraints.



Step1: Retrieves the worst solution vector stored in HM



Step2: Includes the new solution vector in HM

Stopping Criterion. The computation is carried out until the algorithm meets the following stopping criterion:

- Maximum number of improvisations.
- Maximum number of iterations.
- Reaching a solution which satisfies all constraints.

3.3 Harmony Search Algorithm For Automatic Composition of Instructional Units

First of all, we explain the terminology related to the proposed variant of HSA in the following table, then we describe the algorithm steps.

Table 1.

Variable	HSA Curriculum Sequence Terminology
Xi	Learning concept
N	Number of concepts of a learning sequence
HM	A set of learning sequence, each one is a vector of a Matrix
HMS	The number of possible learning sequences that we bill generated by the algorithm.
HMCR	Harmony Memory Consideration Rate: The probability of choosing a learning concept that will be assigned to a decision variable Xi from existing memory.
PAR	Pitch Adjustment Rate: the probability that a specific learning concept in the new learning sequence would be replaced by a new one from a learning repository.
Ni	Number of iterations, it’s the basis for terminating the generation of instruction units.
ωi	Weight assigned by tutor to learning concept i.

In order to automatically generates individualized learning sequence, we set rules that will be used by the algorithm to select suitable learning concepts. This means that the arrangement of learning concepts should be drawn upon learner characteristics but is should also carefully consider intended learning outcomes and learning strategies. The algorithm should return an instructional plan in respect to the following constraints:

Constraint 1: difficulty parameter. Content should be organized in an order of increasing complexity; beginning with simple case and avoiding too complex ones, or concepts already mastered. It is also worth mentioning that learning concepts should be presented one a time with a respect of total amount of time.

Constraint2: Subject-matter coherence. Concepts have relationships to each other's and learning one thing may require student to learning something else first, or learning one concept should be complemented by another one. Relationships within learning concepts are calculated based on students' results on a pre-test. The result is a concept correlation matrix RC. A higher correlation means mutual relation of two or more concepts.

Figure 2 depicts the links between four concepts.

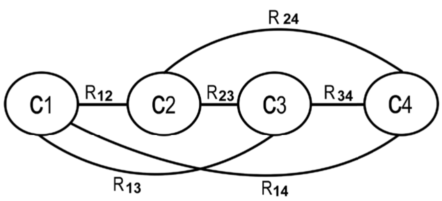


Fig. 2.

In order to determine how a concept is linked to other ones we used formula below:

$$RC(i) = \sum_{j=1}^{N} Rij$$

Each line of the matrix is a solution Vector (X={X_1, X_2, X_3, X_4 … X_N) is an ordered list of learning concepts, each learning concept is covered by a Learning Object. Each solution vector of the Harmony Memory is judged based on a cost function f(x) that the algorithm tries to recursively optimize. Obtained value of f(x) is stored in the last column of the Matrix.

The purpose f(x), in this case is to maximize f(x) subject to xi ∈ Xi, i=1, 2, 3,…, N, with

$$f(x) = \sum_{i=1}^{N} RC(i) \ * \omega i \ Ui$$

For a concept i, Ui is the student level calculated based on a pretest, ωi is the weight assigned by tutor, and RC(i) is the total correlation with other concepts.

HM is first filled with decision variables (Learning Concepts) generated randomly from a range of their possible values in the search space (Learning Repositories).

One optional step is to rearrange, in the initialization step, the order of solution vectors according to f(x), from best to worst solution. The following flow chart depicts the steps the proposed variant of HSA Algorithm.

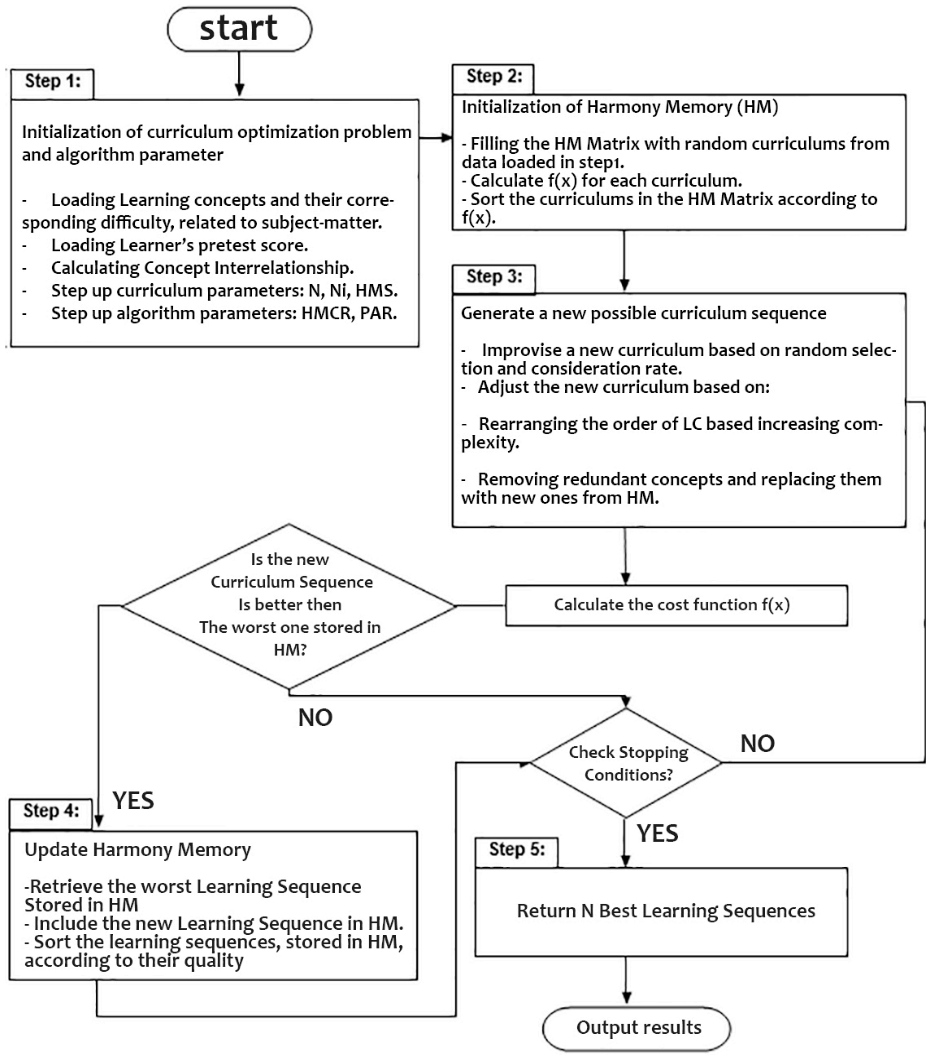


Fig. 3. Flow chart of the proposed variant of HSA algorithm

4 Experiments and results

The purpose of the experiment is to evaluate the efficiency of HSA computational technique in finding the best instructional Units. In order to apply HSA for automatic composition of instructional units, both problem and algorithm parameters are specified. We run a simulation of a "database" courseware with 14 Learning Concepts with an increasing complexity. In order to calculate the relationships within concepts, we used recorded data from a pretest. Table 2 describes data used for experiments purpose.

Table 2. sample data used for experiments

Id	Name
C1	Relational databases
C2	Data Model
C3	Logical Model
C4	Normalization
C5	Create Table
C6	Alter Table
C7	Insert Query Syntax
C8	Select Query Syntax
C9	Multi-table queries
C10	Group By usage
C11	Aggregate functions
C12	Update Query Syntax
C13	Delete Query Syntax
C14	Using Restrictions

The experiment of the proposed HSA variant is conducted under eclipse IDE, the algorithm is implemented using java programing language, in a computer with JDK1.8, an Intel Core i5 and 4 GB RAM with Windows 10.0 operating system.

The experimental setup determines the performance of the proposed variant of Harmony Search Algorithm. For instance, speed and quality of the best learning sequence generated are important factors. In order to determine the computational cost, HSA is performed for 4500 iterations which stands for the number of evaluation of the fitness function, also considered as a basis for terminating the optimization process. Results

It has been observed that when multiplying the number of learning concepts, the algorithm speed remained reasonable. This important since the automatic composition of the instructional unit should be done "on the spot" right after the learner finishes the online assessment of perquisites. Figure 4 depicts HSA computational cost for generating instructional units.

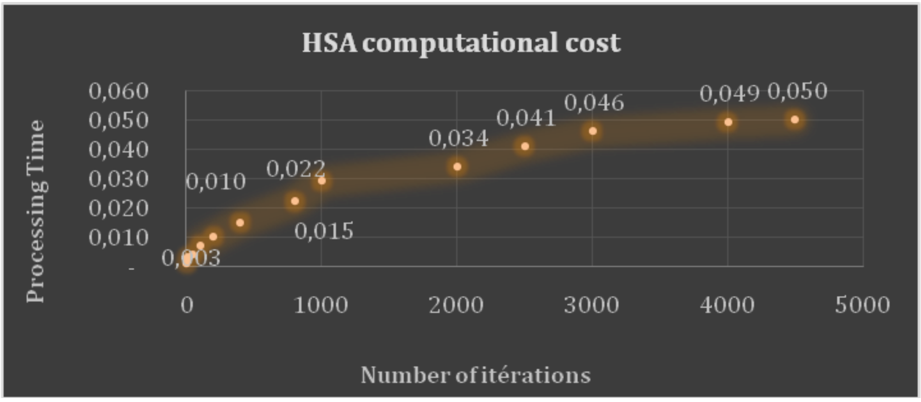


Fig. 4. HSA computational cost

Still, as in contrast with other algorithm the number of iterations, parameters and constraints influence the algorithm behavior. For instance, HMCR parameter influences the convergence of the algorithm. Lower HMCR parameter (between 0 and 0.5) leads the algorithm to converge quickly to local solution and higher HMCR parameter (between 0.5 and 1) leads the algorithm to optimal and global solution but may need a considerable number of iterations. The best solution is yet to find the finest HMCR values suitable to: number of learning concepts to search for and the number of learning concepts in learning repositories respectively.

We concluded that the proposed approach is promising. Pitch Adjustment Rate of Harmony Search Algorithm is modified so to fix three encountered issues: (1) Rearranging the order of Learning Concepts based on increasing complexity. (2) Removing redundant concepts and replacing them with new ones. (3) Taking into consideration that a learning sequence could entail less than Ni concepts for students who showed mastery for some Learning Concepts. The time window violation variable is not yet considered.

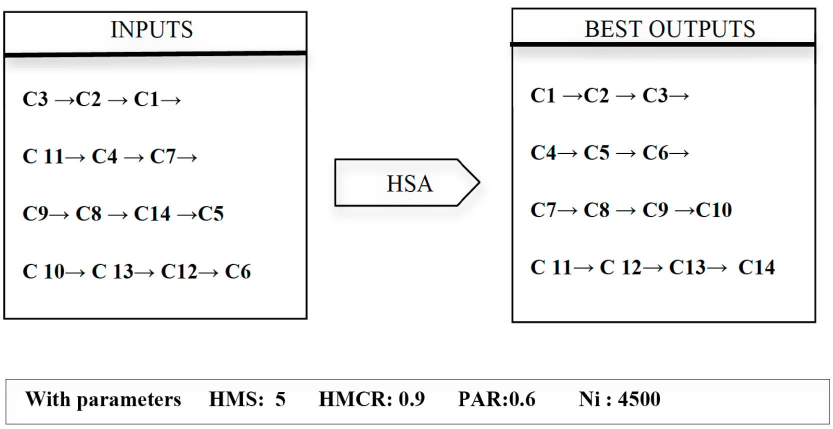


Fig. 5.

5 Summary

In this contribution, a new method to generate the learning path at beginning of online session is proposed. The purpose is to provide each learner with an individualized teaching learning sequence in a step by step process to achieve a standard of performance. More specifically, it is about selecting suitable learning concepts and sequencing them in a way that will be appropriate to student level of mastery with a respect to subject-matter structure.

The first constraint aims to provide students with content which fits their level and in an order of increasing complexity. The second constraint aims to ensure content coherence by maximizing relationships within concepts of the learning sequence. These relationships are calculated based on students' answers to a pretest. The result is a concept correlation matrix. The proposed algorithm uses the matrix to find a learning sequence which maximizes relationships within its concepts and presents learning concepts an order of increasing complexity, beginning with simple case and avoiding content that is too complex for student.

Each iteration, the algorithm improvises a new possible learning path, and then evaluates its goodness using a cost function. If the new learning path is better than the worst solution in the matrix, then the algorithm applies a harmony memory update to include the new solution vector.

As result, the Matrix (HM) contains N best solutions sorted according to their goodness. The output of the algorithm is N Best learning sequences. The best one yet is the first one on top of the matrix.

One advantage of HSA is its stability. For instance, when multiplying the number of learning concepts in the learning sequence and the number of learning objects in the search space, the algorithm speed remained reasonable

6 Conclusion

For several years great effort has been devoted to the study of the field of adaptive e-learning systems. Many researchers pointed out the importance of taking into consideration the learning characteristics in the design of those systems. We addressed the issue of automatic generation of instructional units with two sources of constraints: learner's current knowledge and interrelationship within a subject-matter. We proposed an intelligent mechanism of selecting and rearranging concepts into a learning sequence, using an adapted Harmony Search Algorithm. For future work, we intend to integrate the proposed algorithm into Moodle Learning Management System in order to generate instructional plan for bunch of learners and analyze some algorithm parameters. For instance, we would like to measure the extent to which generated curriculums fit each case of learners, this is by considering both students and teachers point of view.

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Exploration and Practice on Course Teaching in Plastic Injection Mold

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Abstract—The plastic injection mold design course has strong comprehensiveness and practicality. However, most theoretical teaching are separated from practical operation in the current teaching process. The blind lecture of teachers easily leads to the cramming education phenomenon, which has low student acceptance and poor learning effect. To solve these problems, the project-driving method was applied to plastic injection mold design teaching. On the basis of the course content, the present study expounded the implementation method of project-driven teaching which divided the course teaching process into the following stages: determining the theme, executing the theme, and displaying and evaluating the project. The following were also detailed: the principles of project selection, the implementation process of the project, and the tasks of students and teachers in the implementation process, as well as the project result presentation and the evaluation criteria of the quality of student learning. The plastic injection mold design of the refrigerator thermostat knob was used as an example to discuss the application of the project-driving method. Results show that compared with traditional teaching methods, the project-driving teaching method can better improve the learning interest, self-learning ability, engineering practice ability, and innovation and teamwork of students, as well as the satisfaction of employers.

Keywords—Plastic injection mold design, project-driving method, course teaching, practical ability

1 Introduction

Plastic injection mold design is one of the professional technical courses in Mold design and manufacturing profession and is the key course in mechanical manufacture and automation profession. With its strong comprehensiveness and practicality, plastic injection mold design has become a core subject for cultivating vocational skills of design, production, and management in the mold industry. Existing survey results have shown the separation of current theoretical teaching methods of this course from practical applications in most colleges and universities. As a result, students cannot really understand the teaching content, leading to failure in mold design practice.

Considering this undesirable teaching effect, we can summarize the main problems in the teaching process as follows:

1. The theory course easily results in cramming education which fails to fully mobilize the learning initiative and enthusiasm of students. With poor teaching effectiveness, students will regard mold design principles and trivial content as difficult and boring. In addition, although many knowledge points exist in plastic injection mold design teaching, seeking the relationship between these knowledge points is difficult for students. Previously learned content will be forgotten with time. Thus, only some fragmented knowledge points are ultimately accepted without systematization.
2. Teaching assessment is executed through examinations and usual performance indicated by attendance, homework, and recitation. Examinations are mainly prepared on the basis of textbook content, thereby increasing student dependence on textbooks. Evaluating the operational capacity, innovation capacity, and learned knowledge application of students in practice is difficult. Moreover, the ability to adapt to mold jobs is not improved, which negative impacts the future employment of students.

To meet the social requirements for talent in the mold industry, an important direction for curriculum reform is to improve the self-learning ability and overall quality of students when knowledge is taught [1-2]. The project-driving approach refers to the teaching method in which knowledge content in the traditional disciplinary system is transformed into a number of teaching projects. Courses are taught around projects, directly involving students to complete the teaching process. The main feature of the project-driving method is the fact that course teaching is always conducted around projects. The focus of this method is to cultivate the practice, innovation, independent access to information and the independent knowledge-building abilities of students. In the current study, the project-driving method was used in the course teaching of plastic injection mold design, and specific implementation methods were introduced with the case.

2 State of art

Educators have performed much research to develop the practice and knowledge application abilities of students. Zhang Wenyu (2014) explored the aspects of the curriculum system, teaching methods, and teaching staff construction, to build a strong and high-level teaching body by improving teaching quality [3]. Li Baoming (2014) conducted reforms in the practicability and integration of course content, the diversification of teaching resources, the informatization of teaching methods and tools, and the projectization of teaching management [4]. These reform measures are teacher-centered and curriculum-oriented, making them conducive to exploiting the role of teachers. However, the theoretical value of the mode is more than its practical value, separating theories from practice, which is not conducive to the cultivation of professional abilities of students. The teaching method also lacks unique characteristics due to its neglect of practical demands.

Wang Cuifeng (2014) proposed the curriculum model of school–enterprise cooperation [5]. Bi Dasen (2012) advocated the establishment of the industry–university–research base and the cultivation of student ability to serve enterprises [6]. Linda P. (2011) applied the dual system from German in the teaching process, allowing the cultivation of skilled talents to be shared by enterprises and schools [7]. The potential of applying this mode to Asia was demonstrated by Stefan [8]. In comparison, foreign companies have strong interest in school teaching participation due to their increased social responsibility and corporate development. However, many Chinese enterprises are not interested in school teaching for various reasons. Enterprises commonly refuse schools.

Based on work process, the project-driving teaching method brings an actual enterprise project into the curriculum. Driven by this mission, students can quickly grasp the basic theory of a curriculum, organically integrating theory with practice. Scholars have conducted studies on the project-driving teaching method. According to Zhang Shijin (2014), the project method is student-centered, providing room for the potential of students for innovation and practical ability [9]. The stages and the implementation process of the project-driving method were described by Gulimzhan [10]. Emine(2014) also demonstrated the effectiveness of this method in enhancing the social skills of students through examples. In the current study, project-driving method was used in the plastic injection mold design course teaching [11]. Actual projects and cases of enterprises were integrated into the teaching process with a specific implementation process.

3 Teaching mode of plastic mold design based on the project-driving method

The project-driving method refers to the teaching practices of teachers and students to complete specific tasks. Teaching focus is transited from lesson plan to project completion. In the project-driving method, a typical project is selected as the general task throughout the teaching process. The total task is divided into a number of specific subtasks according to knowledge points, integrating main contents of the course into various stages of the total task. Thus, scattered knowledge in various chapters of textbooks is organically linked to help students construct a complete knowledge system. In accordance with project-driving teaching theory and the teaching content of plastic injection mold design, the teaching process is divided into the following three stages:

3.1 Identification of project themes

The themes of learning units are determined according to the teaching program and curriculum objectives. The course project design should be close to the enterprise. The project should be based on the typical workflow of mold design, and it should be practical and pertinent and close to the actual conditions of the school. A large, comprehensive project is first identified to achieve the goal of curriculum development. The large project is then gradually divided into a number of small projects with easy operation and implementation. The small projects usually involve main knowledge points of a unit and typical tasks are formulated to implement them. Before arranging project tasks, teachers explain relevant theoretical knowledge. This, the introduction of project topics focused on inspiring student thinking. The project tasks are then clearly arranged with detailed project objectives, implementation plans, training skills, inspection capabilities, assessment methods, and reference books.

3.2 Implementation of project activities

Project groups are established, and a project leader is appointed for each group. The responsibility of group leaders includes project plan preparation guided by teachers, task assignment, and implementation supervision. Project plan is then formulated. Each team member designs a plan based on theoretical knowledge from the textbook or from self-study bibliography. A scientific and reasonable implementation plan is finally established after each plan is evaluated through group discussion. Each group then divides the tasks on the basis of the implementation plan. The work of each member is carried out according to the undertaken project tasks. During project implementation, teachers need to inspect work progress as well as the organization and management of each group, ensuring the quality and order of project implementation. For problems from students, teachers should provide answers and technical guidance to arouse the enthusiasm and thinking ability of students. Students are also encouraged to solve problems through information search to improve their self-learning abilities and to link theory to practice. After project task completion, students need to check the results by themselves. Meanwhile, teachers tour the groups to examine the progress and quality of group tasks. The learning situation of students is observed and is used as the evaluation reference after project completion.

3.3 Demonstration and evaluation of project activities

After project completion, teachers check and accept the project achievements of students. Projects are evaluated and rated according to workload, accomplishment, and achievement quality. The criteria include "whether the project results meet the requirements" and "whether expected teaching objectives are achieved." Groups and individuals are evaluated. For groups, the completion and quality of the whole project are evaluated. By contrast, individual evaluation includes learning attitude, individual task completion, project implementation participation, and professional quality and ability. After consulting professional teachers about scoring statistics, the following judgment matrix was obtained:

$$A = \begin{vmatrix} 1 & a_{12} & L & a_{1n} \\ \frac{1}{a_{12}} & 1 & L & a_{2n} \\ M & M & M & M \\ \frac{1}{a_{1n}} & 1 & a_{2n} & L \end{vmatrix} \tag{1}$$

After calculating and normalizing the eigenvector of judgment matrix (A), we can determine the evaluation indicators and weights (w_i) of student learning quality (Table 1).

$$W_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}} \Bigg/ \sum_{i=1}^{n} \sqrt[n]{\prod_{j=1}^{n} a_{ij}} \tag{2}$$

In addition, teachers review the theoretical knowledge of the whole project to comment on student performance. After completing the project, teachers document student achievements on file, including their project drawings, manuals, and the implementation process.

Table 1. Index and weights of student learning quality evaluation

Project stage		**Evaluation index**	
Content	***Weight***	***Content***	***Weight***
Preparation	0.2	Material search	0.06
		Learning attitude	0.07
		Self-learning ability	0.07
Implementation	0.5	Assigned workload	0.08
		Organization and plan	0.08
		Practical ability	0.1
		Communication and cooperation	0.08
		Hard work	0.08
		Inspection and correction	0.08
Achievement	0.3	Group project performance	0.06
		Individual task performance	0.04
		Group project quality	0.06
		Individual task quality	0.04
		Project presentation	0.06
		Defense performance	0.04

4 Case study and teaching effectiveness

4.1 Teaching case

The total project of this course was determined as the Injection Mold Design of the Refrigerator Thermostat Knob. Table 2 shows project content division according to the curriculum training objectives and knowledge of each unit.

Table 2. Project contents and task division of the plastic injection mold design

Total project	Project division	Work tasks
Injection Mold Design of Refrigerator Thermostat Knob	Project 1: Product analysis of plastic parts	Task 1: Select plastic raw materials
		Task 2: Design structural machinability
		Task 3: Select molding process
		Task 4: Establish overall mold design and layout
	Project 2: Determination of Injection molding process parameters	Determine parameters of temperature, pressure, and time
	Project 3: Selection of injection molding equipment	Determine injection machine according to injection molding process parameters
	Project 4: Design of injection mold structure	Task 1: Determine basic structure of the mold
		Task 2: Design gating system
		Task 3: Design forming parts
		Task 4: Check forming parts
		Task 5: Design introducing mechanism
		Task 6: Design guide mechanism
		Task 7: Select standard mold base

Product analysis of plastic parts. Teachers provide product photos or samples to define design tasks. According to product usage and molding process, students analyze the plastic molding process to select plastic raw materials. Combined with theoretical knowledge from textbooks, the structural machinability of plastic parts is analyzed from aspects of size, surface shape, internal structure, wall thickness, inserts, whorls, and holes. On the basis of shape structure, mold joints of plastic parts are then determined. The location of mold joints is conducive to mold processing, exhaust, demoulding, surface quality of plastic parts, and process operation. The number of cavities is calculated on the basis of processing accuracy, production volume, and processing costs of plastic parts. We should then determine the pouring system, including gate location, number of gates, gate size, and flow path layout. The Moldflow software is used for analysis and optimization, requiring students to draw a simple layout of the pouring system (Figure 1).

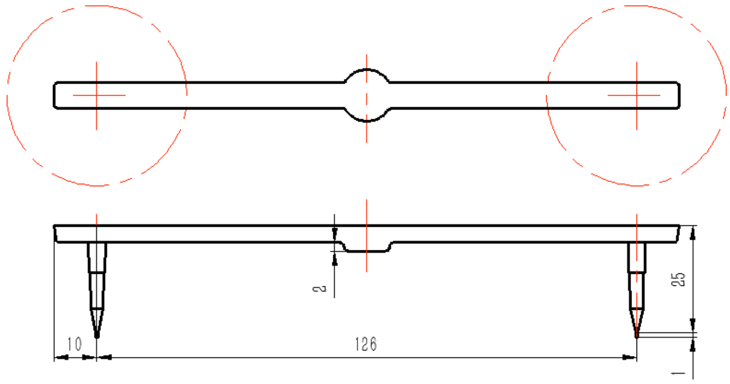

Fig. 1. Flow channel layout and size

Determination of injection molding process parameters. Reasonable process parameters ensure good plasticization of plastic melt and smooth filling, cooling, and setting to produce qualified plastic parts. Temperature, pressure, and time are the three most important parameters affecting the injection molding process. Barrel and mold temperatures are involved in the temperature index as the former mainly controls the plasticizing property and fluidity of the plastic, and the latter affects cooling setting and the capability of the plastic to fill the cavity. By overcoming the flow resistance of plastic melt, injection pressure can provide melt with a certain rate of mold filling to compress it. Labor productivity and injection machine use are directly affected by molding practice. Therefore, the length of relevant stages in the molding cycle should be minimized to guarantee quality. Teachers explain relevant knowledge on the process parameters of injection molding. Then, students consult the process conditions of plastic molding according to the plastic molding situation, formulating plastic molding process cards (Table 3).

Table 3. Polypropylene injection molding process parameters

Plastic name		**Polypropylene**
Injection molding machine type		Screw-type injection molding machine
Preheating and drying	Temperature t/°C	80–100
	Time τ/h	1–2
Barrel temperature t/°C	Back end	160–170
	Middle end	165–180
	Front end	170–190
Mold temperature t/°C		80–90
Injection pressure p/Mpa		70–100
Molding time τ/h	Injection time	20–60
	High-voltage time	0–3
	Cooling time	20–90
	Total period	50–160
Screw speed N/($r \cdot min^{-1}$)		48

Select injection-molding equipment. Students need to estimate the size and weight of plastic parts. The injection molding machine should primarily be selected according to the following parameters: injection capacity, mode locking pressure, injection pressure, mold installation dimensions, ejection and distance, location hole size, and template stroke. Meanwhile, relevant parameters of the injection machine should be checked. Through the selection and checking of injection molding equipment, students can improve their understanding of the principle of injection molding to lay the foundation to further learn mold structure.

Design injection mold structure. Injection mold structure design is the key task of the project, which mainly includes the following aspects:

a) Design forming parts, including the structure design of the mode cavity and core and dimension calculation and strength check. The structure with side holes and concaves should be designed with a side core-pulling mechanism. Pumping distance and extraction force should also be calculated to determine the form, structure, and size of the core-pulling mechanism.
b) Design stripping mechanism after calculating stripping force. Sprue puller, ejector, and reset mechanisms should be determined. Then, the strength, stiffness, and stability of components should be checked.
c) Design clamping guide mechanism, including composed elements, structure size, and installation means.
d) Design temperature control system after calculating mold thermal balance, as well as design and calculation of the structure, size, and location of the cooling system.
e) Select specifications, models, and quantities of supporting and connecting parts.

After determining the mold structure plan, students are required to draw mold assembly illustrations. Figure 2 shows a mold assembly drawing that reflects structural characteristics, working principles, relative positions between parts, and assembly relationship of the mold.

After completing the project, students can display their project results via PPT, CAD drawings, hand-drawn illustrations, and homemade molds. Different groups are mutually evaluated after presentation. Students can re-learn learned knowledge, which enhances their interest in learning and sense of teamwork. Teacher evaluation is given on the basis of encouragement to enhance student confidence. In each link of the project process, teachers should establish complete dynamic evaluation files for students. The classroom discipline, attendance, data collection, and task completion of each student are recorded. Assessment information is included in the comprehensive evaluation results.

4.2 Teaching effectiveness

The project teaching method was introduced to the instruction of plastic mold courses in 2016, with teaching subjects comprising year 2013 undergraduates majoring in Mechanical Manufacturing and Automation. The traditional teaching method was performed on year 2012 undergraduates of the same major. After course completion, we conducted a questionnaire survey on students of both grades, with a follow-up survey on the enterprises where they work. Figure 3 shows the statistics from the survey.

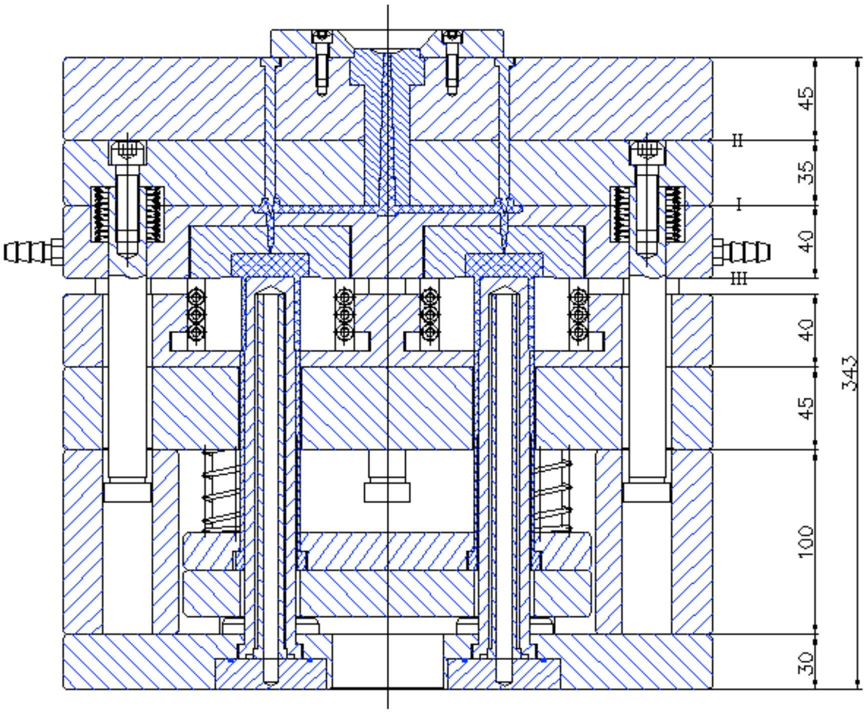

Fig. 2. Mold assembly drawing

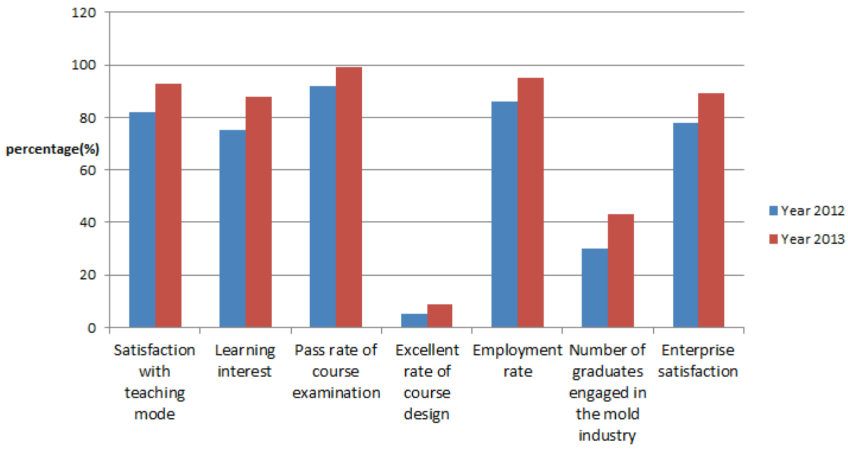

Fig. 3. Comparison chart of teaching effectiveness

The results show that the course reform significantly improves teaching acceptance. The employment rate, professional counterpart rate, and job adaptability of graduates were significantly enhanced after the reform. Meanwhile, the professional knowledge and skills of students were approved by their employers.

5 Conclusions

By reforming the project-diving method, the core of the plastic injection mold design curriculum shifted from teacher to student, textbook to project, and classroom to practical experience. The following conclusions could be drawn:

1. The practice proves that students have a firm grasp of knowledge points with the use of this teaching method, allowing them to achieve teaching objectives and requirements.
2. Multiple abilities of students are improved, including knowledge acquisition, problem analysis, problem solving of practical production, teamwork, social relationship, and professional accomplishment.
3. This method could rapidly improve the teaching quality and effect of the plastic injection mold design course, cultivating high-quality talent in the plastic molding process and in the mold design for the country and society.

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Students Acceptance of Google Classroom: An Exploratory Study using PLS-SEM Approach

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Abstract—Google classroom can work in unidirectional process as it can serve the teachers' strategies and styles on one hand and students' perception, understanding, and effective participation in different classroom skills on the other hand. The acceptance of Google classroom is affected by different factors. Some of them are still not clearly specified and discussed in previous research; therefore, they need further investigation. Based on the previous assumption, this study is an attempt to examine the factors that affect the students' acceptance of Google classroom at Al Buraimi University College (BUC) in Oman. The Technology Acceptance Model (TAM) was adopted to formulate the hypotheses of the current study. The data was collected through an online questionnaire with 337 respondents. The Partial Least Square-Structural Equation Model (PLS-SEM) approach was used to assess both the measurement and structural models. The results of the study prove that both the perceived ease of use (PEOU) and perceived usefulness (PU) positively influence the behavioral intention, which in turn influence the actual usage of Google classrooms. This study helps the decision makers of the higher educational institutions to have a better understanding of the effectiveness of using Google classroom by their students. It is assumed that it helps in measuring the level of students' acceptance to the previously mentioned technology.

Keywords—Google classroom, acceptance, PLS-SEM, TAM

1 Introduction

The distance, online or blending learning style of teaching offers many advantages over the traditional classroom teaching style. The most influential advantages lie in its accessibility, students' scheduling flexibility, and adaptability for working [1]. Google classroom is a kind of blending way of learning that was initiated in 2014. It takes into consideration the achievement of specific functions such as simplifying the students-teacher communication, and the ease of distributing and grading assignments. It provides the students with an opportunity to submit their work to be graded by their teachers online within the deadlines. Similarly, teachers can have a complete vision concerning the progress of each student, and they can return work along with the necessary comments so that the student can revise their assignments.

Accordingly, Google classroom can be effective for both the learners and faculty members due to its features. As for the students, it provides a stream line of communication and workflow for students. Being free of paper is a crucial factor in developing learning strategies. Thus, students can keep their files more organized and need less stored paperless in a single program [2]. The previously given view is supported by [3] who points out that Google classroom is useful in facilitating teaching and learning process. Students are able to use it with ease whenever the need arises. The teachers' most important task is to make students aware of the way of using the apps. The main purpose of this paper is to study the factors that affect the Google classroom acceptance among undergraduates' students at Al Buraimi University College in Oman.

The rest of this paper is organized as follows: section two provides a summary about the relevant studies that were carried out concerning Google classroom. Section three shows the research hypotheses. Section four illustrates the research methodology. The results and discussion are provided in section five. Finally, section six demonstrates the conclusion and future work.

2 Literature Review

There have been lots of research papers that are related to an e-learning, online or blending learning, the number of research papers that focuses on Google classroom as a means of learning are still limited, though. One of the most recent studies by [4] who make use of a unified theory of acceptance and use of technology 2 (UTAUT2) model to investigate the main factors that affect the implementation of Google Classroom in specific courses. The survey with 24 five-point Likert-scale questions was collected from students who enrolled in these courses. The main findings support the fact that Google classroom can enhance the students' self-directed learning (SDL) cognitive skills. The study makes use of 'The Google Form questionnaires' as a tool to measure the level of users' satisfaction and self-evaluation. Additionally, it makes use the assessment in term of grading.

The Google classroom is available as a tool for developing teaching and learning process all over the world. A study that has implemented in Bangladesh tries to investigate the importance of this e-learning tool for both students and faculty members. It focuses on certain factors that rely behind the poor engagement of students in Google classroom. The most important findings emphasize the fact that students prefer the engagement in Google classroom where the teachers have passive roles rather than being engaged in a class where the teachers have more active roles. However, when the Google classroom is compared with Facebook, the Google classroom suffers from certain limitations [5]. The results are collected from a questionnaire that has been developed to serve the same purpose. In this respect, it has been stated that "The analysis of the results of the questionnaire indicate that this study can be effective in understanding and evaluating teachers' and learners' perceptive to ensure quality teaching and learning through Google classroom" [5]. Google classroom can have an effective role in developing the learning abilities of with learning disabilities as it is shown in a study by [6] who proposes that the Google classroom can be effective in social studies and it can improve students' learning abilities in the field of vocabulary development and unit-test. The study shows that although the students can increase the number of the vocabulary, but they still suffer from certain limitation at the level of content knowledge in comparison with the knowledge obtained based on the textbook and printed material as teaching resources.

Within the domain of self-learning and self-development, a study carried by [7] who put more emphasis on the role of Google classroom as a self-directed learning tool in chosen courses. It has been found that self-satisfaction on the students' behalf is evident when it comes to the usage of Google classroom due to its usefulness, easy to use, and its practicality in accomplishing the intended tasks. Accordingly, Google Classroom can be used as an effective tool in active learning. This view is supported by [3] where the paper shows that teachers can constantly control their observations, surveys, and analyses of student demography through Google classroom technology. They can design their courses to suit students' satisfaction on the used method of learning. The effective use of online learning technology can pave the way to a better design of online training courses for instructors and educational support programs that allow students to succeed in the online environment. This implies that Google classroom can be integrated with other software such as data mining to increase the chances of flexible usage.

Based on the available research studies, it has been observed that there is a limited number of research articles that examined the factors that affect the Google classroom acceptance among university students in general, and the Gulf region countries in particular. According to [8]–[11], BUC has become one of the growing Colleges in Oman that is keen on providing a reliable technological environment to their students and faculty members. Recently, BUC has implemented the Google classroom in all its departments creating a need to investigate the role of the factors that can influence the students' acceptance of Google classroom through an empirical study. Thus, the main objective of this study is to examine the factors that affect the Google classroom acceptance by undergraduates' students at BUC.

3 Theoretical framework and research hypotheses

There are various information system (IS) theories/models that were developed to study the acceptance of new technology. One of such well-known models is the Technology Acceptance Model (TAM) that was developed by Davis in 1989 [12]. TAM has been developed based on the Theory of Reasoned Action (TRA) [13]. TAM suggests that the student's behavioral intention to use Google classroom is determined by two main beliefs; perceived usefulness (PU) and perceived ease of use (PEOU). PU refers to the degree to which a person believes that using a particular system would enhance his/her job performance, whereas, PEOU refers to the degree to which a person believes that using a particular system would be free from efforts. Various scholars have adopted the TAM to study the technology acceptance and usage. For instance, it has been successfully adopted in similar contexts like E-learning [14] and M-learning [15].

In the present study, the TAM [12] is adopted for measuring the students' acceptance of Google classroom as a technology in their daily academic lesson. In this respect, TAM provides a solid background for the effectiveness of a new technology. Besides, TAM also suggests that when students are exposed to a new technology, many factors can influence their acceptance decision. Based on that, we are interested in testing the following hypotheses:

H1: Perceived ease of use positively influences the perceived usefulness of Google classroom.

H2: Perceived ease of use positively influences the behavioral intention to use Google classroom.

H3: Perceived usefulness positively influences the behavioral intention to use Google classroom.

H4: Behavioral intention to use influences the actual use of Google classroom.

4 Research Methodology

4.1 Context and subjects

The study was conducted at Al Buraimi University College (BUC) in Oman. By the end of 2016, BUC has evolved the initiative of implementing the Google classroom in all its departments. The sample of this study consists of students who have used the Google classroom in their study from different departments at BUC. A total of 305 valid responses were received from a total of 337 questionnaires administrated, which shows a response rate of 90.5%.

4.2 Survey instrument

An online questionnaire survey was sent to all the enrolled students on the first semester of the academic year 2017-2018 for the purpose of data collection. The survey consists of 3 different parts. The first part aims to collect the students' demographic information. The second part is dedicated to collect data regarding the Google classroom usage. The third part is devoted to collect data regarding the Technology Acceptance Model (TAM) factors. These factors include: the perceived usefulness (PU), the perceived ease of use (PEOU), the behavioral intention (BI), and the actual use (AU). The items used for this study were adopted from [12] with further adjustment to fit the scope of this study. Appendix A shows the constructs' items.

4.3 Data Analysis

In the present study, the Partial Least Squares-Structural Equation Modelling (PLS-SEM) using SmartPLS 3 is used for the statistical analysis [16]. Besides, since this study is an exploratory based-research, PLS-SEM is considered the suitable approach for such type of studies [17]. In terms of the measurement model, [17] suggested that scholars should consider the outer loadings of the items and the average variance extracted (AVE) in order to establish the convergent validity. In addition, [17] suggested two measures for establishing a discriminant validity namely: cross loading and Fornell-Larcker criterion. Moreover, [18] suggested examining the Heterotrait-Monotrait as another criterion for assessing the discriminant validity. In terms of the structural model, the path coefficients and the coefficient of determination (R^2) will be measured [17]. Accordingly, we will apply all the aforementioned criteria in order to assess the measurement and structural models.

5 Results and Discussion

5.1 Descriptive statistics

The sample demonstrates the responses collected from BUC students which were 337 in total. Nevertheless, the usable responses after removing the missing values and outliers are 305. In addition, Table 1 shows the demographic information of the participants. We can observe that females constitute 74% of the collected data while only 26% as males. Furthermore, most of the students are aged between 18 and 22 years, which represent 79% of the sample. In terms of department, 41% of the students are from the Business Administration & Accounting; this is followed by 35% from the English Language, 17% from the Information Technology, and 7% from the Law, respectively. With regard to the year of study, it is clearly shown that 37% of the participants are year 1, followed by 31% as year 2, 16% for both year 3 and year 4, respectively.

In terms of the Google classroom usage, results showed that 66% of the participants have less than 3 months as experience in using the Google classroom in their education. Additionally, findings revealed that 75% of the students are using the Google classroom in their pedagogical process. Furthermore, results indicated that 59% of the students are favoring both (Google classroom learning and traditional learning) in their education, followed by 21% of those who preferred the Google classroom, and 20% for those who preferred the traditional learning, respectively.

Table 1. Demographic information

Item	Values	Frequency	Percentage
Gender	Male	78	26%
	Female	227	74%
Age	18 to 22	242	79%
	23 to 28	35	12%
	Above 28	28	9%
Department	English Language	106	35%
	Business Administration & Accounting	125	41%
	Information Technology	53	17%
	Law	21	7%
Year of study	Year 1	114	37%
	Year 2	94	31%
	Year 3	49	16%
	Year 4	48	16%

5.2 Measurement Model Assessment

In order to measure the reliability of each item, the factor loading should be measured. According to [17], a threshold value of equal or greater than 0.7 for each item's loading is considered as reliable. In addition, the Cronbach's Alpha and composite reliability values should be equal or greater than 0.7. Based on Table 2, we can observe that all the items are reliable and satisfy the set criteria with an exception for PU6 and PU7 which their factor loadings were below 0.7 and therefore, PU6 and PU7 were removed from the construct's structure. Besides, the average variance extracted (AVE) is defined as the grand mean value of the squared loadings of the items related to the construct, and the common measure for establishing the convergent validity. A value of 0.5 or greater for the AVE specifies that the construct elucidates more than half of the variance of its items [17]. As shown in Table 2, the Cronbach's Alpha and composite reliability values are greater than 0.7, and the AVE values are greater than 0.5. Thus, the constructs' convergent validity is established.

Table 2. Measurement Model Results

Constructs	Items	Loadings	Cronbach's Alpha	Composite reliability	Average Variance Extracted
Perceived Usefulness	PU1	0.868	0.880	0.909	0.599
	PU2	0.858			
	PU3	0.832			
	PU4	0.864			
	PU5	0.845			
	PU6	0.473			
	PU7	0.570			
Perceived Ease of Use	PE1	0.840	0.920	0.937	0.714
	PE2	0.862			
	PE3	0.850			
	PE4	0.860			
	PE5	0.767			
	PE6	0.886			
Behavioral Intention to Use	BI1	0.893	0.873	0.922	0.797
	BI2	0.894			
	BI3	0.891			
Actual Use	AU1	0.912	0.814	0.915	0.843
	AU2	0.924			

In order to establish the discriminant validity, the Fornell-Larcker criterion, cross loadings, and the Heterotrait-Monotrait Ratio should be examined. In terms of the Fornell-Larcker criterion, the square root of AVE (diagonal value) for each variable should exceed the correlation of latent variables, which is met in the present study as described in Table 3. With regard to the cross loadings, the loading of each indicator should be higher than the loadings of its corresponding variables' indicators. Based on Table 4, we can observe that the cross loadings criterion is fulfilled. Regarding the Heterotrait-Monotrait ratio (HTMT), a value of less than 0.85 for HTMT should be confirmed. According to Table 5, it can be deduced that the HTMT criterion is met, thus indicating that the discriminant validity is established.

Table 3. Fornell-Larcker Criterion Results

	AU	BI	PEOU	PU
AU	**0.918**			
BI	0.673	**0.893**		
PEOU	0.613	0.740	**0.845**	
PU	0.589	0.682	0.772	**0.774**

Table 4. Cross Loadings Results

	AU	BI	PEOU	PU
AU1	**0.912**	0.597	0.559	0.507
AU2	**0.924**	0.637	0.567	0.573
BI1	0.558	**0.893**	0.651	0.597
BI2	0.642	**0.894**	0.659	0.622
BI3	0.600	**0.891**	0.672	0.605
PE1	0.492	0.667	**0.840**	0.639
PE2	0.574	0.603	**0.862**	0.664
PE3	0.556	0.665	**0.850**	0.649
PE4	0.528	0.609	**0.860**	0.674
PE5	0.411	0.536	**0.767**	0.603
PE6	0.540	0.664	**0.886**	0.684
PU1	0.542	0.607	0.698	**0.868**
PU2	0.513	0.575	0.642	**0.858**
PU3	0.480	0.547	0.683	**0.832**
PU4	0.498	0.558	0.667	**0.864**
PU5	0.447	0.539	0.645	**0.845**

Table 5. Heterotrait-Monotrait ratio (HTMT) Results

	AU	BI	PEOU	PU
AU				
BI	0.797			
PEOU	0.707	0.825		
PU	0.695	0.782	0.848	

5.3 Structural Model Assessment

The explanatory power of the model is evaluated by measuring the discrepancy amount in the dependent variables of the model. According to [17], the R^2 and the path coefficients are the essential measures for assessing the structural model. As shown in Figure 1, the model has R^2 value of 58.7% for PU, 56.4% for BI, and 45.3% for AU.

In terms of path analysis, Figure 1 and Table 6 demonstrate the path coefficients and *p*-values for each hypothesis. It can be noticed that all the hypotheses are supported, which in turn indicates that all the paths are significant between the independent and dependent variables. $\mathbf{H}_1$ ($B = 0.766$, $p < 0.05$) describes the path between perceived ease of use and perceived usefulness; indicating that the perceived ease of use enhances the perceived usefulness of Google classroom. $\mathbf{H}_2$ ($B = 0.588$, $p < 0.05$) shows the path between perceived ease of use and behavioral intention; representing that the perceived ease of use leverages the behavioral intention to use Google classrooms. $\mathbf{H}_3$ ($B = 0.199$, $p < 0.05$) demonstrates the path between perceived usefulness and behavioral intention; revealing that perceived usefulness positively influences the

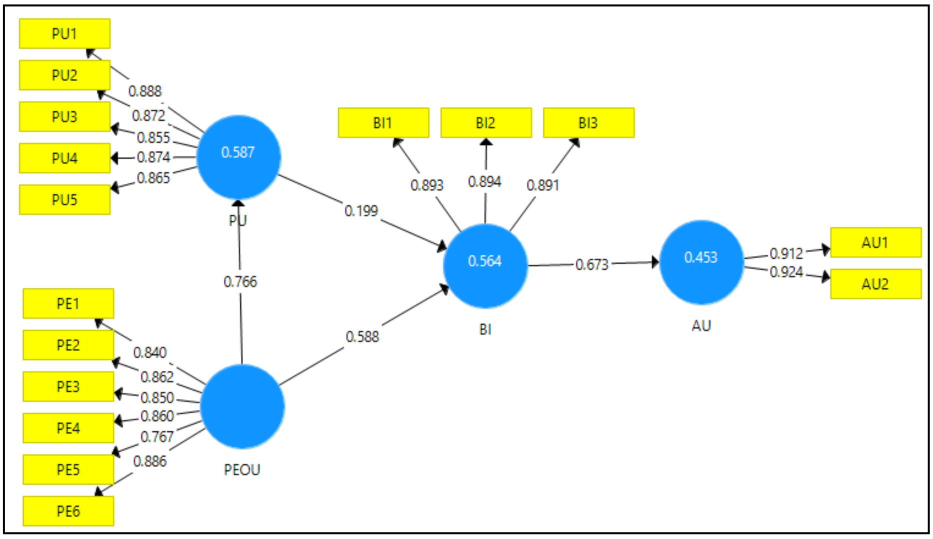

Fig. 1. Path Analysis Results

Table 6. Hypotheses Test Results

Hypothesis	Path	Path Coefficient	*p*-value	Remarks
H1	PEOU → PU	0.766	0.000	Supported
H2	PEOU → BI	0.588	0.000	Supported
H3	PU → BI	0.199	0.003	Supported
H4	BI → AU	0.673	0.000	Supported

behavioral intention to use Google classrooms. $\mathbf{H}_4$ ($B = 0.673$, $p < 0.05$) describes the path between behavioral intention and actual usage; indicating that behavioral intention is significantly affecting the actual usage of Google classrooms.

The results of this research study suggest that both PEOU and PU positively affect the behavioral intention by undergraduates' students who perceive the use of Google classrooms as easy and useful, and they are highly motivated toward the incorporation of such pedagogical tools in their learning process. Similarly, a study by [3] found that PEOU and PU positively affect the students' satisfaction toward adopting Google classrooms in the learning process. Thus, it can be concluded that PEOU and PU enhance the behavioral intention to use Google classrooms. In addition, the decision makers of the higher educational institutions should take these results into their consideration in their future attempt to construct Google classroom infrastructure.

6 Conclusion and future work

This study determines the factors affecting Google classroom acceptance among the undergraduates' students at BUC by adopting the TAM. The PLS-SEM approach is used to assess the measurement and structural models. The outcomes reveal that all the factors are significantly effective in terms of both the behavioral intention and the actual usage of Google classrooms. The emphasis is placed on the familiarity in usefulness and ease of use as crucial features of Google classroom. These two features affect significantly the chosen sample of undergraduates' intention as Google classroom works as a facilitator to develop their learning activities.

One of the outstanding results that can be of great importance to any decision makers in academic institutions is the fact that the students who rely on Google classroom technology will be able to use it as a new gadget for leveraging their educational system. This conclusion is supported by BUC students' high reliance on this technology due to the previously mentioned factors which are the ease of use and usefulness. Accordingly, the decision makers of the higher educational institutions should acknowledge the features of Google classrooms and build their infrastructure based on the result achieved in this study. To implement this technology practically, the higher educational institutions should provide the students with training-opportunities so that students' abilities to discover the comprehensive and effective features of Google classrooms will be more apparent and implemented widely by the end-users.

Due to the fact, each study has a few limitations. The limitations of this study could be summarized as follows: first, this study adopts the TAM factors with no further extensions. Hence, further research should focus on determining further factors that may influence the acceptance of Google classrooms. Second, the data was collected from BUC students only, thus, the results could not be generalized to all the higher educational institutions in Oman. Therefore, further research is required to collect data from other colleges and universities in Oman in order to increase the generalizability of the results. Third, the data collection was constrained on students only. Thus, future research should involve the faculty members in order to understand the factors that affect their Google classroom acceptance.

7 Appendix A. Constructs' items

Perceived Usefulness

PU1: Google Classroom enhances my efficiency.
PU2: Google Classroom enhances my learning productivity.
PU3: Google Classroom enables me to accomplish tasks more quickly.
PU4: Google Classroom improves my performance.
PU5: Google Classroom saves my time.
PU6: Google Classroom doesn't have any distinctive useful features.
PU7: Google Classroom is not applicable to all academic courses.

Perceived Ease of Use

PE1: Google Classroom is easy to use.
PE2: Google Classroom enables me to access the course material.
PE3: Google Classroom is convenient and user-friendly.
PE4: Google Classroom allows me to submit my assignments.

PE5: Google Classroom requires no training.
PE6: Google Classroom makes it easier to avoid future academic difficulties.

Behavioral Intention to Use

BI1: I intend to increase my use of the Google Classroom.
BI2: It is worth to recommend the Google Classroom for other students.
BI3: I'm interested to use the Google Classroom more frequently in the future.

Actual System Use

AU1: I use the Google Classroom on daily basis.
AU2: I use the Google Classroom frequently.

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Model of Incorporation of Emerging Technologies in the Classroom (MIETC)

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Abstract—This work aims to design, implement and validate a model of incorporation of emerging technologies in the classroom using a design-based research methodology through two iterative cycles. In the first iterative cycle, this model was validated by 8 experts and implemented by 13 public school teachers from Bogotá-Colombia. The second cycle was validated and implemented by 25 teachers. A univariate statistical analysis was used to describe the samples in each cycle as well as content analysis to determine the different components of the model. The model is composed of four conditioning factors: motivation, infrastructure, ICT competencies and perceived usefulness; four principles: teacher reflection, pedagogical flexibility, dialogical communication and roles; two recommendations: temporality of the phases and peer-to-peer work and six phases: initial reflection, context analysis, pedagogical foundation, didactic application, implementation and finally evaluation.

Keywords—Emerging Technologies, Educational Technology, Models, Learning, Teaching.

1 Introduction

Incorporating technology in the classroom has been and will be a dynamic and complex process to be carried out by governments, educational institutions, teachers and students due to different social, political, economic and organizational factors, among others [1], which affect positively or negatively the incorporation of technology in teaching and learning processes. For this reason, many educational systems have aimed through policies to improve aspects such as infrastructure and teacher training [2] to generate transformations in educational practice and finally improve the quality of education in some countries. However to achieve this, it is essential to understand that the main agent of change are teachers since they are who decide or not to incorporate technology into their processes [3] [4].

Considering the teacher as a transforming agent, it is necessary to know those factors that affect the incorporation of technology in the classroom in order to generate strategies so teachers can acquire the necessary skills to reconfigure traditional paradigms and achieve social change [5], through the use of technology as an effective and efficient means to improve different educational processes. Consequently, this work uses design-based research (DBR) to generate a model of incorporation of emerging technologies (ETs) in the classroom (MIETC) that allows teachers to improve their various teaching processes.

Before describing the method used for the design, implementation and validation of the model, it is necessary to conceptualize Emerging Technologies (ETs) and understand the meaning of a model. ETs refer to resources, artifacts, tools, concepts and innovations associated with digital, that have a disruptive potential to transform or generate changes in the processes where they are used, regardless of whether these are new or old technologies" [6]. This definition, implies two aspects, the first one, is that ETs are contextualized; for example, from the perspective of those schools that have never used technology such as video, mobile applications, augmented reality, this type of technology is considered to be still emergent. On the contrary, it is not emergent for those schools that normally use these resources because students have already been touch with them. The second aspect is that ETs have a very general definition not only because they involve technological tools but also because they refer to innovations that can be made with the use of technology as an inverted classroom or gamification aiming to produce a radical change in the teaching and learning processes [7], [8], [9] and [10].

“A model is a representation of a real object that in the abstract plane man conceives to characterize it and to be able, on that basis, to solve the problem posed, that is, to satisfy a need" [11, p.12]. According to this, a model in the context of the classroom must be composed of different aspects, elements or principles that allow from the characterization and representation of reality to solve a problem of the student or teacher in order to improve the teaching and learning processes. Therefore, "What the models propose in all cases is to configure and structure a practice (application of the model) based on a theory (theoretical part) in an open, adaptable and modifiable way" [12, p.35].

2 Method

As mentioned above, a Design-based Research (DBR) was used to design, implement and validate MIETC. This methodology focuses on in-depth design and exploration in order to produce artifacts or products [13] that help "understand the relationships among educational theory, designed artifact, and practice. Design is central to efforts to foster learning, create useful knowledge, and advance theories of learning and teaching in complex settings" [13, p.5].

On the other hand, Edelson [14] affirms that from the design three types of theories can be generated; the first, a domain theory which generalizes some part of the problem, that is, describes the learning situations where students, teachers and learning environments interact. The second one is about a design framework where the design solution is generalized, which provides a set of design guidelines for particular cases. Finally, the third one refers to design methodologies where guidelines or guidelines are provided to apply the process in order to solve a problem. This work has been mainly framed in this last theory.

Additionally, the DBR is characterized by the following aspects according to Van den Akker, Gravemeijer, McKenney, and Nieveen [15]:

- It is interventionist, because it looks for the design of interventions in the real world.
- Look for the iteration, incorporating a cyclical approach in the design, evaluation and revision.
- It is process-oriented, the important thing is to understand and improve interventions.
- It focuses on utility, since the validity of a design is measured, in part, by the practical nature of its users in real contexts.
- It is oriented to the theory, since the design, at least in part, is based on theoretical propositions, and the in situ design tests contribute to the creation of theory.

There are different models to develop a DBR, such as the Wademan model [16] that consists of 5 phases (identification of the problem from different actors and tentative identification of products, principles of design, tentative products and theories, implementation and preliminary evaluation of products and finally, theories and the solution of the problem and advance of the theory). Plomp's model [17] has three phases, preliminary research, prototype and evaluation. The model of Reeves [18] has 4 phases, which the first one starts from the identification and analysis of the problems by the researcher and collaborative professionals; then, it moves on to the development of solutions based on existing principles and innovations; subsequently, it involves iterative cycles of testing and the refinement of solutions in practice; and, finally, a reflection is carried out to produce the design principles and improve the application that allows to solve the problem. For this work, the Reeves model [18] and the guide proposed by Herrington, Mckeney, Reeves and Oliver [19] have been implemented in order to generate an investigation using the DBR.

2.1 Phases of the investigation

This research was developed in 4 phases. The first one is the Analysis of practical problems by researchers and practitioners in collaboration. The problem was defined with the help of researchers and teachers, in addition the research question was determined and the literature review was carried out as well. The second phase is the development of theoretical frameworks informed by existing design principles and technological innovations. The first version of the model of incorporation of Emerging Technologies in the classroom (MIETC) was designed taking into account the results obtained in phase 1 and the experience of researchers in the processes of incorporating technology.

The third phase refers to the Iterative cycles of testing and refinement of solutions in practice. Two iterative cycles were carried out to implement and validate the model; in the first cycle MIETC was validated by 8 experts and implemented by 13 teachers and the second was assessed by 25 official school teachers from Bogota Colombia. In this last phase, all the suggestions and recommendations of the teachers and experts were analyzed to improve the model. Finally, the fourth phase was a Reflection to produce "design principles" and enhance solution implementation. The research question was answered and the final version of MIETC was developed. For this purpose, the contributions and suggestions of each one of the participants of phase 3 were analyzed through computer programs like the Excel 2013 and ATLAS.ti 8.1.

2.2 Instruments

For phase 1 of the research, two surveys were designed, one for teachers and another for experts in the object of study, both surveys had sociodemographic questions and questions related to the incorporation of technology in the classroom, the purpose of the surveys was to determine the limitations and facilitators so that teachers incorporate technology into their processes. With the results, the MIETC conditioning factors were obtained.

For phase 3, two questionnaires were designed, one for the experts and the other for the teachers. A Likert scale was used for both to validate each one of the components of the model considering degree of agreement, relevance, clarity in the formulation and writing. Additionally, some open questions were placed to give opinions and suggestions about MIETC in the final part of each instrument. The only difference in the instruments is that the teachers were asked about the changes experienced in the teaching and learning processes when implementing the model and the experts were asked if the model designed would allow teachers to improve the different processes in the classroom.

2.3 Analysis of data

Because the instruments consisted of both quantitative and qualitative questions, two types of analysis were carried out. The first was a univariate statistical analysis to describe the participants' samples in each of the phases and to determine the degree of agreement, relevance, clarity in the formulation and writing of each of the components of MIETC. The technological tools used for this analysis were Excel 2013 and R x64 3.4.0. The second was a content analysis to openly and axially codify each of the answers, observations and suggestions given by the experts and teachers who participated in this work and allowed the model to be improved. For this analysis, the ATLAS.ti 8.0 and 8.1 were used.

3 Results and discussion

The results and discussion are presented according to each of the phases, emphasizing that phase 4 is where the final model is described.

3.1 Phase 1

One of the purposes of this phase was to find the main factors that affect the incorporation of technology in the classroom from the perceptions of teachers and experts, the factors were classified as intrinsic and extrinsic to the teacher. The intrinsic factors are those that are specific to the teacher as: their beliefs regarding the usefulness and ease of use of technology [20],[21],[22],[23],[24],[25],[26],[27],[28]; the intrinsic motivation to decide to incorporate technology [20],[21],[29]; the resistance to change to innovate the educational practice [4],[20],[30],[31],[32] among others; and the extrinsic factors are those external to the teacher and depend on the institutional, national and international policies, some factors found in the literature that affect the incorporation of technology, which are: development of a technology incorporation plan in each institution [20],[31]; provide technical support [20],[21],[31]; open spaces for work among teachers [20],[31]; generate the necessary times to plan the classes [4], [20],[21],[27],[28],[33] and demands of students to use technology [20],[34].

As mentioned above, two surveys were used to determine the factors. The survey was conducted by the 241 teachers, 61% were women and 39% men and the age range was between 23 and 64. Reading years of teaching practice, new teachers who had just began their experience were found as well as teachers with 41 years of teaching career. Finally, in terms of geographical distribution, teachers from most of the locations of Bogota-Colombia participated.

With respect to the area of teaching participated: teachers of natural sciences (14.84%), humanities, Spanish and English language (13.83%), mathematics (12.82%), social science (12.14%), artistic education (9.11%), ethics and human values (8.94%), religious education (8.09%), technology and computing (9.78%), physical education (6.75%) and other areas (3.71%) The level of performance of teachers was also varied, 6% teach in early childhood; 21% in primary school (first, second, third, fourth and fifth grades); 37% at the secondary level (sixth, seventh, eighth and ninth grades) and 36% at the high school level (grades tenth and eleventh).

In the survey applied to the 132 Ibero-American experts who also had the role of teachers, 52% were men and 48% were women. The age range was between 26 and 73. Regarding geographical distribution, teachers from 20 countries participated (Colombia 23%, Ecuador 11%, Uruguay 8%, Chile 8%, Mexico 7%, Peru 6%, Venezuela 6%, Argentina 5%, Guatemala 4%, El Salvador 3%, Paraguay 3%, Bolivia 2%, Brazil 2%, Costa Rica 2%, Spain 2%, Honduras 2%, Panama 2%, Portugal 2%, Dominican Republic 2%, Nicaragua 1%) and finally, in terms of the maximum level of training reached, 20% were doctors, 58% magister, 3% specialists and the rest had a degree in teaching. It is important to clarify that the participants from Colombia are different from those who participated in the previous survey and the surveys were applied using the forms tool in google.

As it is observed, a varied sample was obtained, which allows having a greater reliability concerning the obtained data. As for the content analysis of each of the 372 answered surveys, a great variety of extrinsic and intrinsic factors was found for this article, so only the most representative will be mentioned.

The intrinsic factors that positively or negatively affect the incorporation of technology in the classroom are: the teachers' own motivation to decide to incorporate ETs in the classroom; the perceived usefulness to improve teaching and learning processes; ICT competencies, understood as knowledge, skills and necessary attitudes for teachers to incorporate technology [35]; the feelings generated by the use of technology and the resistance to change generated by fear of losing control of the classes and understanding that students are experts in managing technology. The findings related to motivation and utility reaffirm the findings of Sosa et al. [20], Mumtaz [21], Park and Ertmert [29], Yuen and Ma [22] and Zyaan [27], ICT competencies are confirmed according to the study by Carver [28] and Jones [31] and the resistance to change is evident in the study by Villalba et al. [30], Jones [31], Abarzúa and Cerda [4] and Ertmer [32].

The extrinsic factors that positively or negatively affect the incorporation of ETs in the classroom, are: the infrastructure related to the provision of devices, the Internet connectivity, the availability and updating of equipment and programs; initial and permanent teacher training so they can acquire the necessary skills to incorporate technology into their processes; the requirements of the context, mainly regarding the students' needs, the institution, the peers themselves and the district, national and international policies that demand to incorporate technology in the educational processes and the exchange of experiences with other teachers on the ways of integrating ETs in the classroom. Just like the intrinsic factors, the findings regarding infrastructure confirm what was found by authors such as Claro [36], Mumtaz [21], Jones [23], Sosa et al. [20] and Zyand [27], teacher training reaffirms the studies of Jones [31], Zyand [27], Sosa et al. [20] and Ertmer [32], the requirement of context in relation to students was also found in the studies of Kafyulilo et al. [34] and feelings was a finding of Jones [23] and Eickelman [37].

Both extrinsic and intrinsic factors can be facilitators or limiters. This depends on the circumstances of the context and the teacher himself. For example, in an educational institution with excellent infrastructure, this factor becomes a facilitator but that would be all the opposite if the infrastructure is poor. In that case, this factor would represent a limiter. Factors are also relational. For example, when improving teacher training, other factors become facilitators that enhance the development of ICT skills or lower the fear caused by having to incorporate technology in educational processes.

On the other hand, a review of the literature was made in this phase regarding different models. Several ICT incorporation models were found such as: Teaching Model of Integrating Constructivist & Sociocultural Learning Principles and Information & Communication Technology [38]; A2I: a Model for Teacher Training in Constructive Alignment for Use of ICT in Engineering Education [39]; MAGDAIRE: a Model to Foster Pre-service Teachers' Ability in Integrating ICT and Teaching in Taiwan [40]; the IRIS Model [41]; a Generic Model for Guiding the Integration of ICT into Teaching and Learning [42]; 4-E Model [43]; A Model for E-education: Extended Teaching Spaces and Extended Learning Spaces [44]; a Two-Dimensional Model for

Teachers' ICT Integration [45]; a Maturity Model for Assessing the Use of ICT in School Education [46]; Model of ICT Incorporation in the Process of Teaching Innovation for the Implementation of a B-learning [47]; a Five-stage Model of Computer Technology Integration into Teacher Education Curriculum [48]; MITICA Model [49]; TPACK Model [50] and models of instructional designs such as ASSURE, ADDIE, Dick and Carey, among others.

After analyzing the previous models, it was found that these can be classified into two levels at a macro level and even a micro level, at the macro level they explain how technology should be incorporated in institutions and at the micro level a route is provided so that teachers incorporate technology into their educational processes. Additionally, it was found that the models have elements related to didactics, pedagogy, technology, reflection and evaluation.

Finally, in this phase, the research question was drafted. What are the components of the model of incorporation of emergent technologies in the classroom (MIETC) that allow to show changes in the teaching processes through the generation of didactic strategies by the teachers of the official schools of Bogotá-Colombia?

3.2 Phase 2

In this phase, the first version of the model was designed taking into account the results found in phase 1 and the experience of the researchers. The model was structured from 3 conditioning factors (motivation, infrastructure and ICT competencies) that are conditions or basic and necessary requirements to be able to implement MIETC, 4 principles (teacher reflection, pedagogical flexibility, dialogical communication and roles) were considered throughout the implementation of the model and 6 cyclical phases (Initial Reflection, analysis of the context, pedagogical rationale, didactic application, implementation and evaluation) to guide the teachers to transform their teaching practice. Additionally, in each of the components of the model, some questions were generated to guide teachers during the implementation of the model. In phase 4 of this section, each of the components of the final model is described, after making adjustments or suggestions found in phase 3.

3.3 Phase 3

The results of this phase are described according to the two iterative cycles that the implementation of MIETC had.

First Iterative cycle: As mentioned earlier in this cycle, MIETC was sent to 8 experts to be validated and it was also implemented and assessed by 13 teachers and based on the results it was adjustmented in order to generate a second version of the model. 8 experts had the title of doctor, 5 in the area of technology educational and 3 in education. 13 teachers had the master's degree related to educational technology, 54% were women and 46% men, the average age of teachers was 39.2 within a range between 29 and 55, belonging to various educational institutions, to different teaching areas (38.4% mathematics, 30.8% technology and computer science, 7.7% social sciences, 7.7% natural sciences, 7.7% humanities and English and 7.7% arts). The model was implemented in students from 5 to 16 years old, 8% corresponding to early childhood, 31% to primary school, 38% to secondary school and 23% to the high school and was implemented in various areas. The results obtained are shown according to the components of the model.

In the *conditioning factors* (motivation, infrastructure and ICT competencies) 88% of experts and 100% of teachers agree with the inclusion of these in MIETC and 12% of experts do not agree or disagree. In perceived usefulness, 100% of experts and teachers agree that the conditioning factors are timely and correct. Finally, 75% of experts and 97% of teachers say that clarity, formulation and writing is sufficient and excellent, however the rest of teachers and experts say that they can be reformulated.

In the *principles* (teacher reflection, pedagogical flexibility, dialogical communication and roles) it was found that 100% of teachers agree with the inclusion and relevance of these in MIETC. However, in the response of experts with regard to the pedagogical flexibility 63% agree, 25% neither agree nor disagree and 12% do not agree in the inclusion of this principle, with the other principles 88% agree on the inclusion of them. In perceived usefulness, 100% of experts agree that the principles of teacher reflection and dialogical communication are timely, 88% agree that the principle of roles is relevant in the model and 75% agree that the flexibility is also suitable to the model. Regarding clarity, formulation and writing, 96% of teachers state that they are well formulated and dialogical communication and roles must be rephrased, on the other hand, experts state that the principle of roles and dialogical communication, teacher reflection and pedagogical flexibility in terms of clarity and writing must be reformulated.

In the *phases* of the model it was found that: in the phase of initial reflection and context analysis, 88% of the experts and 100% of the teachers agree with the inclusion of this phase in MIETC, 100% of the experts and Teachers say they are relevant and only 12% of experts say they should be reformulated. In the phases of pedagogical foundation and didactic application 100% of teachers and 75% of experts agree with the inclusion of these in the model, 100% of teachers and 88% say they are relevant and the 25% of experts suggest reformulating them.

In the implementation phase, 100% of teachers and 88% of teachers agree with the inclusion and relevance of this in the model and only 12% of experts suggest to reformulate it. Finally, in the evaluation phase 92% of the teachers and 88% of the experts agree with the inclusion of this phase in the model, 100% of the experts and 92% of the teachers state that it is relevant in MIETC and 8% of the teachers and the 12% of experts recommend reformulating this phase.

In addition, 92% of teachers agree that the model of incorporation of Emerging Technologies in the classroom (MITEA) guides them in the process to incorporate ET in the classroom and allowed them to show changes in teaching and learning processes.

Regarding content analysis, it was found that experts recognize that MIETC will allow teachers to improve their teaching and learning processes because it offers a methodological route to incorporate ET in the classroom through a cyclical process (Expert 4); it is easy to implement (Expert 1); its structure is clear and precise in each of the components (Expert 8) and it has spaces for constant reflection on the use of technology in the classroom (Expert2; Expert5).

Moreover, teachers evidenced changes in their teaching processes when implementing MIETC because it motivated them to create learning activities according to the needs of the students (Teacher1; Teacher9; Teacher12); it allowed them a greater organization to plan the classes (Teacher2, Teacher3, Teacher4, Teacher8, Teacher13); optimized times, spaces and resources (Teacher2); they transformed their educational practice by using new forms of teaching breaking traditional schemes (Teacher5; Teacher6; Teacher13); it allowed them to train and acquire knowledge in an autonomous way to incorporate technology in the classroom thinking about the good use, the why to incorporate them (Teacher6; Teacher8; Teacher12); and it really reduced levels of frustration (Teacher8).

Among the changes to make the model are: add the conditioning factor of the perceived utility (Teacher 7); determine the timing of some phases because there are some that take place at the beginning of the year (Expert2); involve collaborative work among teachers (Expert2; Expert3; Teacher9); demonstrate the value of the ETs in the implementation phase (Expert7); delimit ICT competencies in the conditioning factor (Expert2); improve the instruments of the didactic application (Teacher6; Teacher13; Expert3); reformulate in terms of clarity and writing the principles of MIETC (Teacher4; Teacher12) and review in a general way the spelling and punctuation of the whole model.

Taking into account the previous suggestions, the second version of the model is generated, a new conditioning factor emerges, the perceived usefulness and 2 recommendations to implement MIETC, the same principles and phases are maintained, some instruments of the phases of the didactic application are redesigned and the implementation and finally the wording and spelling of the whole model was revised.

Second Iterative cycle: The second version of the model was implemented by 25 teachers. 60% were women and 40% men, the average age of teachers was 41.1 within a range between 20 and 62 years, belonging to several educational institutions, at different teaching areas (16% mathematics, 16% natural and environmental sciences, 12% humanities, Spanish and English, 12% natural sciences, 4% philosophy, 4% physical education, 4% dance, 4% commercial, 4% plastic arts and 24% was implemented by teachers who dictate all areas), the model was implemented in students between 4 and17 years old, 16% corresponding to early childhood, 20% to primary school, 36% to high school and 28% to average and it was implemented in various areas. The results obtained are shown according to the components of the model.

In the *conditioning factors*, it was found that 100% of teachers are in agreement with the inclusion and relevance of the motivation and perceived utility in the model, in the infrastructure 92% agree to its inclusion and 88% with the relevance of this in the model, in the ICT competencies, 100% agree on their inclusion and 96% with the pertinence of this in the model; finally, 100% affirm that the clarity, formulation and writing is sufficient and excellent.

In the *principles* it was found that in teacher reflection, pedagogical flexibility and dialogical communication 100% of teachers agree with the inclusion of these principles in the model and 96% agree with the inclusion of the roles as a principle. Regarding relevance, 100% agree that dialogical communication and roles are appropriate for MIETC and 96% affirm that Teacher reflection and pedagogical flexibility is relevant; finally, 100% state that clarity, formulation and writing is sufficient and excellent.

One emerging component after the first iteration of the model were the *recommendations*, it was found that in the temporality of the phases (recommendation 1), 88% of the teachers agree with their inclusion and relevance in the work. among peers (recommendation 2) 92% agree with their inclusion in the model and 88% state that this recommendation is relevant in MIETC and 100% state that the clarity, formulation and wording is sufficient and excellent.

It was found in the *phases* that: in the initial reflection phases, analysis of the context, pedagogical foundation, implementation and evaluation, 100% of the teachers agree with their inclusion and their relevance in the model, in the didactic application phase. 96% agree with its inclusion and 100% with its relevance in the model, in addition all teachers report that clarity, formulation and writing is sufficient and excellent.

Additionally, it was found that 100% of teachers agree that the model of incorporation of Emerging Technologies in the classroom (MIETC) guides them in the process of incorporation ET in the classroom, 96% affirm that it allowed them to show changes in the process of teaching and 88% say that it allowed them to show changes in the learning process of students, finally, comparing the results of iteration 1 and iteration 2, MIETC was improved in each of the aspects evaluated and especially the one related to the clarity, formulation and wording of each of the components.

Regarding content analysis, it was found that teachers evidenced changes in their teaching processes when implementing MIETC because: they made a constant process of reflection on the teacher's task to work on improvements (Teacher2; Teacher4; Teacher11; Teacher13); it allowed them to acquire, update and reinforce knowledge about different aspects worked on in the model (Teacher11; Teacher16; Teacher24; Teacher25), it allowed them to carry out an organized process to plan the classes according to the needs of the context (Teacher2, Teacher12, Teacher19, Teacher24); they transformed their educational practice by using new forms and strategies of teaching (Teacher6; Teacher; Teacher; 20) and new forms of evaluation (Teacher10; Teacher22) using ETs; they improved the communication process with students by breaking time-space barriers using technology (Teacher3, Teacher20; Teacher10). Finally, the teachers affirm that the model improves the classroom environment because: it changes the role of the teacher to be a guide and a guide of the process (Teacher5); it allows to teach in a more practical and easier way (Teacher10, Teacher15) and clarity is observed in the teaching and learning process (Teacher4).

Among the changes to make the model are: check in some sections if the guiding questions are repeated and only leave one (Teacher, teacher25); describe and extend the recommendations of the model (Teacher2; Teacher5); deepen pedagogical flexibility not only in the strategies but also in the spaces (Teacher 7). On the other hand, teachers make some recommendations to take into account in future implementations: exemplify the model (Teacher12, Teacher23); develop a tool such as an application or software (Teacher23) and make it a little shorter regarding the instruments. These suggestions are not part of the conceptual structure of the model but they will be taken into account in a phase following this investigation.

3.4 Phase 4

According to the analysis carried out in a general way to the two iterations and the suggestions of the experts and the teachers, the final version of the model is presented. The model is composed of 4 conditioning factors, 4 principles, 2 recommendations and 6 phases. Figure 1 shows the structure of the model.

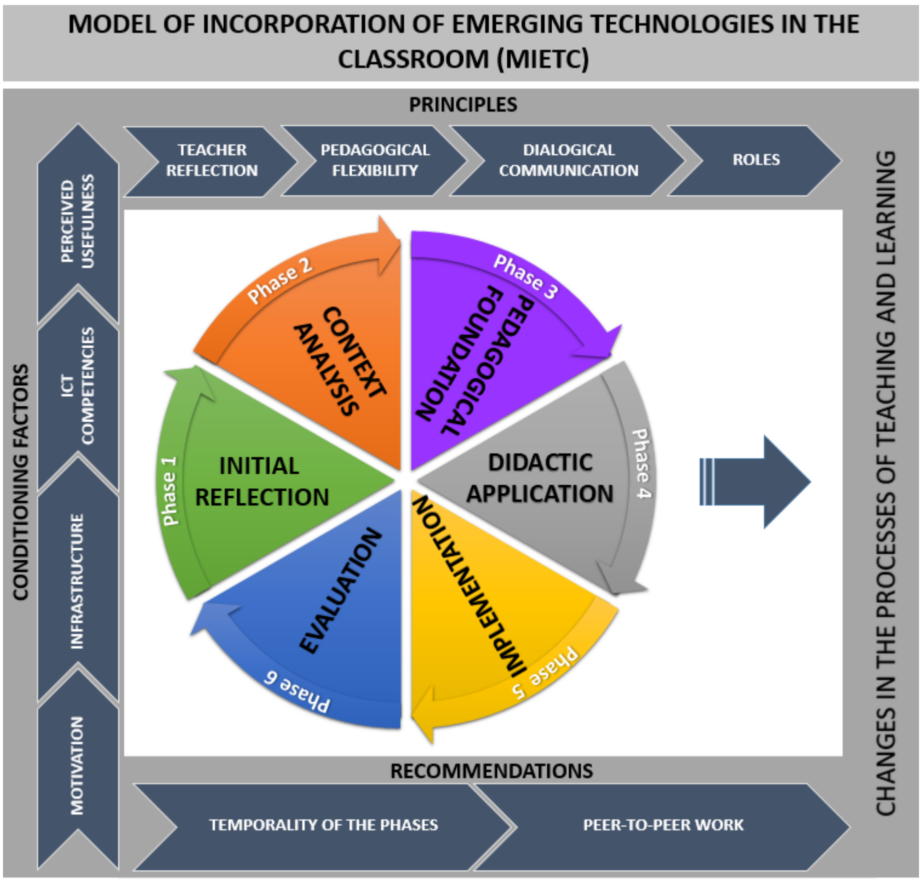

Fig. 1. Model of Incorporation of Emerging Technologies in the Classroom (MIETC)

The **conditioning factors** of the model are those aspects or requirements teachers have to take into account before the implementation of the model. The first conditioning factor is the *motivation* that drives teachers to perform actions, activities or strategies in the classroom and maintain the quality of their work [51] to improve teaching and learning processes.

The second conditioning factor is the *infrastructure*, regarding different services such as internet connectivity, spaces and resources that allow the development of different educational activities [52] related to the incorporation of ETs in the classroom. This infrastructure can generate changes in the teaching practice because they constitute "a basic input for the educational processes and their absence, inadequacy or inadequacy represent additional challenges to the teaching tasks" [53, p.43] or simply continue with the same educational practices and not incorporate ETs due to the lack of resources. According to the research of Gil-Flores et al. [2] availability and access is an obvious requirement to incorporate ICT in the classroom and therefore a requirement to apply MIETC.

The third conditioning factor is *ICT competencies* regarding "the knowledge, skills and attitudes of teachers when incorporating technology in the classroom" [35, p.11] use of technological, pedagogical, communicative, of management and research [54] that allow the construction, implementation and evaluation of learning environments supported by significant ICTs and contribute to the comprehensive education of the student [55].

The fourth conditioning factor is the *perceived utility* understood as the extent to which a teacher or individual considers that the use of a particular technology will improve their performance in an activity [56] and [57], that is, if the teacher perceives that ET will improve a teaching or learning process, there is a high probability to incorporate it into the classroom.

Both the motivation conditioning factor, the ICT competencies and the perceived utility are internal factors in teacher, that is, the teacher must overcome these disadvantages in order to implement MIETC from his own initiative. Additionally, they are in a causal relationship, because the motivation and the perceived utility are affected by the confidence in the skills needed to carry out any activity successfully and this can be increased if the necessary skills, knowledge and attitudes are acquired to incorporate technology in the classroom. In order to become competent in ICT teachers need to work on their own training strategies. For Valencia-Molina et al. [55] the strategies can be to learn from others (courses, workshops, diploma courses, seminars, congresses), learn with others (participation in forums, webinar) and learn autonomously (video tutorials, educational videos, reading investigations, massive and open online courses-MOOCS).

The conditioning factor of the infrastructure is an external factor in teachers. For this reason institutions need to have the necessary technological resources to improve the teaching and learning processes. Consequently, it is not enough to provide schools only with technology but also to design training plans for teachers to acquire the necessary skills to incorporate them in a meaningful way. In the first phase of this research it was found that it is necessary to inform the teachers about the resources of the institution to promote using them. Unfortunately, in many cases they have the resources but they don't know how to incorporate them in class, very often because of lack of skills or initiative.

The **principles** of the model are the characteristics to be taken into account during the whole process of incorporation of ETs in the classroom. The first principle is the tea*cher reflection* where the teacher must be in constant reflection to pose, face and respond to the problems that arise in the classroom [58] through reflection on action and action, the first refers to a reflection in real time [59] where the teacher makes decisions to refocus their educational practice [60], through questions such as what happens or what will happen, what can be done, how can it be done better, what risks or benefits there is to do an activity [61], and reflection on the action consists of thinking retrospectively about the activity taking into account mainly what worked, what did not work and how it could be improved [59]. The purpose of this principle is not only to seek a quick solution to the problems [62] that can occur during the incorporation of ETs in the classroom but always make a process of reflection to find the best solution. This way MIETC makes this principle explicit in the first and last phase but the teacher must be aware of it in order to implement it all times.

The second principle is the *pedagogical flexibility* where MIETC must provide a great variety of activities and be able to organize and reorganize them [63] according to the place, the time, the methods, teaching and learning rhythms [64], to the diversity of needs, interests and motivations of students [64] and [65], for this reason teachers must recognize the existence of different contexts and learning styles and from these generate different "learning opportunities" for students to develop the competencies of the 21st century.

The third principle is the *dialogic communication* that must be maintained throughout the implementation of the model that allows the different educational actors to learn, develop their personalities, improve their perceptions and abilities to explain and understand the world [66], through an "open and negotiated debate process" in which both students and teachers exchange ideas and opinions [67, p.325] with respect and where the teacher does not manipulate the communication to achieve their goals but to make effective feedback and provide useful information adapted to each student so they can achieve the goals during implementation.

The fourth principle is the *roles* of the student, the teacher and the Emerging Technology that are used during the implementation. The student is placed in the center of teaching and learning, this implies that they assume an active role [68]. They must be collaborative, responsible, participatory and self-reflective about what, how, where and when they learn and thus they can be aware of their own learning guided by the teacher who have the role of a tutor or advisor in both class activities and extracurricular. Teachers need to encourage students to be committed with their own learning process, discuss with each other, and take advantages of different learning opportunities, continually ask questions, find answers to their questions, discover and structure knowledge, use a variety of resources both analog and digital. Consequently, teacher need to be flexible in the development of the classes, generate authentic activities that arise the curiosity of students, structure and organize the learning process, evaluate and provide feedback to the student [69][70], finally it should be an example of life for the students.

The ETs also play a role within the model and become a transforming agent of teaching and learning processes by being mediating instruments of relationships between students and learning contents (for example, searching for information, accessing repositories, use simulators), between teachers and learning contents (e.g. keep track of activities carried out, prepare classes), between teachers and students, or between students themselves (e.g. carry exchange exchanges) communication), who together carry out an activity suggested by teachers (e.g. explaining a topic, providing feedback, keeping track of them) using the instruments that configure learning environments (e.g. use of self-sufficient materials) [71].

The **recommendations** of the model are those aspects that may vary in the implementation, the first recommendation to implement the model is to take into account the *temporality of the phases* and this refers to the moments or times in which each of the proposed phases of the model is applied. This depends on the following criteria:

- If this is the first time the model is implemented, start with phase 1 until the end of phase 6, regardless of whether it is applied for the development of a period, a teaching unit or the development of a single class. It is advisable to use it as a gradual process, that is, initially to plan a class, later a didactic unit, then a period, this is for teachers to acquire the experience of using MIETC.
- If the model has been implemented more than once and phase 1 is applied in the same institution and in the same population: Initial reflection and phase 2: Context analysis won't need to be repeated. Only phases 3, 4, 5 and 6 are reconfigured taking into account that in phase 6 corresponding to the evaluation is done at the end of the entire implementation.

The second recommendation is *peer-to-peer work*, keeping in mind that the purpose of the model is to get teachers to start incorporating ET through a systematic and intentional process, initially autonomously but as they acquire the experience they can work with peers in the next implementations, because this allows them to "recognize and value their own abilities and those of others, and in that exchange, together, imagine, devise, design and make changes in their practices" [72, p.43] related to the incorporation of technology. In addition, peer-to-peer work allows cross-cutting projects that encourage different types of competencies in students.

The **phases** of the model are those that allow the teacher to carry out a systematic and intentional process when it comes to incorporating ETs into the classroom; additionally, they are cyclical and dynamic, which allows a process of continuous improvement. Next, each one is described.

Phase 1: Initial Reflection is intended to prevent teachers from carrying out activities or strategies in an impulsive and routine way, to elucidate between the purely affective, blind and impulsive of intelligent action and to allow events to advance [73], in order to transform the educational practice and resignify learning spaces from the beginning of any educational activity. In this phase, the teacher must answer the questions. What would be the benefits of incorporating one or more emerging technologies in the classroom for students and teachers? And what could be the main problems that might arise during the implementation of the teaching and learning activities to be developed and how could they be solved?

Phase 2: Context Analysis is carried out in two parts. The first corresponds to the analysis of the context referring to the population; this is done in order to identify the main problems of students to learn certain content or to strengthen some skills. This means that the problematic environment is explored to subsequently propose solutions in a general way [74] incorporating ETs and thus improving the teaching and learning processes. If the context is not known and especially to the students it is impossible to generate learning activities that respond to the needs and expectations of them and the current society. The questions that guide this part are: With what course will you work? What are their ages? What are the motivations and interests of the students? What strengths do students have to learn? What limitations do students have in the learning process? In addition, the need to learn or the problem to be solved must be described.

The second part of the context analysis corresponds to identifying the ET's that the institution has, the students and the teachers with the purpose of designing both individual and group activities that make significant use of the technologies. The questions that guide this part are: What emerging technologies does the institution, the students and the teacher have and what are their requirements and availability?

Phase 3: Pedagogical foundation, the teacher determines the purposes of training and the necessary content to develop during the implementation of the model, the purposes and contents must respond to the learning need or problem detected, to the interests, motivations, strengths and weaknesses of the students mentioned in the previous phase. In addition, must be in accordance with the institutional policies (institutional educational project, the pedagogical model, among others) and national (basic competency standards, basic learning rights, among others).

The purposes must answer the question regarding what students should learn through formative and comprehensive statements that guide learning. To build them, the teacher must bear in mind that they are written in terms of what the student is expected to learn and not what he will build or perform to demonstrate his learning [75] (District Education Secretariat, 2012). In addition, in this phase teachers must relate their implementation to the development of 21st century competencies, according to Binkley et al., [76] who define ten (10) competencies and group them into four (4) categories, the first one is ways of think (creativity and innovation - critical thinking, problem solving and decision making - learning to learn, metacognition); the second one refers to way of working (communication - collaboration and teamwork); in the third one is about tools to work (information literacy - literacy in information and communication technologies (ICT)) and finally live in the world (citizenship, local and global - life and career - personal and social responsibility).

The contents must respond to what students should learn to achieve the purposes of the training, which can be declarative (refers to the learning of facts, data, concepts and principles, these relate to knowledge), procedural (actions ordered to achieve the proposed objective and develop the ability to know) and attitudinal and axiological (values, norms, beliefs, which allow the student to live in peace and harmony within a society, make reference to knowing how to be and knowing how to live together) [77]. Additionally, the metacognitive contents must be worked on in the classroom (they are the necessary learning so students can direct, control, regulate and evaluate his way of learning from the knowledge of themself, of the task and of the strategies and thus orient them towards the autonomy that allows them to "learn to learn" and transfer his learnings to their daily life [78].

Phase 4: Didactic application, the teacher must ask himself how to guide the teaching and learning process in the most efficient and effective way, in order to improve and strengthen in students their different knowledge, skills and attitudes. This phase is divided into sequencing, activities, processes, ETs-resources and times.

The sequencing, is the organizational, logical and intentional structure of the different activities, actions and interactions related to each other, necessary to achieve the purposes of training [79], can be for the development of a class or session or for several, it is the teacher's decision to determine the time and following the approaches of Smith and Ragan [80] and Alfonzo [81], it can have three moments, which are initiation, development and closure.

At the beginning, the aim is to prepare the student for the development of the different activities in order to activate attention, establish or say the purpose of training, increase interest and motivation, present the preliminary vision of the activities and investigate the beliefs, knowledge and previous knowledge of students. For this purpose, you can use strategies such as "present new information, surprising, incongruent with the prior knowledge of the student, plan or raise problems, describe the sequence of the task to be performed, relate the content with the previous experiences of the student" [82, p.230], it is generally suggested that this moment means between 10 and 15% of the implementation.

In the development, new information is presented to the student (explicitly, or what the student investigates) so it can be processed and applied and handled easily. It is necessary focus students' attention, teach activities aimed at promoting learning and generate activities where they can apply and transfer what they have learned in different contexts [80][81], at this time the teacher must spend the a big quantity of time, 60 and 70%.

In the closing it must be observed if the student achieved the purposes of training, for this reason, the teacher should review and summarize what has been worked on, re-motivate and close explaining the importance of what has been learned and propose links with other areas, [80][81]. In addition, a moment should be created for students to perform metacognition of what was worked during the implementation, the time of this phase is between 30 and 15% of the implementation. The sequencing must answer the question: what is going to do the logical and intentional order of the activities?

The activities are actions designed by teachers for students to carry out and achieve the purposes of training individually or in groups. They must be coherent, meaningful and appropriate to the needs of the students and the context. Currently, there are different types. One of them is the District Education Secretariat [75] that proposes motivational activities, experiential, exemplary learning development and application, but finally, teacher are in charge of deciding the kind of activities to choose for the implementation of MITEA, based on their knowledge and experience. The activities must answer the question How to teach to achieve the purposes of training?

The processes are about describing the way the interaction, evaluation and feedback will be performed during the implementation of MITEA. The interaction is defined as "a type of communicative activity carried out by two or more participants that influence each other, in an exchange of verbal and non-verbal actions and reactions" [83]. For this reason, the main purpose of using interaction processes is to find common leaning interests between the different actors to achieve the purposes of training using different media, whether they are face-to-face or technological. The evaluation must be conceived as an "integral, dialogical and formative process that favors the achievement of the expected results in terms of learning" [84] and guide the teaching and learning processes. Consequently, the evaluation process should be structured based on the purposes of training and be based on the contents; that's why the evaluation modality is chosen first (who evaluates and when) and then, some evaluative criteria is set (what is evaluated) and finally the evaluation strategy is determined (how it is evaluated) [75]. The feedback refers to how the teacher makes improvement processes to the products, procedures, strategies and self-perceptions [85], it must be carried out at all times and must be linked to the evaluation because, based on the results, the teaching and learning process can be reoriented.

The ETs and resources are those mediations that the teacher uses to support both teaching and learning processes, they can be related to the digital world (tablets, computers, videos, social networks, etc.), which is identified in the phase 2) and the analogical educational resources (guides, board, evaluations, workshops, colors, books, among others). They are subject to the creativity of the teacher, to the possibilities offered by the context and can be elaborated, reused or adapted for their pedagogical relevance, accessibility and usability, recognizing that resources do not determine pedagogical success but rather facilitate the development of learning [75]. In this part, the two important questions are answered regarding, what to teach, and what the function or purpose of the ETs within the implementation is.

Time refers to the duration of the implementation of MIETC, the teacher must ensure that the students are committed to all the activities, which implies understanding the characteristics of all the learners involved. The time can be measured in several scales; for example, for example, the right time for a class or work session would be couple of minutes, but for several classes or sessions the time vary depending of the number of weeks or classes or sessions.

Phase 5: Implementation, materializes what was planned in the previous phase. It is composed of a before, during and after. In the before, a preparation of the spaces and the necessary ETs-Resources for the proposed activities must be carried out. It is important to have a plan B in case any resource or ET fails as well as be able to use instruments to collect information in order to show evidence of the learning process of each student. During the implementation, the student must be constantly informed so that he / she is aware of what is going to happen. The planned activities must be carried out in the didactic application phase, using different instruments to gather information that allow to demonstrate the learning process of each student based on the qualitative and quantitative assessment. It is also necessary to be aware of the changes on the progress that may occur due to extrinsic elements that can vary the didactic application. In the after, the implementation is determined in a general way if the students achieved the purpose of training from the observed, based on the collection of information and of the evaluation processes carried out. In addition, in this part we must respond to "How did the incorporation of ETs contribute to achieve the purpose of training?" This question is asked so the evaluation can determine if the incorporation of the ETs affects or not the teaching and learning processes.

Phase 6: Evaluation is carried out once the implementation of MIETC is finished, based on reflexive observations and specifically on the reflective cycle of Gibbs [86] which consists of 6 steps (Description, Feelings, Evaluation, Analysis, Conclusions and Plan of action). With this evaluation, the teacher is expected to evaluate the process carried out and approach to the implementation in a critical way in order to perceive its meanings and become aware of what happened [87] with the intention of reconstructing the educational practice [88] in the incorporation of ETs in the classroom.

According to Gibbs [86] and the Academic Services & Retention Team, University of Cumbria [89] in the description, the teacher must respond to what happened in the implementation, in an objective, concise and relevant way, in feelings must respond to What were your reactions and feelings?, referring to the various situations experienced, if they were emotions of joy, frustration, stress, despair among others, in the evaluation should answer to what was a good or bad experience?, in the analysis should answer to what sense did you find to the implemented?, and what was really happening? In the conclusions, some answers must be given to questions such as, what can be concluded from the whole experience, if it was positive or negative, what did you learn from the experience?, and what else could I have done to improve the experience?. Finally, the action plan should summarize everything that needs to be known and done to improve the next implementations, for this the teacher must respond to what elements should be taken into account for future experiences?, and what should be done differently next time?

4 Conclusion

MIETC provides a route for teachers to begin to incorporate ET in the classroom through a reflective, systematic, intentional and dynamic process in an autonomous way, where the center of learning is the student and technology becomes a mediation that enables changes in the teaching and learning processes. To achieve changes in educational practice, the model proposes four conditioning factors (motivation, infrastructure, ICT competencies and perceived usefulness), four principles (teacher reflection, pedagogical flexibility, dialogic communication and roles), two recommendations (temporality of the phases and peer-to-peer work*)* and six phases (initial reflection, context analysis, pedagogical foundation, didactic application, implementation and evaluation). Finally, the only conditioning factors that do not allow MIETC to be implemented are the motivation and the perceived usefulness, since the others can be overcome by applying the model itself. It is recommended phases 1 and 2 to be carried out at the beginning of the year or a period and the other phases are developed to plan either one or several classes. Phases 3, 4, 5 and 6 become cyclical phases which aim to improve teaching and learning processes each time MIETC is implemented, taking into account the successes and errors of previous implementations.

5 Limitations and prospects

A limitation of this work was the low participation of teachers to implement the model even though in the first and second cycle of iteration they were given a bonus of 35 dollars to participate. Additionally, MIETC should be implemented to more teachers and in different contexts in order to reconfigure the model and finally strategies must be generated to evaluate how effective MIETC is in learning not only from the perceptions of teachers but through standardized tests applied to students.

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A Teaching Model of Urban and Rural Planning Curriculum Integrating Virtual Simulation Technology

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Abstract—In the teaching process of Urban and Rural Planning, students not just need to learn relevant theoretical knowledge, but also should flexibly apply relevant theoretical knowledge to practice urban and rural planning. Virtual simulation technology can construct the teaching situation which organically combines theory and practice for the course of Urban and Rural Planning, help students deepen the understanding of theoretical knowledge and enhance theoretical knowledge application and practice ability so as to make up for the defects in Urban and Rural Planning teaching. Thus, virtual simulation technology was integrated in Urban and Rural Planning teaching to form the complete teaching mode in this paper. Practical teaching application shows the teaching mode has good effect on improving students' theoretical knowledge study and practical ability.

Keywords—Virtual simulation; Urban and rural planning; Teaching mode

1 Introduction

Virtual simulation technology, also called virtual reality technology, simulates the real system in practical world through information technology system. This technology is a new technology which gradually becomes mature with the continuous development of information technology. In virtual simulation technology, the computer generates a virtual world through technological means. The virtual world may be the projection and reappearance of a real world, or a world which does not exist [1]. In the virtual world, users may interact with the virtual world through auditory sense, tactile sense and visual sense. Like the real world, virtual simulation technology can make the interaction result present in the virtual world [1]. With the development of multiple cuttind0edge techniques such as computer graphics, computer vision and computer simulation technology, authenticity, instantaneity and interactivity of virtual simulation technology have developed to a high level, so that it has been widely and deeply applied in many fields [2].

Urban and Rural Planning is a subject with strong practicalness. In the teaching process, students not just need to learn relevant theoretical knowledge, but also should flexibly apply relevant theoretical knowledge to practice urban and rural planning. In traditional course mode of Urban and Rural Planning, the practical link of Urban and Rural Planning is often completed through applying real building and road models or requiring students to draw. Such method is difficult to let students immerse in practical situation of urban and rural planning. Meanwhile, such practice form is usually separated from course teaching [3]. Finally, students cannot closely combine theoretical knowledge and practice of Urban and Rural Planning, which reduces teaching effect. Virtual simulation technology can construct the teaching situation which organically combines theory and practice for the course of Urban and Rural Planning, help students deepen the understanding of theoretical knowledge and enhance theoretical knowledge application and practice ability so as to make up for the defects in Urban and Rural Planning teaching. Therefore, the application of virtual simulation technology in Urban and Rural Planning teaching has great value. The course mode will be deeply studied in this paper.

2 Review of research status

As urbanization goes deep in China, higher theory and practice ability has been proposed for the students of urban and rural planning major. How to make students integrate theoretical knowledge and design philosophy of urban and rural planning in practice has been the research emphasis of teaching personnel. Fen et al. [4] comprehensively analyzed the teaching conditions of Urban and Rural Planning in the research process, and conducted the teaching research with the principal line of motivating students' learning interest and cultivating their thinking reason. Song et al. [5] applied SWOT analysis method in strategic management theory to deeply investigate strengths, weaknesses, internal and external environments of Urban and Rural Planning, and proposed the teaching framework of linking SRTP with Urban and Rural Planning.

The third technological revolution dominated by information technology overturned traditional thinking in many fields. Virtual simulation technology which develops in this process can help people experience the real world in the virtual world through constructing a virtual world. Authenticity, instantaneity and interactivity of virtual simulation technology makes it widely applied in the education field, and the good effect has been gained. For example, Liu discussed the application of virtual reality technology in architecture teaching. Through virtual simulation technology, learners can observe the things in the space from various angles so that they can have the brand-new learning feelings so as to promote learning effect [5]. Arain et al. [6] introduced the potential application of Second Life (SL) in strengthening study and training of construction project management. Through the virtual environment, students can visualize the construction projects in 3D. The experiment has verified that virtual reality technology contributes to promoting students' learning initiative. Francis et al. [7] deeply discussed the advantage and method of introducing virtual simulation technology in higher education. The author considered the construction of virtual environment could gain the good teaching effect in multiple fields such as business studies, architecture, engineering science and medical science. In the research process, the author proposed the technology and framework for applying virtual simulation technology to conduct immersion teaching in the field of engineering science.

However, in the existing research process, there are short of research achievements on organic combination of virtual simulation technology and Urban and Rural Planning. But, Urban and Rural Planning is a subject with strong practicalness, and it is difficult for the existing teaching mode to construct effective practical situations. Thus, the teaching mode in which virtual simulation technology is integrated is studied in this paper, in the hope of improving teaching effect of Urban and Rural Planning. The innovation of this research is mainly reflected in the following two aspects:

First of all, the teaching mode which integrates virtual simulation technology in Urban and Rural Planning is proposed in this paper. Meanwhile, the principle and general framework of this teaching mode ware constructed so as to offer theoretical basis for teaching Urban and Rural Planning in which virtual simulation technology is integrated. Secondly, based on the teaching mode of Urban and Rural Planning in which virtual simulation technology is integrated, corresponding teaching process is put forward in this paper. The teaching examples are explained from two aspects: teaching stage and tasks in each stage, and the teaching effect was tested.

3 Teaching mode of Urban and Rural Planning in which virtual simulation technology is integrated

The teaching mode of Urban and Rural Planning in which virtual simulation technology is integrated combines the advantages and features of virtual simulation technology as well as specific requirements of Urban and Rural Planning. Besides, modularized and staged teaching mode is applied. First of all, the foundation framework for Urban and Rural Planning teaching is constructed by virtual simulation technology. On this basis, the specific teaching module of Urban and Rural Planning is developed.

3.1 Teaching mode construction principle

Virtual simulation teaching mode for Urban and Rural Planning needs to organically combine detailed requirements of Urban and Rural Planning teaching with advantages and features of virtual simulation technology, and considers the needs of students with different knowledge and ability. The main purpose of the teaching mode is to construct rich, real-time and interactive practice situations for Urban and Rural Planning through virtual simulation technology. In the teaching mode framework, the following principles should be followed (see fig.1):

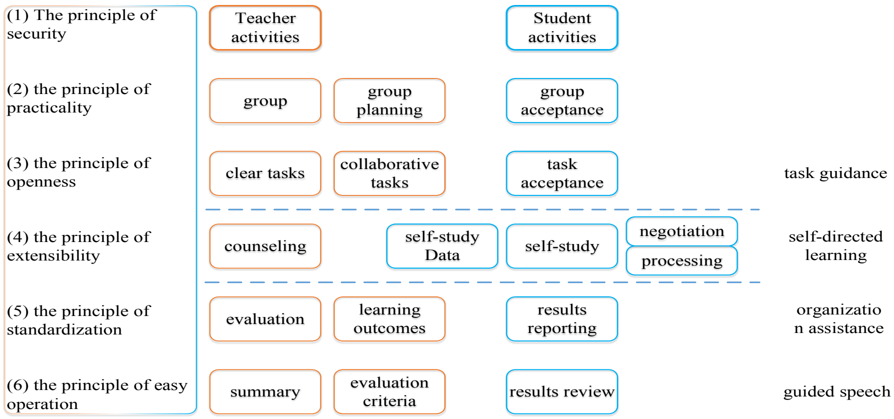

Fig. 1. Teaching thought chart of Urban and Rural Planning in which virtual simulation technology is integrated

1. Security principle. The teaching mode framework constructs a virtual environment through virtual simulation technology for students to practice urban planning. Students may complete the practical environment in the virtual environment according to course requirements and their own understanding. In students' practice process, students may interact with virtual environment and conduct their own operation [9].
2. Practicability principle. The virtual simulation teaching mode is used for Urban and Rural Planning teaching. This requires customized development of the system in accordance with the actual situations of Urban and Rural Planning teaching so as to make sure the system can plan and arrange teaching process as well as provide assignment correction and score management functions.
3. Openness principle. Openness principle means the virtual simulation teaching mode framework should own certain expandability. Teachers may adjust the system according to specific teaching needs so as to achieve individualized customization. When there is tiny change in teaching needs, the system also supports the teacher to modify the system through parameter setting so as to improve teaching efficiency.
4. Expandability principle. Virtual simulation teaching mode offers real-time and interactive practical environment for Urban and Rural Planning. Through this virtual environment, students may freely conduct urban and rural planning practice. Since current urban and rural planning theory and the specific requirements of government for urban and rural planning are in the continuous development and change [10], the teaching process also needs to be expanded and changed.
5. Standard principle. China sets many national standards and industrial standards for urban and rural planning. Hence, the specific planning process must abide by these standards in order to reach the expected purpose and effect [11]. Therefore, these national standards and industrial standards must be followed in the process of constructing virtual simulation teaching mode.

6. Operability principle. The main feature of virtual simulation teaching mode of Urban and Rural Planning is that, students may utilize virtual simulation environment to effectively practice basic theory of urban and rural planning so as to enhance their theory level and practical ability. Operability principle can make students avoid use of precious time in system operation study, and focus on improvement of theoretical knowledge application and practical ability. Fig.1 shows teaching mode principles of Urban and Rural Planning in which virtual simulation technology is integrated.

3.2 General framework of teaching mode

The general framework of teaching mode of Urban and Rural Planning in which virtual simulation technology is integrated mainly includes two modules: course teaching module and virtual simulation practice module. The system structure is shown in Fig.2.

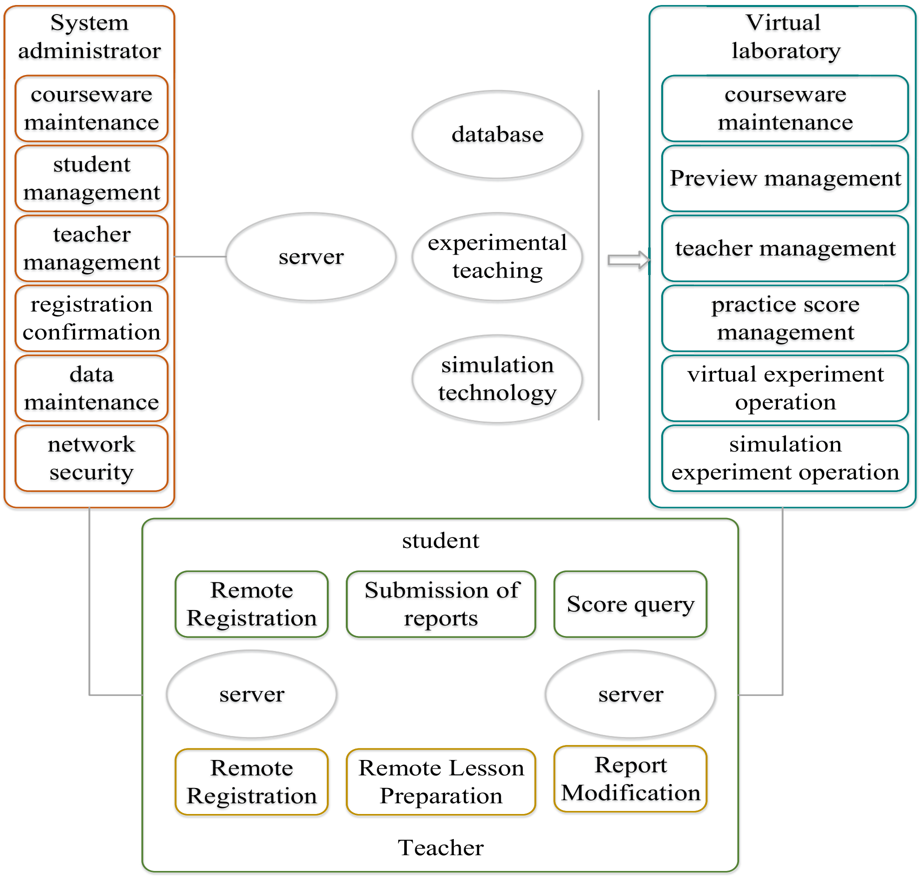

Fig. 2. General framework of virtual simulation teaching mode of Urban and Rural Planning

The advantage of virtual simulation teaching method of Urban and Rural Planning is as follows: theory teaching and practice teaching serve as a unified whole to formulate practice content in different stages, experimental project, course design and graduation design and form a teaching system which integrates theory and practice. Course teaching module refers to traditional Urban and Rural Planning teaching classroom. The major task of this module is to explain and learn theoretical knowledge of Urban and Rural Planning. This part is the foundation of the whole teaching mode. Only when students own certain theoretical basis can they better apply virtual simulation practice module to verity theoretical knowledge and complete corresponding urban and rural planning practice.

Virtual simulation teaching mode is the core and main innovation point of this teaching mode. The module applies computer graphics, computer vision technology and computer simulation technology to construct a virtual environment. Students may practice urban and rural planning through this virtual environment. Virtual environment also shows the interaction result to students. Students may further modify and optimize the urban and rural planning scheme according to the teaching result shown by the virtual environment. Through virtual simulation teaching module, students may deepen their understanding of theoretical knowledge and enhance their practical ability.

3.3 Virtual simulation practice module of Urban and Rural Planning

Virtual simulation practice module integrates course resources and teaching requirements of Urban and Rural Planning and constructs a simulation system for students to complete urban and rural planning practice. The general architecture of this module is shown in Fig.3.

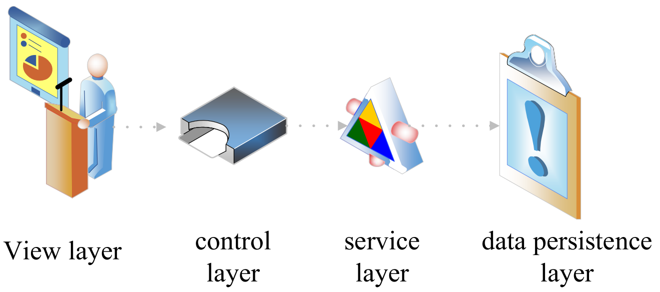

Fig. 3. General architecture of Virtual simulation practice module of Urban and Rural Planning

Virtual simulation practice module adopts hierarchical architecture, including data persistence layer, service layer, control layer and view layer. Data persistence layer provides persistent resource storage service, including database server and distributed file system server which are respectively used to store relational data as well as the pictures, videos and audio required by virtual simulation system. Service layer implements specific virtual simulation environment and generates the virtual environment through gaining the resources and data gained from data persistence layer. Besides, it is responsible for receiving processing request from control layer and carrying out corresponding treatment. Control layer is the middle layer of view layer and service layer, responsible for receiving users' request, handling it and sending it to service layer as well as receiving simulation result data from service layer. View layer is responsible for providing users with graphical interfaces to gather users' operation request and sending iy to control layer. Meanwhile, it also receives simulation result data from control layer and presents simulation result through computer graphics.

4 Teaching example and teaching effect

Urban and Rural Planning is a subject with strong practicalness. Pure theoretical knowledge teaching will let students difficult to fully train and enhance their practical ability. The expected teaching effect may be reached only through organically combining theoretical knowledge and operation time. Based on the teaching mode of Urban and Rural Planning in which virtual simulation technology is integrated, the specific teaching example will be designed in this paper, and the teaching effect will be tested.

4.1 Teaching example

The core of enhancing teaching quality of Urban and Rural Planning is to improve course system and teaching content construction so as to promote students' ability to connect theory with practice. To achieve this goal, the core is to increase the proportion of practice module in the course. But, if organic combination of theory teaching and application practice fails, period waste will be caused. The design of teaching example will be conducted from two aspects: teaching order and teaching process.

Selection of teaching order. There are mainly three forms for combining theory with practice: application practice is before theory teaching; application practice is after theory teaching; application practice is embedded in theory teaching. The first form will make students lack guidance of theoretical knowledge in practice and also lack the purpose. As a result, it is hard to achieve the good effect. Although the second form has made students have certain cognition of theoretical knowledge in application practice link, application practice and theory teaching are separated. The third form can keep strong interactivity in teaching process. Students cannot just verify theoretical knowledge in the virtual simulation system in time. Meanwhile, students can grasp students' learning effect in real time so as to optimize the teaching process. Thus, the third form is chosen in this paper to design virtual simulation teaching mode of Urban and Rural Planning.

Teaching process design. The teaching mode of Urban and Rural Planning in which virtual simulation technology is integrated includes four stages: adaptive practice stage, verification practice stage, design practice stage and comprehensive practice stage, as shown in Fig.4.

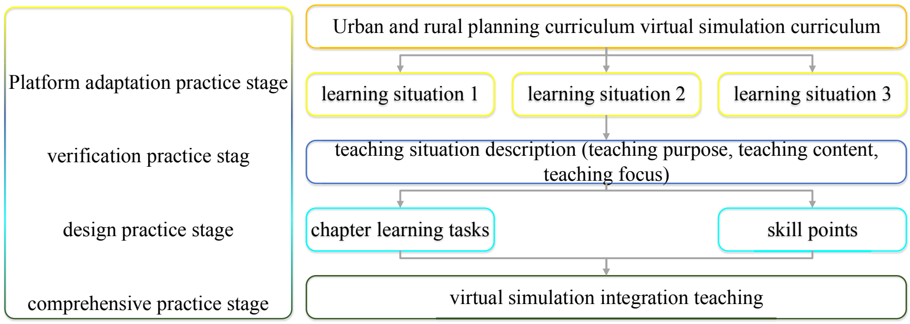

Fig. 4. Teaching process chart of virtual simulation teaching mode

Adaptive practice stage. The main task of this stage is to let students learn theoretical knowledge of Urban and Rural Planning, and make them preliminarily know environment and operation method of virtual simulation system. This stage puts particular emphasis on teacher's explanation in classroom, and considers preliminary statement of virtual simulation system operation. In this stage, students need not grasp the specific urban and rural planning method, but explore basic system operation in a relatively relaxing environment. To cope with possible period shortage, the teacher may distribute system operation manual and let students freely choose time and place to learn basic system operation so as to complete system adaptation training.

Verification practice stage. The main task of this stage is to let students deepen the understanding of basic theory of Urban and Rural Planning through practice, and cultivate students' skills of applying virtual simulation system in design. During designing the practice item, the teacher should reinforce basic principles and design experiment of typical cases so that students can deepen the understanding of course content in practice. For the difference between design mode and design philosophy and occasions applicable, the teacher also should let students observe the differences through corresponding practice link so as to deepen their mastery of key content. In addition, the teacher may acquire students' practice process and problems from the system in real time, and explain them in classroom teaching. Teaching Urban and Rural Planning is taken for example. Fig.5 shows schematic diagram of urban land status. The teacher shows the situation of planning in the virtual simulation system. Students may feel practical application of basic principles of urban and rural road planning from the virtual environment, and analyze the defects so as to deepen their cognition of road planning theory.

Design practice stage. The main task of this stage is to let students comprehensively apply theoretical knowledge of urban and rural planning to finish corresponding planning tasks. In the teaching design of this stage, it is required to fully consider students' practical ability and theoretical knowledge mastery ability, and adopt the layered teaching mode of teaching students according to their aptitudes. In other words, in the design of practice tasks, the tasks may be classified into required task and selective task. The required task puts particular emphasis on the application of basic theoretical knowledge in planning process, and the difficulty is relatively small.

The selective task stresses planning topics with strong comprehensiveness, and the difficulty is relatively large. All students must complete the planning topics included in the required task. The students with strong learning ability may choose the topics included in the selective task according to their needs. In this stage, students need to apply the knowledge learned to finish a design task within a small area. Fig.6 shows the schematic diagram of a plot in the suburb, and the land nature is for commercial use. The teacher simulated the plot in the virtual simulation system, and asked students to complete planning task for the land. The scope involved in this task is small, so it well adapts to teaching in this stage.

Fig. 5. Schematic diagram of land use of village in the city

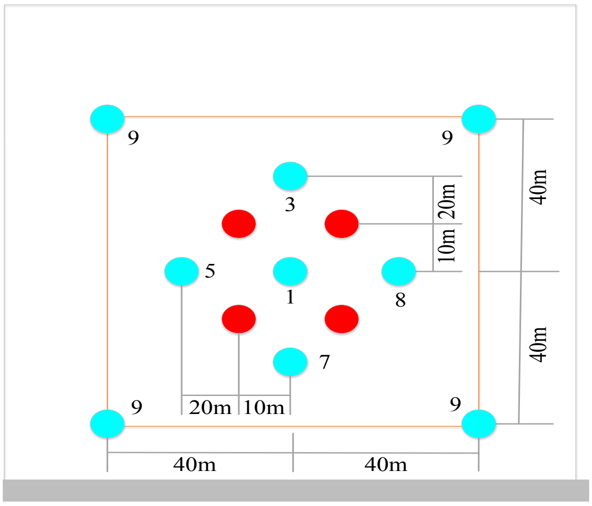

Fig. 6. Schematic diagram of a plot in the suburb

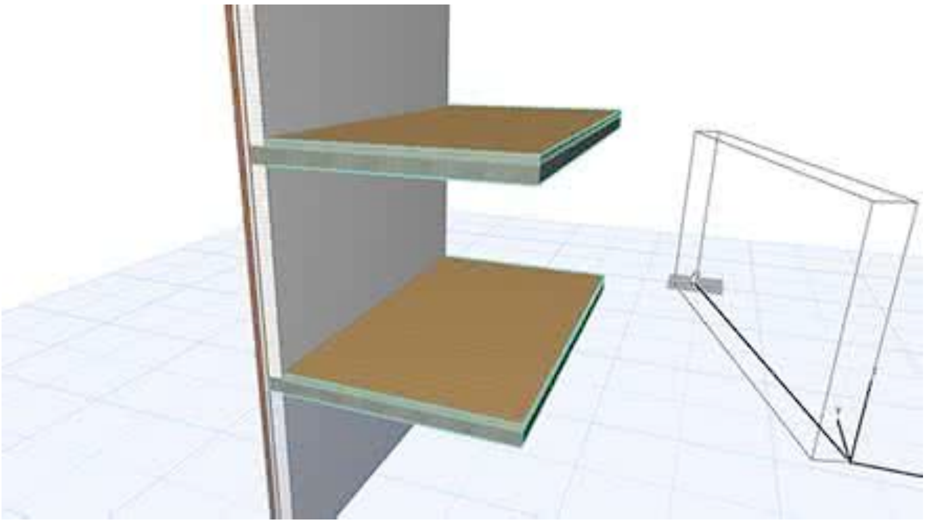

Fig. 7. Architectural design modeling

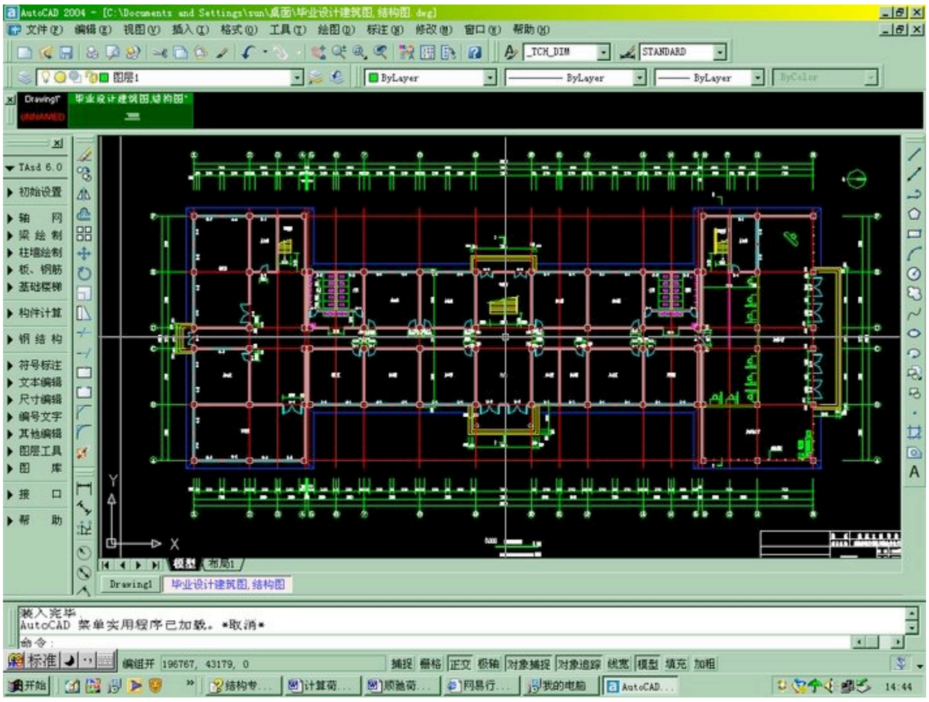

Fig. 8. Software practice stage of architectural design

Comprehensive practice stage. The main task of this stage is to cultivate students' ability to solve practical problems with theoretical knowledge learned in Urban and Rural Planning course. In this stage, the teacher will no longer design the specific planning task, but will propose corresponding tasks according to actual urban and rural planning, and require comprehensive application of knowledge for analysis and thinking and give corresponding solutions. In this stage, the mode and process of solving problems will not be specified to give full play to students' innovative ability. With the help of virtual simulation system, students may utilize spare time to complete the tasks. For example, Fig.9 shows simulation effect of the plot in virtual simulation system. Architecture, road and function planning is required for the plot. The teacher simulates the plot through virtual simulation system, and requires students to study the topic in groups and generate the detailed design scheme. The teacher may examine students' designs and put forward the defects.

Fig. 9. Simulation effect diagram of virtual simulation system for the plot

4.2 Teaching effect

To test the teaching effect of teaching mode in which virtual simulation technology is integrated, this mode was applied in the teaching process. Meanwhile, a class was chosen as the control group. Traditional teaching mode was still applied for the control group. After the course ended, corresponding test paper was designed for experimental group and control group. The main content of the test paper was the course content of Urban and Rural Planning, and the full score was 100. The test results are shown in Tab.4-1. SPSS statistics software was used for data statistics, and t test was applied for data test. When, this means the difference between two groups has statistical significance, the calculation of t value is shown in Formula 1.

$$t = \frac{\bar{x} - u}{\frac{\sigma_x}{n-1}} \tag{1}$$

According to Table 1, the performance of experimental group is obviously superior to that of control group, indicating the course mode proposed in this paper has gained the expected teaching effect.

Table 1. Result comparison of both groups

Group	Average score	Standard deviation	t	P
Control group (n=45)	81.20	4.67	3.621	0.001
Experimental group (n=45)	76.23	6.82		

Except testing the teaching effect through the test paper, the questionnaire was also designed to evaluate the reaching effect of both groups, including learning initiative, practical ability training, theoretical knowledge mastery, innovation ability training and problem solving ability. Students evaluated according to their performance and feeling in the learning process, and each item included two dimensions: “agree” and “disagree”. The questionnaire was filled in in the form of anonymity. A total of 90 questionnaires were distributed, and 90 effective questionnaires were recovered, with the recovery rate of 100%. In data statistics, SPSS software was applied, and x^2 test was used for data test. When P＜0.05, this means the difference between two groups has statistical significance. The calculation of x^2 is shown in Formula 2. We can see from Table 2 that, Urban and Rural Planning teaching mode in which virtual simulation technology is integrated has the significant effect in learning initiative, practical ability training, theoretical knowledge mastery, innovation ability training and problem solving ability.

$$x^2 = \sum_{i=1}^{k} \frac{(f_i - np_i)^2}{np_i} \tag{2}$$

Table 2. Statistical result of questionnaire survey

Item	Control group (n=45)	Experimental group (n=45)	x^2	P
Learning initiative	43	29	13.617	0.000
Practical ability training	42	26	9.891	0.001
Theoretical knowledge mastery	44	28	11.091	0.000
Innovation ability training	41	30	10.021	0.001
Problem solving ability training	42	29	8.098	0.002

5 Conclusions

Urban and Rural Planning as a subject with strong practicalness not just requires students to grasp theoretical knowledge, but also requires them to own corresponding ability to link theory with practice. To improve the teaching effect of Urban and Rural Planning, virtual simulation technology was integrated in Urban and Rural Planning teaching to develop a new teaching mode for the course. Meanwhile, the teaching effect of this mode was tested. The results show that, this teaching mode has good application effect on students' theoretical knowledge mastery and ability training. In conclusion, the integration of virtual simulation technology in Urban and Rural Planning has the following three advantages:

Firstly, the teacher may design corresponding course tasks in the virtual simulation system according to teaching progress and actual needs so as to organically combine theoretical knowledge study and practical ability training. Virtual simulation experiment platform can make students finish experiments without time and space restrictions, which greatly saves the time of both teachers and students.

Secondly, in this teaching mode, the teacher may acquire students' learning conditions and their weak links in real time so as to adjust teaching content and method in time. Virtual simulation experiment can not just relieve period contradiction, well reach the preview purpose and expand the experiment content, but also break the limit of traditional experiment, integrate and optimize experiment resources as well as make the best of superior experiment resources.

Finally, this teaching mode offers the strong support for students to overall apply the knowledge in analyzing, thinking and solving the specific urban and rural planning problems. Distance virtual simulation experiment impossibly rejects or replaces current object experiment form, but can enhance students' enthusiasm and initiative for experiment participation and make students fully exploit their thinking. In one word, it has good effect on students' innovation ability training and problem solving ability training. The course reform for Urban and Rural Planning based on virtual simulation technology is a topic worthy of exploration.

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A Space Design Teaching Model Using Virtual Simulation Technology

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Abstract—With the rapid advancement of information technology, virtual reality technology has also gradually developed, accompanied by the dramatic growth of virtual reality experiment technology. At present, the space design-oriented virtual experiment teaching method usually contributes to the formation of undesired experiment habits among students, such as caring less about experiment instruments, attaching less importance to the norms of experiment operation, and the lack of awareness of safety precautions. At the same time, virtual experiment may lead to reduced communications in the learning process and fewer opportunities for students to exercise interpersonal skills, thus affecting the teaching effect to a certain extent. On this basis, a teaching method of applying virtual simulation technology to the course of space design was proposed in this study. The analysis of the current development status and characteristics of virtual simulation technology was followed by a detailed description of the use of software in the construction entity and a series of computer-aided teaching and developing processes concerning space, design, function, etc. in the case of space design. Through the survey, it was found that students have more recognition of the new teaching method and their learning efficiency is improved, indicating that this teaching model is significantly better than other traditional teaching methods.

Keywords—Virtual reality technology, Experiment teaching model, Space design

1 Introduction

The progress of information technology has brought the development of the entire Internet world. As a result of its high-speed evolution, the Internet is able to provide increasingly diversified services and functions. The most important reason for the existence of the Internet lies in the interaction of information between different personal computers and individuals. The Internet can eliminate the barrier of information between individuals and realize the communication of all resources from the software level to the hardware level. In practice, the most typical mode of information exchange and communication is the exchange of curriculum knowledge that occurs in school. In the classroom, the teacher is the sender of information and students are the receivers of information. Meanwhile, the teacher can also obtain the corresponding teaching achievement information based on the feedback of students' corresponding learning situation [1]. Therefore, the Internet also reflects in the virtual world based on this mode of exchange of information.

If classroom teaching in school is applied to the Internet, a new teaching model of online courses will be formed to overcome the restrictions of geography, time and other material conditions [2]. Apart from the field of education, information, electronics and other fields in the society are also exploring hardware and software suitable for online course teaching, so that online course teaching develops as the main way that adapts to teaching in the new era.

Therefore, "space design", an architecture course, was employed in this study as the main online course teaching content, to study the feasibility of online course teaching. Besides, online course teaching proposed in this study was effectively combined with simulation virtual technology to generate an online course teaching model with virtual reality functions, which can effectively improve the teaching efficiency and teaching level of architecture courses and cultivate architecture talents with more design experience for the community.

2 State of the art

With the development of computers and sensors, simulation virtual technology has gradually become a hot topic in the field of science and technology. At the same time, noticing the outstanding advantages of simulation virtual technology in their application to teaching practice, many schools, companies and research institutes at home and abroad have begun to pay attention to the development and application of simulation virtual technology in course teaching. At present, a large number of virtual reality laboratories and virtual reality teaching systems have been used in many colleges and universities.

The United States was the first country to invest in virtual reality laboratories and teaching systems. As early as the end of the 20th century, University of Virginia in the United States put forward the concept of virtual reality laboratory. With the development of virtual reality technology and the gradually deepened research on virtual reality technology in the United States, lots of virtual reality experiment systems have come into being in the United States. Massachusetts Institute of Technology (MIT), the best-known university in the United States, has developed a virtual experiment teaching system called Microelectronics Web Lab [3] that cannot only be used for teaching related microelectronics courses in MIT, but also allow external students to gain access to corresponding resources, thus improving the teaching effect of the course in terms of information sharing and teaching experiment research. At University of Central Florida, a virtual system laboratory named Visual System Laboratory was also established [4]. The advantage of this experiment system over that of the virtual experiment system in MIT lies in its ability to more effectively combine 3D graphical representation by computer with virtual reality technology and a higher level of the entire virtual reality human-computer interaction. Carnegie Mellon University in the United States also integrated virtual simulation technology with the course of chemistry, developing the corresponding virtual chemical laboratory. In this virtual chemical laboratory, students can wear the corresponding head-mounted display and joystick to capture oxygen and hydrogen atoms in the vividly simulated virtual scenes to create water molecules [5].

The study of virtual experiment teaching system in China did not start until the 21st century, so that China still lags behind developed countries such as the United States and Britain in the scale and degree of realization of virtual reality laboratories, many colleges, universities and institutes in China have made corresponding positive research on virtual laboratory. Through communicating with MIT, Dalian University of Technology established the first virtual reality laboratory in China [6], which incorporated Microelectronics Web Lab of MIT into the course experiment of microelectronics and has acquired a good response. At the same time, Dalian University of Technology conducted an in-depth study of the virtual experiment system of MIT and used Virtools technology which can effectively achieve the functions of virtual reality. Dalian University of Technology also applied Virtools technology in the construction of virtual chemical laboratories. Using the virtual experiment teaching technology, students can select the appropriate virtual experiment equipment for the corresponding virtual chemistry experiment. The application of virtual experiment in education can effectively improve the teaching quality and is of great importance to reforms of the experiment teaching model. However, it is not a panacea, but has many shortcomings and deficiencies. First, the experiment environment and experiment objects of virtual experiments are all virtual items. Although the high simulation level enables learners to be immersed in the virtual environment and have difficulties in distinguishing between true and false, these objects are not real items after all. During the experiment operation, it is hard for the experimenter to get the real feeling and experience via various senses [7]. Second, virtual experiments are applications developed by using virtual reality technology and computer technology. In this sense, the experiment process, experiment phenomena, experiment feedback have already been designed in advance. Nevertheless, the actual experiment process is a very complicated process. Any subtle change in the order of experiment operations, experiment conditions, experiment time and many other factors will have a large impact on the experiment results, and therefore it is difficult for a virtual experiment to simulate the uncertain phenomena that may occur in a real experiment [8]. Third, virtual experiment usually contributes to the formation of undesired experiment habits among students, such as caring less about experiment instruments or devices, waste of experiment drugs, attaching less importance to the norms of experiment operation, and the lack of awareness of safety precautions, which are not conducive to the development of scientific and rigorous experiment attitudes [9]. Fourth, virtual experiment may lead to reduced communications in the learning process, increasing problems and fewer opportunities for students to exercise interpersonal skills, thus affecting the teaching effect to a certain extent [10].

To overcome the shortcomings above, a virtual experiment teaching model based on Virtools was put forward in this study. This experiment teaching model mainly relies on the course of "space design", which is mainly used in the teaching of architecture courses. Generally, this course requires students and teachers to provide this design course practical feasibility. The innovation of the model lies in: First, this model uses the simulation resource teaching and training system which can engage architecture students in virtual simulation training consisting of three modes, namely teaching, training and examination, covering training in various aspects like the structure and principle of the system and equipment, operation, maintenance, troubleshooting and repair. Second, the design of the system follows the theoretical principle of the lesson plan teaching method, which is conducive to strengthening the interaction between teachers and students and the communication between students. In short, the virtual experiment teaching model based on Virtools proposed in this study is the application of the corresponding simulation virtual technology in the architecture direction. Meanwhile, a case teaching method that is suitable for the teaching of architectural courses was also introduced, for the purpose of providing reference for corresponding multimedia course teaching.

3 Specific Ways of Integrating Simulation Virtual Technology into Space Design Teaching

3.1 Integrating the case teaching method into space design teaching

The case teaching method [11] can effectively allow students to experience the environment and to incorporate their current knowledge into the entire typical case, playing a good role in substitution. The main characteristic of this teaching method is the establishment of teaching situations suitable for the whole course teaching according to the corresponding teaching content in the course and the learner's own learning mode and method. The case teaching method can make full use of the multimedia technology and computer information resources now available to create a vivid and creative classroom teaching scenario that enables students to take full advantage of their own knowledge and deepen their understanding of knowledge in realistic teaching situations, thus building a more complete knowledge structure system. This teaching method can express complex theories in simple terms through practical engineering examples or real-life examples, so as to effectively improve students' ability to analyze problems and stimulate their enthusiasm, which is also the most significant advantage brought by the case teaching method.

3.2 Integrating the simulation resource packet technology based on Virtools into space design teaching

The simulation resource packet technology is a kind of data packet technology which can effectively support the virtual experiment teaching model proposed in this study by using the related software of Virtools technology [12]. This technology can determine the simulation resource packet suitable for the whole teaching process according to the specific content and training way of different professions. Besides, the simulation resource packet technology can effectively realize the modular management of information resources and effectively improve the operation efficiency of the entire virtual experiment teaching model. The entire simulation resource packet technology mainly includes four simulation resource packet modules: structure principle simulation resource packet, post operation simulation resource packet, maintenance simulation resource packet and troubleshooting simulation resource packet. The relationship between the simulation resource packet technology and the entire experiment teaching model is shown in Figure 1.

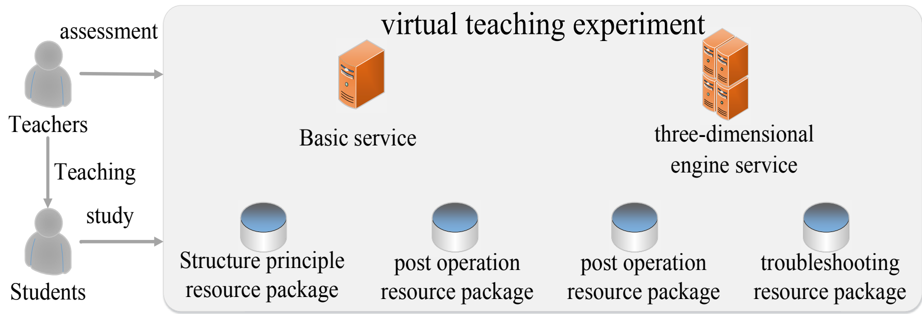

Fig. 1. Relationship between simulation resource packets and experiment teaching

The structure principle simulation resource packet is the most important experiment frame of the entire virtual experiment teaching. Its major function is to enable the clear three-dimensional virtual presentation of the entire virtual experiment teaching. The pixel coordinates of the presentation can be simulated by the structural principle through formula (1) and formula (2). The content that needs to be displayed in virtual reality can be effectively displayed in real time through the virtual reality device. It can achieve the unified function connection between devices, and train the cognitive ability and operation ability of students or virtual experiment teaching operators concerning the entire device structural components, working principle, working structure and the relationship between devices.

$$x' = x\cos\theta\text{-}y\sin\theta \tag{1}$$

$$y' = y\cos\theta\text{+}x\sin\theta \tag{2}$$

The post operation simulation resource packet is the simulation resource packet technology developed based on the corresponding structural standards and resources environment provided by the entire structure principle simulation resource packet to meet the use requirements of the entire virtual experiment teaching model. The maintenance simulation resource packet offers the underlying maintenance feature for the entire virtual experiment operation system. For the virtual experiment teaching model, the troubleshooting simulation resource packet is a functional resource packet put forward by combining the functions of the maintenance simulation resource packet to play a complementary role.

The simulation resource packet technology relies on the use of Virtools virtual experiment simulation technology. The main compilation language of Virtools virtual experiment simulation technology is the VSL programming language. This language can effectively integrate the simulation resource packet technology proposed in this study into the entire virtual experiment teaching. At the same time, as Virtools virtual experiment simulation technology does not cover the corresponding three-dimensional modeling technology, the combination of the simulation resource packet technology and Virtools virtual experiment simulation technology can form unique virtual experiment teaching of online courses. Virtools virtual experiment teaching is characterized by the use of the VSL programming language which is not single combinations of character codes, but corresponding combinations through the existing Building Blocks. When Building Blocks are given the appropriate objects and attributes, and the combination of corresponding functions and placement of the order of different Building Blocks are finished in the entire script editing area, the cycle of different modules can form a complete virtual experiment teaching model, which contains both the corresponding module functions provided by Virtools and the existing three-dimensional modeling capabilities contained in the simulation resource packet. The two functions weree combined to form the unique Virtools-based simulation resource packet technology in this study.

3.3 Integrating simulation virtual technology into the space design teaching model

The virtual experiment teaching model is mainly used in the teaching of “space design”, an architecture course. The main research object of such courses is the interior space after decoration. Through the placement of movable decorations such as furniture, interior decoration and ornaments, the overall interior space in the building reflects the decoration taste or the interior design style. Therefore, what the entire “space design” teaching needs most is to the capacity to determine the appropriate virtual experiment operation environment and realize the placement of specific mobile decorations in the simulated three-dimensional virtual building space through the three-dimensional virtual experiment operation. Meanwhile, it is also necessary for the whole course teaching to include the corresponding information learning module, the feedback module for exchanges between students and the experiment evaluation module. The overall framework of the virtual experiment teaching model is shown in Figure 2.

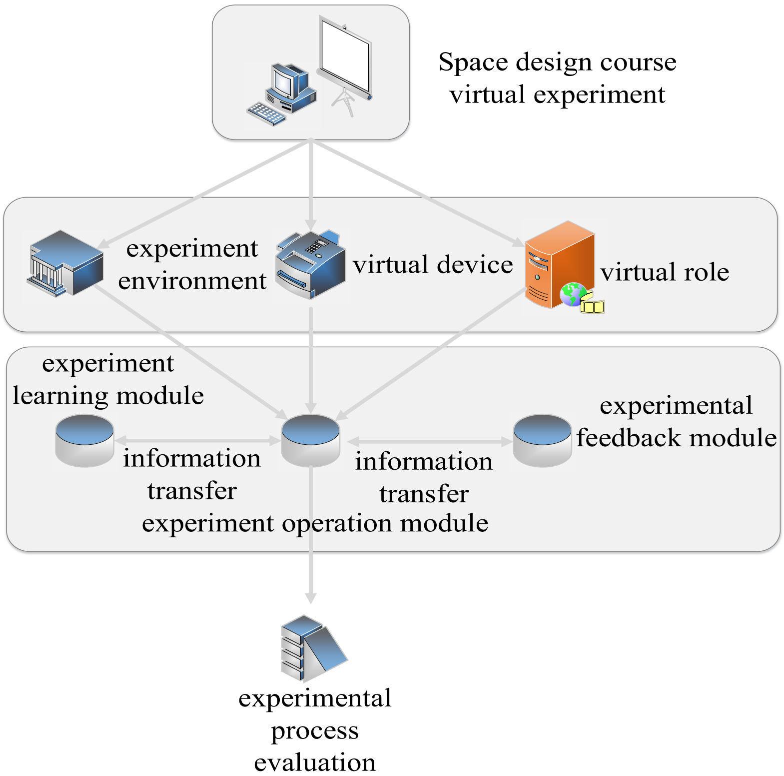

Fig. 2. Space design teaching model integrating simulation virtual technology

4 Teaching Case and Teaching Effect

4.1 Teaching case

Experiment operation. The Building Blocks module in Virtools is mainly used in the design of the entire experiment operation module. The major form of the graphical operation codes for this module is shown in Figure 3. The virtual experiment operation module is primarily aimed at enabling students to control their positions and postures of placing different decorations in a three-dimensional virtual space through input devices such as somatosensory and wireless mouse according to the corresponding virtual reality images they receive in the 3D glasses or the computer screen, and allowing experimenters to switch between different perspectives in the virtual space for the purpose of adjusting to a suitable angle to obtain the same visual experience as the actual decoration.

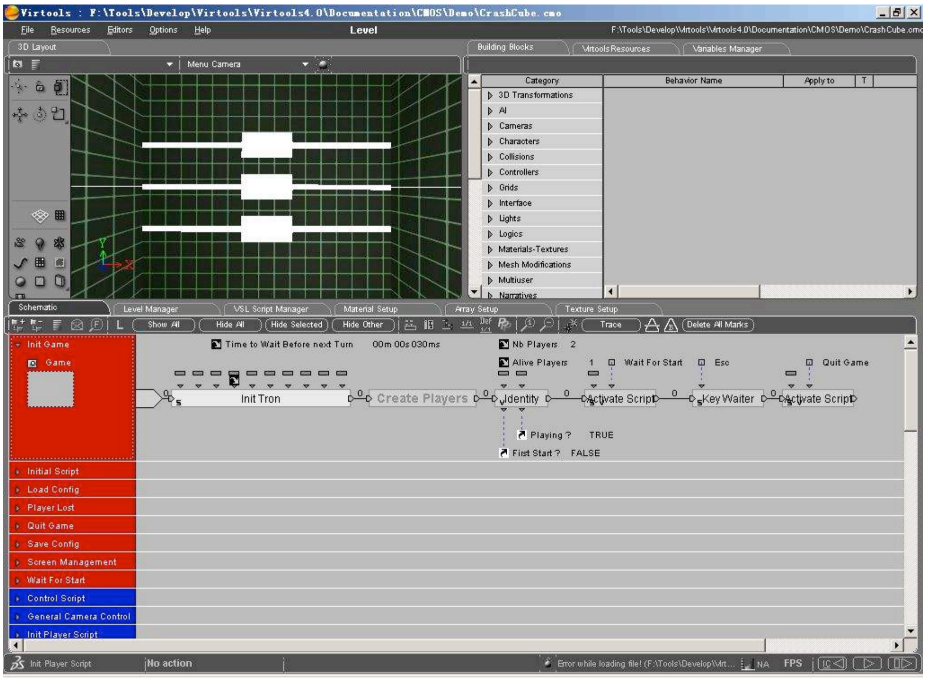

Fig. 3. Screenshot of application of the Virtools-based virtual experiment teaching model

Experiment Learning. In the process of carrying out the virtual technology experiment, the corresponding learning module should be designed for users to acquire knowledge, including the corresponding precautions in the whole operation process, the experiment demonstration process, etc., so that students can obtain the appropriate classroom knowledge on the output interface of the device in the two-dimensional form. The demonstration process is shown in Figure 4. The whole experiment learning module contains three parts, namely equipment function demonstration, experiment demonstration and experiment instruction. In this experiment learning module, the appropriate video text file should be used to display these resources.

Experiment feedback. In the entire virtual experiment teaching process, the feedback of the effect is also the focus of the whole teaching model. With the feedback, the users and teachers of experiment teaching can know in real time whether the user utilizes the method correctly. At the same time, the experiment feedback module can well prevent the user from damaging the experiment equipment due to incorrect operation of virtual experiment teaching. A partial screenshot of the Virtools-based virtual experiment teaching feedback module is shown in Figure 5. Figure 6 illustrates the video screenshot of the experiment operation of placing boxes and decorative balls.

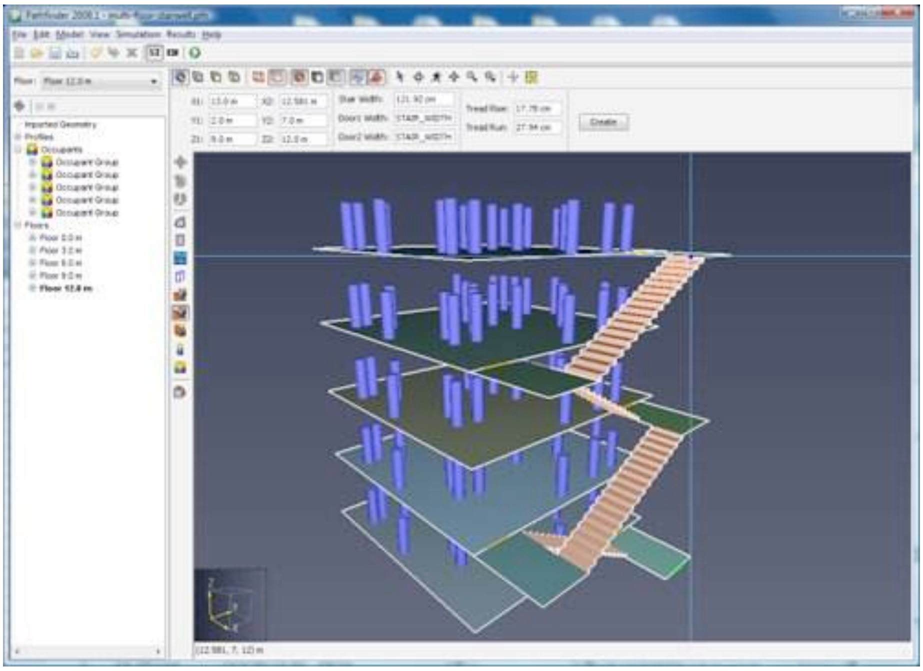

Fig. 4. Demonstration of using the left mouse button to convert the perspective

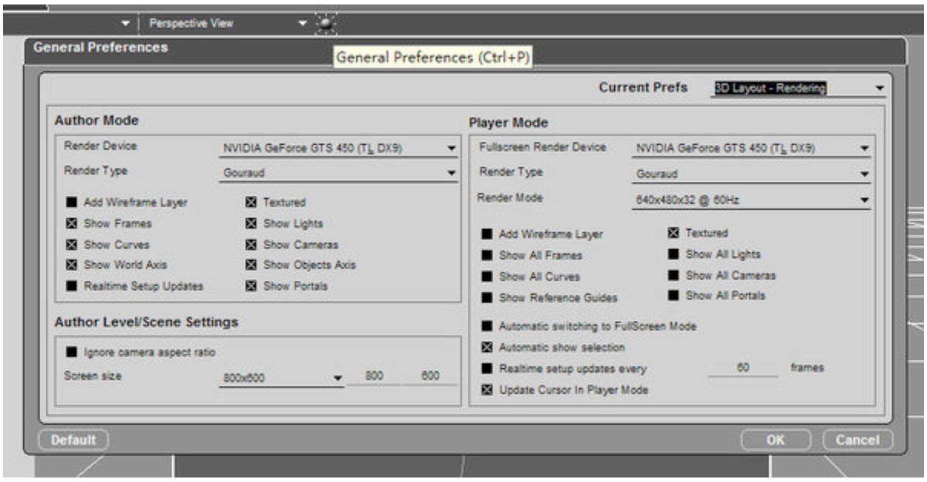

Fig. 5. Partial screenshot of the Virtools-based virtual experiment teaching feedback module

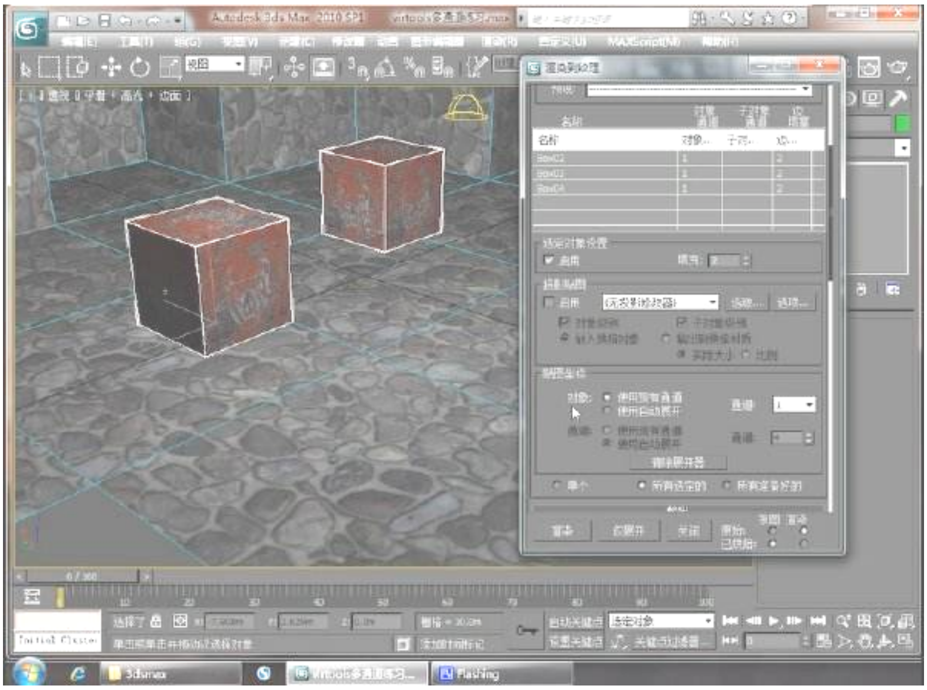

Fig. 6. Video screenshot of the experiment operation of placing boxes and decorative balls

4.2 Teaching effect

Based on Virtools software, a virtual experiment teaching model was designed in this study for the architecture course of "space design". This virtual experiment teaching model can realize the free placement of corresponding decorations in a certain architectural space. The effect of the entire experiment process is shown in Figure 7. In order to test the teaching effect of the whole virtual teaching system, two classes of "space design" were selected in this study as the experiment group and the control group respectively. A questionnaire was designed to explore the satisfaction with "space design" among students in the group that used the virtual teaching system and the group which did not used the virtual teaching system. The researchers also investigated the corresponding teaching effect evaluation among students in the experiment group which used the virtual teaching system. There are 23 students in both classes, suggesting a total of 46 participants.

Table 2 shows the teaching effect evaluation among students in the experiment group which used the virtual teaching system.

As can be seen from Table 1 and Figure 7 regarding the comparison of the experiment group and the control group, the virtual teaching system proposed in this study is more in line with students' learning acceptance characteristics. The satisfaction degree of the experiment group with "space design" is far higher than that of the control group, fully showing that using the virtual teaching system proposed in this study has some advantages in improving satisfaction with the teaching of architectural courses. It can be observed from Table 2 concerning the investigation on the experiment group's evaluation of the teaching effect after using the virtual reality teaching system proposed in this study, using the virtual reality teaching system effectively improves the efficiency of learning "space design" and other architectural courses, and enables students to combine the corresponding knowledge learned in the classroom with the formal space design process. Therefore, it not only arouses students' interest, but also contributes to the more harmonious relationship between teachers and students in the process of experiment practice. Students also made it clear in the investigation that they hope to continue using the virtual reality experiment teaching system in the subsequent course of "space design".

Table 1. Comparison between traditional teaching platform with 3D multimedia teaching platform

Group	Very satisfaction	Satisfactory	Normal	Not Satisfaction
Experimental group	63	23	11	0
Control group	36	37	27	0

Table 2. Teaching effect evaluation

Investigation content	Very agree	Agree	Normal	Disagree
Strengthen the mastery of knowledge	46.09	29.13	24.78	0
Makes the relationship between teachers and students harmonious	60.43	28.48	11.09	0
Stimulates interest in learning It is necessary to continue to use	45.13	47.17	3.7	0
Investigation content	50.43	37.83	11.74	0

5 Conclusions

The simulation resource packet technology was combined with the teaching of space design experiment course in this study. The initial analysis of the current development status of simulation virtual technology was followed by the combination of the corresponding characteristics of simulation virtual technology for the application of a virtual teaching training system based on simulation resource packet by using Virtools and then followed by the description of the use of simulation technology for physical construction and space, design, function and other computer-aided teaching and development processes. A questionnaire was employed to examine students' and enterprises' evaluation of the teaching effect, leading to the following conclusions:

1. Throughout the operation of the virtual reality experiment, the boring process of knowledge learning can be directly displayed through plenty of multimedia means, so as to improve students' learning motivation and improve their academic performance.

2. Case teaching put forward in this study exposes students to real case scenarios and improves the communication between teachers and students in some virtual teaching. Case teaching attaches great importance to the subjectivity and enthusiasm of students. It enhances the interaction between teachers and students during the analysis and discussion of teaching cases, assists students to apply the acquired knowledge to solve case problems and thereby enable students to obtain autonomous learning methods and opportunities.
3. The virtual experiment teaching model can cultivate students' sense of responsibility. Responsibility education for students is also an important aspect of quality education in schools. Notably, the major of architecture aims to solve the contradiction between structural safety and economy. Reasonable application of engineering accident cases can prompt students to consider not only objective factors, but also subjective factors appropriately.

In short, with the development of virtual reality technology, the virtual experiment teaching model proposed in this study can have a broader space for development. Therefore, this virtual reality experiment teaching model can provide a significant and feasible direction for the corresponding teaching reform.

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Construction of Multifunctional Video Conversion-based Multimedia Teaching System for College Basketball

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Abstract—Animation demonstration is an important manifestation of multimedia technology. In the past, low flexibility and long research and development cycle are typical problems of animation demonstration system and video conversion technology. Through introducing an advanced teaching method (understanding approach) and multimedia technology (video conversion system based on SOPC) for theoretical construction, this study designed a video conversion system based on SOPC, finally constructed a multifunctional video conversion-based multimedia teaching system from the aspect of module design and functional design, and used a randomized controlled experiment to test students' learning outcomes in the course of college basketball. The results show that students' offensive understanding ability and defensive understanding ability improved greatly after the system was used in teaching. It plays an important role in improving the usability and effectiveness of multimedia teaching system.

Keywords—Video conversion software; animation demonstration teaching mode; FLASH; College Basketball

1 Introduction

With the rapid development of internet and network technology, animation demonstration has gradually become a technology with urgent demand and broad market prospect in recent years. Animation demonstration mode emerged with the appearance of network media environment and has gained the rapid development. Animation demonstration is characterized by interesting contents and rich pictures. It cannot just motivate students' learning interest, but also enrich their creativity [1]. Through vivid animation demonstration, some theories which are difficult to deeply explain in traditional teaching can be demonstrated effectively so that students can grasp them better. Meanwhile, animation demonstration offers convenience for teacher's teaching. For example, many basketball teachers and coaches adopt Flash animation or other software to produce basketball animation so as to enhance technique and tactics of basketball fans.

As animation demonstration teaching mode becomes mature continuously, people's requirements for video conversion system technology becomes higher and higher. The previous video conversion system technology generally has the problems of low flexibility and long development period, which seriously restricts the application of animation demonstration in teaching practice. The emergency of SOPC-based video conversion system offers a flexible embedded solution to the techniques based on ARM, DSP and FPGA, and it has the features of flexible design, splicing, upgrade and reuse [2]. Meanwhile, the design and research of SOPC-based video conversion system can play a great role in transiting analog interface to digital interface and inject the new vigor for the development of video conversion technology.

At present, animation demonstration teaching mode has played an important role in the major teaching with high requirements for space such as civil engineering [3], fashion design [4] and sports. Students may understand new knowledge and new skills through watching animation demonstration. Animation demonstration teaching mode can effectively solve a series of problems in traditional teaching, then greatly reduce teaching cost and provide visualized and spatialized learning environment for learners.

2 State of the art

The discussion on the application of multimedia technology in PE courses such as college basketball has existed for a long time, and the researches are also rich. Zhigang et al. [5] deeply discussed necessity and feasibility of multimedia technology application in college basketball teaching, and proposed the introduction of multimedia technology could greatly enhance basketball teaching efficiency and prominently promote students' basketball knowledge and skills. The scholar also put forward the specific ways to combine multimedia technology and basketball teaching and offered the good reference for this paper. Yuan et al. [6] analyzed the feasibility of comprehension teaching method application in basketball teaching and considered such teaching method is an important way to cultivate professional talents. It contributes to improving teaching efficiency and can make students grasp basketball skills easily. Thus, it will be welcomed by teachers and students in the future. Animation demonstration teaching mode is one of hot topics researched by domestic and overseas scholars. Choi et al. [7] designed SOPC-based video conversion system, and flexibly reused IP nuclear resource to shorten the development cycle. Meanwhile, they gave full play to Micro Blaze property and simplified hardware circuit so that the design task concentrated on system function and algorithm implementation. Their research is of great significance for the development of video conversion technology. Robinson et al. [8] applied animation technology in Australian PE teaching and considered that Global Positioning System (GPS) allows coaches and sports scientists to track metrics across team and individual sports. With RunKeeper available on iPhones and Android devices, users can track speed, distance, and time during outdoor activities. The video analysis is also applied for improvement of athlete performance. Matthew et al. [9] applied video games in basketball teaching in order to confirm the relationship among basketball knowledge, skills and video games. The research result shows that the video game may be a beneficial learning tool for teachers or students. Liu [10] proposed Kinect-based 3D role model rebuilding scheme and utilized this method to accurately re-establish 3D role model in real time. Finally, motion capture data were used to drive 3D role model to generate 3D animation. The practice indicates that Kinect-based 3D role model rebuilding precision is high, with good visualization effect and high application value. In general, the previous animation demonstration teaching mode and video conversion technology have many problems. Multimedia video conversion software designed with SOPC-based video conversion system will be the development trend of multimedia teaching, and has great significance for improving system usability and enhancing students' learning interest and creativity.

Based on the development of animation demonstration teaching mode and video conversion technology, multifunctional video conversion software design is conducted in this paper. The defects of previous video conversion software are solved through introducing SOPC-based video conversion system. The innovative points of multifunctional video conversion software designed in this paper include the following: on the one hand, the application of animation demonstration teaching mode in basketball teaching can change the insufficient deepness and high understanding difficulty in traditional teaching, and construct the thorough knowledge frame for students. It greatly enhances basketball teaching efficiency. On the other hand, to expand the application scope of animation demonstration, multimedia video conversion software (Format Factory) is applied in this paper. SOPC-based video conversion system is implanted in the software to achieve video signal decoding, video format conversion, video access and output, etc. It is of great significance for teaching practice.

3 Theoretical construction for multifunctional video conversion software

For college multimedia courses and especially PE courses such as basketball, to change the problems of low teaching efficiency and insufficient learning interest, advanced teaching methods and multimedia technologies should be introduced. Comprehension teaching method is a teaching method which combines teaching and practice, and it is praised by many PE scholars. SOPC video conversion system is also widely approved. Thus, theory construction for multifunctional video conversion software is conducted from the following two aspects.

3.1 Introduction of comprehension teaching method

Different from traditional teaching method, comprehension teaching method pays attention to students' comprehension in the learning process[5]. In basketball teaching, comprehension teaching method mainly makes students grasp basic knowledge and skills through their experience of ball sport laws. For example, with comprehension teaching method, students can cognize the essence of ball sport through competitions and continuously improve competition level.

The teaching process of comprehension teaching method is as follows. Firstly, the teacher will let students view contests or videos, and explain action skills and competition rules in the meantime so as to lay a foundation for the follow-up teaching. Then, the teacher asks students to participate in ball sports to enhance their understanding of small-scale competitions. Finally, students' understanding of basketball sport rules is enhanced through formal competitions to improve students' basketball level and finally form lifelong exercise awareness. The comparison between comprehension teaching method and traditional teaching method is shown as table 1.

Table 1. Comparison between comprehension teaching method and traditional teaching method

Item	Comprehension teaching method	Traditional teaching method
Classroom subject	Student	Teacher
Key teaching point	Tactical consciousness	Skills
Training objective	Learning ability	Creative ability
Learning motivation	Active absorption	Passives listening

3.2 SOPC technology development

SOPC technology is the embedded technology of software and hardware collaboration technology, including digital information processing, high speed data reception and transmission, and complex calculation, etc. The emergency of SOPC embedded system can reduce FPGA design difficulty, and greatly shorten development period. SOPC technology has the features of flexible design, splicing, upgrade and reuse, and the system based on SOPC has significant advantages in terms of scale, performance and cost. The development of SOPC technology cannot be separated from flexible IP kernel. It is the rich and sound IP kernel that drives the development of SOPC technology. IP kernels can be classified into three types. (see table 2)

Table 2. Classification of IP kernel

Type	Description	Feature
Soft kernel	Verilog or vhdl language is used to describe circuit function, and the design is at the register level or gate level.	Short design period, high flexibility, expandability, low cost
Hard kernel	T is described with the graph. Users can only use it, but cannot change it.	Long development period, high cost and low flexibility
Fixed kernel	Compromise of soft kernel and hard kernel	Revisable, optimizable

It is known from the table that, rich IP kernel resources make SOPC-based system own the advantages of small structure, tailoring, IP and resource reuse, and can effectively reduce repeated work in the design.

The development of SOPC technology includes three links: soft or hardware collaborative development process, embedded processor model selection and control bus. In this paper, soft or hardware collaborative development process is mainly introduced.

In SOPC design process, real soft and hardware collaborative design makes FPGA-based embedded design convert to C language function description form hardware logic design. According to SOPC design process provided by Xilinx, hardware development focuses on SOPC system platform creation, and embedded processor type, bus type and peripheral can be chosen according to actual design demands. Hardware design of customized IP includes hardware description language design, synthesis, simulation and implementation. Software development refers to system application program design and API function writing to achieve function calling. Software process includes C language code writing, compiling and linking process.

3.3 SOPC-based video conversion system design

By referring to ASIC, DSP and FPGA, it is known that main functions of video conversion system include video decoding, processing and display. SOPC-based video conversion system improves its processing property through embedding MICROBLAZE in FPGA. When the system decodes different video data, conversion and access of video signals of different format are conducted correspondingly to achieve real-time video transmission and conversion among different interfaces. Thus, SOPC-based video conversion system includes four parts: video signal decoding, video signal processing, local output and display as well as expansion property. Correspondingly, SOPC-based video conversion system includes four parts: video signal decoding, video format conversion, video buffer, output and display. The system design scheme is as fig.1:

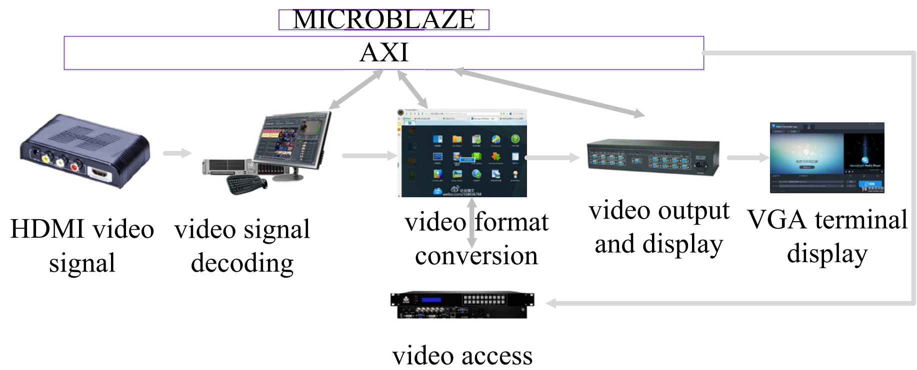

Fig. 1. Design scheme of SOPC-based video conversion system

The four parts of the system are effectively combined by SOPC platform, and video conversion speed is accelerated by parallel processing of FPGA so that it owns high real-time property. The design of video format conversion link is mainly introduced in this paper.

Video format conversion converts video signal into another format from one format. In essence, it is a matter of video sampling rate conversion. Video sampling rate conversion can be achieved through three steps. Firstly, equivalent sampling dot matrixes of input and output signals as well as corresponding middle dot matrix must be confirmed. Secondly, filter frequency response is determined based on the three dot matrixes. Finally, a filter approximating the required response is designed. The detailed design is as follows:

Non-interlaced and interlaced scanning: raster scanning mechanism includes non-interlaced and interlaced scanning. The diagram is as fig.2:

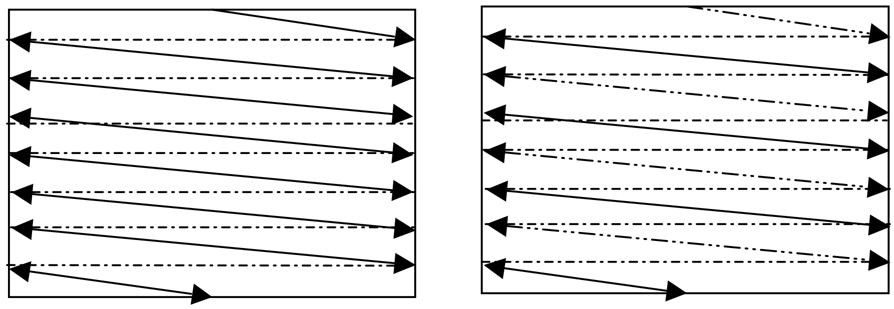

Fig. 2. Non-interlaced and interlaced scanning of SOPC-based video conversion system

In non-interlaced scanning process, electron beam or light beam scans according to the continuous motion track from the top to bottom and then to top again so as to gain conventional frame signal separated by inter-frame space △t. The gained frame signal consists of horizontal scanning lines formed by conventional vertical segmentation. Finally, image signals synthesized by a series of frames can be gained.

Interlaced scanning is based on the way that each frame is divided into two fields. Frame frequency is the half of field frequency. In interlaced scanning, the interval time between two fields is the field interval, and the time is a half of frame interval. The scanning line of two successive fields translates half line space of each field.

Video sampling: video signal actually includes 3D signals at three directions: horizontal, vertical and time. In the design process, horizontal direction is often ignored to simplify the research. △t refers to field interval, and △y refers to line interval. Sampling dot matrices of non-interlaced and interlaced scanning are as fig.3 and fig.4:

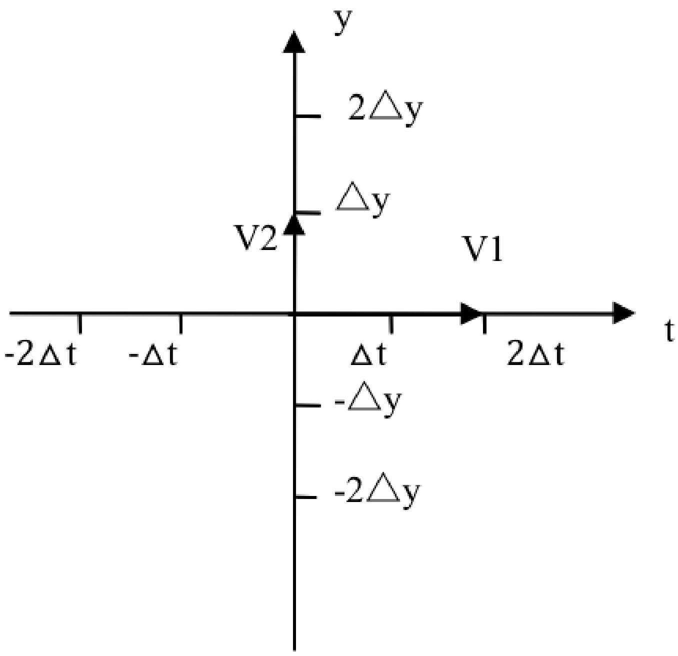

Fig. 3. Dot matrix of non-interlaced video sampling

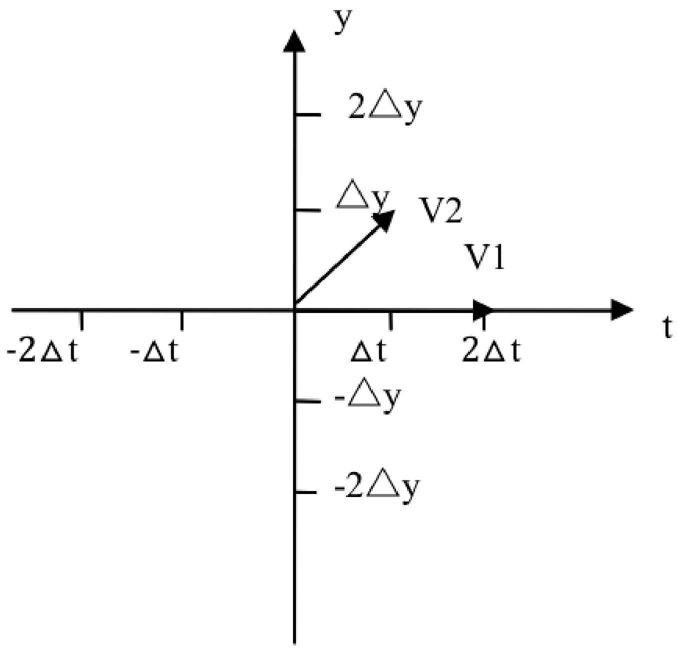

Fig. 4. Dot matrix of interlaced video sampling

The following matrix can be generated according to the base vector shown in the figures:

Non-interlaced scanning: $[V_1] = \begin{bmatrix} 2\Delta t & 0 \\ 0 & \Delta y \end{bmatrix}, [U_2] = \begin{bmatrix} \frac{1}{2\Delta t} & 0 \\ 0 & \frac{1}{\Delta y} \end{bmatrix}$

Interlaced scanning: $[V_2] = \begin{bmatrix} 2\Delta t & 0 \\ 0 & \Delta y \end{bmatrix}, [U_2] = \begin{bmatrix} \frac{1}{2\Delta t} & 0 \\ \frac{-1}{2\Delta t} & \frac{1}{\Delta y} \end{bmatrix}$

Video sampling rate conversion: deinterlacing conversion is to fill in the skipped lines in each field so as to gain the ideal interpolation filter.

$$H\left(f_y, f_t\right) = \begin{cases} \dfrac{d\left(\wedge_2\right)}{d\left(\wedge_1\right)} = 2, \left(f_y, f_t\right) \in v_1^* \\ 0, \left(f_y, f_t\right) \in \dfrac{v_2^*}{v_1^*} \end{cases}$$

4 Development of "Format Factory" conversion software in College Basketball multimedia course

4.1 Development of "Format Factory" conversion software in College Basketball multimedia course

Module design. According to the classification of core subjects, multifunctional video conversion software designed in this paper is composed of three modules: HDMI signal decoding module, video access and format conversion module, video output and display module. To be specific, HDMI signal decoding module includes HDMI receiver, IIC bus control and signal input IP, where IIC bus control part and signal input IP are on SOPC platform. Video access and format conversion module is the core of multifunctional video conversion software, including AXI-MPMC controller, AXI-Scaler IP, and AXI-VDMA IP kernel. Video output and display module includes video output IP and VGA hardware interface, where video output IP is implemented by SOPC platform. The interface of multimedia video software (i.e. "Format Factory") is shown in Fig.5.

Fig. 6 shows the operating interface screenshot of CD audio track converted to MP3, WMA, OGG and AAC in SOPC-based "Format Factory" conversion system.

Fig. 5. Main interface of SOPC-based "Format Factory" conversion system

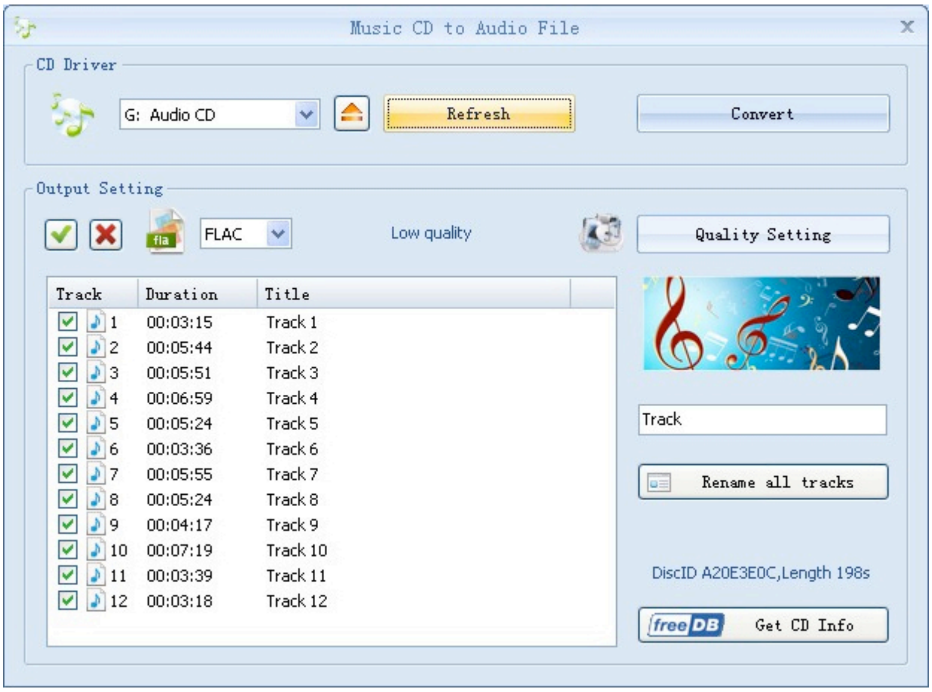

Fig. 6. Operating interface I of SOPC-based "Format Factory" conversion system

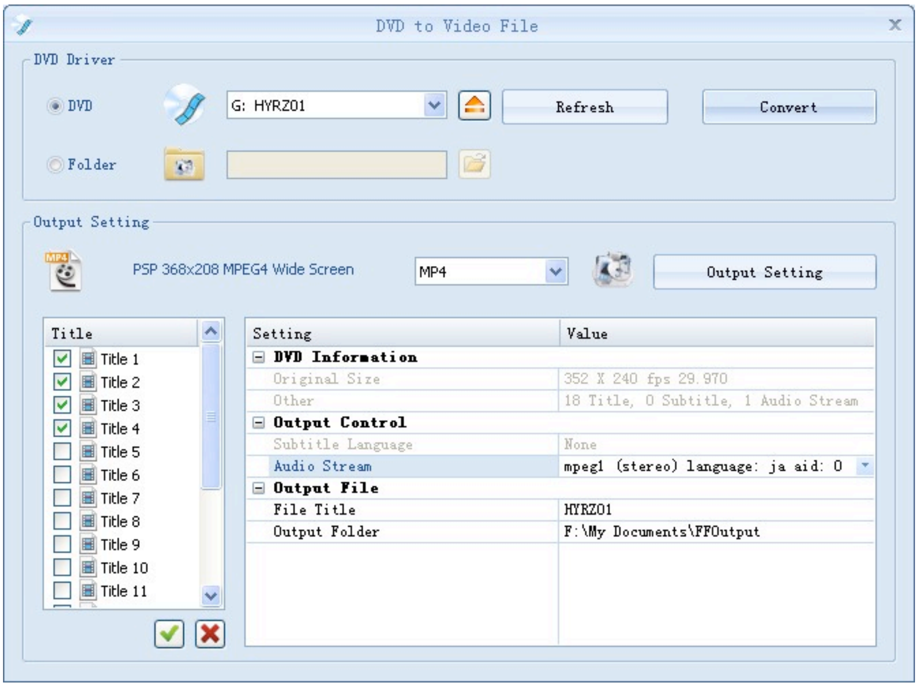

Fig. 7. Operating interface II of SOPC-based "Format Factory" conversion system

Fig.7 shows the operating interface screenshot of DVD converted to MP4, AVI, 3GP and WMV in SOPC-based "Format Factory" conversion system.

Function design. Multifunction video conversion software designed in this paper needs to implement the following functions. Firstly, it needs to implement HDM signal decoding control. The solution is that HDMI receiver control is implemented by IIC bus and then HDMI video signal is decoded. Secondly, DDR3 access is implemented by designing AXI-MPMC controller, and then video data access is achieved. Thirdly, video format conversion is implemented by AXI-Scaler controller. Fourthly, video signal is outputted after the conversion. Fig.8 shows function design process of SOPC-based "Format Factory" conversion system.

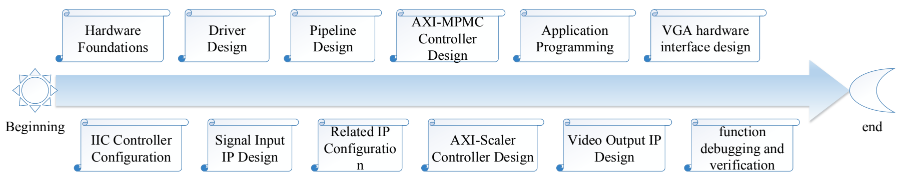

Fig. 8. Function design process of SOPC-based "Format Factory" conversion system

It is known from the figure that, function design process can be roughly divided into five links:

- Use XPS to set up hardware platform and use BSB guide of XPS to create the foundation platform for embedded design engineering. BSB cannot just save processing time, but also meet more customization needs. BSB can automatically generate the common hardware and software platform for design of most processors. The relevant peripherals include IIC controller and UART, etc.
- Import hardware design in SDK on XPS main interface, and then use SDK to design driver program for HDMI decoding control; then input IP.
- Add and configure relevant IP according to module pipeline control thought and bandwidth requirement; design AXI-MPMC controller and AXI-Scaler controller, and implement pipeline-type video access and format conversion.
- Formulate video output IP and VGA hardware interface circuit so as to meet VGA output requirements for different video resolution ratio.
- Test and verify function module; conduct system function test, modification and verification after each module is effectively linked in one video conversion process so as to implement the expected result.

4.2 Effect check

Based on completing multifunctional video conversion software design, College Basketball was chosen in this paper to analyze the application of multimedia video conversion software. College Basketball is a common PE course in colleges, including basic theories and special skills. Theory teaching focuses on the development history and tactics of basketball sport. Special skills are composed of motion, passing and catching, shooting, ball handling, breaking and defending, etc. Through basketball teaching, students could set the feasible training plan according to their ability, improve basketball ability, cultivate good sportsmanship and teamwork spirit and develop the good training habit and sport culture quality.

One male class of a college was chosen, and 50 students participating in the experiment had no obvious differences in physical quality, basketball foundation and learning ability. The actual curriculum time of College Basketball is one school year. In the period from September 2017 to December 2017, comprehension teaching method and “Format Factory” conversion software were applied. In the period from March 2017 to July 2017, traditional teaching method was used. The experiment conclusion was drawn through comparing learning effect in the two semesters. After the course ended, 5 basketball teachers were invited to evaluate students’ skill application and tactics comprehension. After removing one highest score and one lowest score, the average score of three students was chosen as the evaluation criterion.

Attack comprehension scoring shows that, except quick attack and three threats which require high cooperation ability, experimental group and control group have significant differences in sense of space and fixed cooperation, and show highly significant differences in free attack, motion without the ball and timing choice. Defense comprehension scoring of experimental group and control group:

Table 3. Attack comprehension scoring

	Experimental group	Control group	T	P
Quick attack skill	3.04±0.55	3.41±0.25	1.45	>0.05
Three threats	3.66±0.42	3.47±0.57	-0.55	>0.05
Sense of space	2.50±0.50	2.06±0.49	4.60	<0.05
Fixed cooperation	3.21±0.52	2.49±0.62	4.81	<0.05
Free attack	3.26±0.61	2.79±0.73	6.13	<0.01
Motion without the ball	3.77±0.68	2.45±1.10	5.76	<0.01
Timing choice	3.52±0.77	2.89±0.25	4.93	<0.01

Table 4. Defense comprehension scoring

	Experimental group	Control group	T	P
Defense motion	3.59±0.41	3.47±0.57	-0.55	>0.05
Defense path	2.53±0.48	2.06±0.49	4.60	<0.05
Defense momentum	3.26±0.58	2.49±0.62	4.81	<0.05
Defense position choice	3.19±0.65	2.79±0.73	6.13	<0.01
Defense flexibility	3.68±0.78	2.51±1.00	5.76	<0.01
Collaborative defense	3.56±0.67	2.76±0.65	5.43	<0.01
Defense reading ability	3.57±0.74	2.72±0.35	4.93	<0.01

Seeing from defense comprehension scoring, experimental group and control group have significant differences in defense path and defense momentum, and highly significant differences in defense position choice, defense flexibility, collaborative defense and defense reading ability. Both groups have no significant difference in defense motion with high requirements for physical quality.

On the whole, the experimental group is significantly superior to the control group in terns of attack and defense, indicating "Format Factory" conversion software has the significant advantages in improving students' basketball skill level and tactics comprehension. Through the video conversion software, the students in the experimental group not just had a deeper understanding of basketball rules, but also experienced the sense of space for basketball court more vividly. The application of comprehension teaching method and "Format Factory" conversion software could help students establish correct movement presentation in advance before the practice, simulate rational motion path and tactics path, and effectively solve the difficulty in teaching movements and expressing in words in tactics teaching. Basketball teaching scene with comprehension teaching method is shown in Fig.9.

Fig. 9. Basketball teaching scene with comprehension teaching method

5 Conclusions

The practice proves that, the introduction of comprehension teaching method and "Format Factory" conversion software in basketball teaching is very necessary. They can offer new thoughts for basketball skill and tactics teaching and has certain promotion value and practical significance. Compared with previous teaching mode, through comprehension teaching method, teachers will choose features of ball games and tactical consciousness as teaching breakthrough and design diversified teaching competitions to motivate students' interest and then give play to their subjective initiative. "Format Factory" conversion software can provide large quantities of superior resources for teaching. It further highlights the effect of animation demonstration in teaching and offers more help for students' employment and further study.

6 Acknowledgment

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An Interaction Theory-based New Distance Teaching Model for Cross Talk

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Abstract—At present, most distance education platforms are often featured by the lack of specialty, only deposit teaching resources on the server, and fail to meet students' needs of selective learning and periodical learning. Secondly, there is no Internet-based online teaching platform system in the current technology to support interactive teaching services. In order to improve the teaching effect, a teaching model was proposed in this study to apply the new distance education technology integrated with interaction theory into art performance courses. The concrete combination method was introduced using the course of Cross Talk as an example. From the comparison between the traditional teaching model and the improved teaching model, it can be seen that integration of the new distance learning model into the teaching of Cross Talk can enhance the teaching effect and improve students' learning attitude. Moreover, the courseware resources and interactive Q&A module provided via the platform can assist students to reinforce their comprehension of all the knowledge, more intuitively recognize the characteristics of Cross Talk as an art performance course and meet the requirements of modern society on art performance graduates.

Keywords—Cross Talk, teaching model, reform, teaching effect

1 Introduction

The birth of the Internet has promoted the development of information technology, which has further brought many changes to people's lives. Following the derivative products induced by information technology, travel, tourism, shopping, finance and other aspects have demonstrated new features [1]. At the same time, higher education models and teaching approaches have also gone through corresponding technical and structural innovations with the development of information technology. Based on the Internet and local area networks in the information age, the construction of digital campuses with new features has become an inevitable trend for higher education and is regarded as an effective foundation for the implementation of a new education model in colleges and universities [2], namely, the new distance teaching model proposed in this study. This model works through the Internet and realizes multiple purposes such as information management, classroom teaching and resource sharing.

Currently, many colleges and universities in China have effectively applied the new distance teaching model put forward in this study to course teaching, including a number of excellent national courses such as Advanced Mathematics [3], College English [4], An introduction to Socialism with Chinese characteristics [5] and other courses, proving that the new distance teaching model can effectively meet the corresponding teaching requirements of higher education.

Meanwhile, in the construction and development of the new distance model, the model can effectively enhance the enthusiasm of students, break the traditional one-way teacher teaching model and meet the requirements of network-based open teaching. The new distance model not only allows students to browse appropriate teaching resources provided by teachers, but also enables teachers and students to engage in interactive counseling. The new distance model proposed in this study can availably improve the teaching efficiency and teaching level in higher education course, so as to provide more skillful talents for the society.

2 State of the art

At present, Israel is the nation that started to use distance education technology earlier than others and has a wider application range. Particularly, the Israeli government implements an agricultural science and technology distance education platform throughout the country. The platform is applied not only to higher education but also to the dissemination of agricultural science and technology nationwide. Besides, the Israeli government has also established a nationwide agricultural science and technology distance education platform based on agricultural science and technology distance education [6]. Malinovski et al. [7] predicted the enthusiasm of students using the distance learning platform by constructing a structural equation model, found that the learning enthusiasm of students is directly influenced by the interaction between teachers and students, and suggested the use of this platform as one of the methods of distance teaching reform. In the field of art performance teaching, many researchers at home and abroad have put forward their own suggestions on how to improve students' learning attitude in art performance courses. For example, research proposed that distance education in the major of art should pay attention to diversified content, and highlighted the necessity to improve the teaching effect by providing students with diversified teaching experience based on the construction of theories [8]. Salman et al. [9] created Khan Academy, a type of educational institution which has a correspondingly significant impact on the field of online education worldwide. The "flipped classroom" education model thereby developed is used in the teaching of art performance, further changing people's view of the traditional teaching model. The entire video education process lasts about ten minutes. This model of education has also been recognized by students. The research on distance education platform in China started gradually from the end of the 20th century. To date, through cooperating with local education and broadcasting departments, Tsinghua University has established more than 120 distance education stations for its courses, forming a distance education network that combines the Internet with television and broadcasting networks [10]. Through distance education video classrooms, art performance students can watch online teaching by corresponding lecturers in real time via television, computer and other multimedia devices. Online teaching also enables the user to get some excellent performance videos of the teacher [11]. In addition, with access to classroom videos and courseware that have been recorded for distance education technology broadcasting, students can organize collective learning or independent learning. School of art in Xi'an Jiaotong University in China adopts a CERNET multimedia distance education platform based on the Internet and satellite network. This distance education platform can organically combine satellite communication and campus LAN, forming an open and standardized multimedia distance education system [12].

Taking a broad view, it can be seen that the development of distance education platforms at home and abroad has begun to take shape. Corresponding "virtual universities" and digitized campus websites have emerged in some higher education institutions and research institutes, accompanied by the constant expansion and promotion of using distance education platforms. However, there are still some shortcomings in this aspect. For example, most distance education platforms in China are used by those who have already graduated. These distance learners can only normal spare time, which is fragmented, so that it is difficult for them to follow the distance teaching classes on time; second, most distance education platforms are often featured by the lack of specialty, only deposit teaching resources on the server, and fail to meet students' needs of selective learning and periodical learning. Secondly, there is no Internet-based online teaching platform system in the current technology to support interactive teaching services.

To solve the existing problems in the teaching process mentioned in the introduction part, it was proposed in this study based on the literature review above that the new distance education information technology can be incorporated into the teaching process. On the one hand, the combination of modern technology and traditional theoretical knowledge can enrich the teaching content and improve students' learning attitude. On the other hand, teachers can also interact with students in time, share teaching experience with them, cultivate their interest in learning, enhance their cognitive ability to absorb knowledge, and lead them to truly apply their knowledge. More details are given in the following sections.

3 Specific Ways of Integrating the New Distance Education Technology into the Teaching of Cross Talk

The interaction theory-based new distance teaching model proposed in this study uses two main theories in order to meet the teaching requirements of art courses such as Cross Talk. The first theory is interaction theory applied in the whole course teaching process. By connecting the lecturer and the imparted knowledge with the students on the other side of the screen during the whole online course, this teaching method not only enriches the learning process in the whole class, but also enhances students' interest in learning. The second theory is a new micro-video distance education model based on database. This distance education model system overcomes some shortcomings of the original distance education course resource system including instability and slow transmission. All the course learning resources are integrated into the database, thereby effectively meeting the individual needs of students in learning.

3.1 Integrating interaction theory into distance education

Interaction theory is the main theory that runs through the new distance education model proposed in this study. In terms of distance classroom education, we need to deepen the study of interaction theory and improve the interaction between users of distance education and classroom teaching content as well as teachers. In other words, interactive teaching should be implemented in distance education. In fact, interactive teaching emphasizes mutual support and promotion among learners. Teachers should help students discuss on their understanding of the text, deepen students' comprehension of the whole teaching content through vivid examples, lead students to identify their own learning purposes, and also make timely feedback on students' learning. Corresponding classroom teaching conducted via interactive theory cannot only improve students' interest in learning, but also enhance their learning efficiency in distance education courses and reinforce their subjective initiative in distance education. The framework of applying interaction theory to the distance education platform is shown in Figure 1.

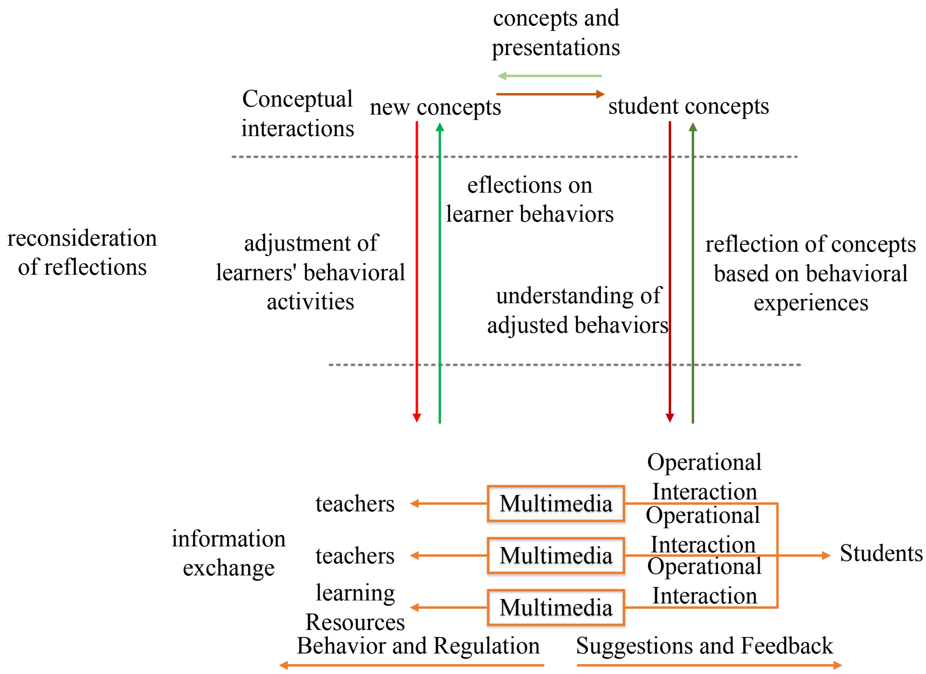

Fig. 1. Theoretical framework of applying interaction theory to distance education

3.2 Integrating distance education database technology into the teaching of Cross Talk

Distance education database technology is another technology used in the new distance teaching model proposed in this study. The main features of this database platform include: the teaching data storage end, the distance teaching data end and the open teaching data end stored on the server, wherein, the teaching data storage end consist of an account database, course database, periodical learning allocation database, learning resource database, test question database, knowledge question database, exam question database, scoring database and learning progress database. These databases are mainly utilized as storage ends to provide course selection, periodical allocation, learning resources, test questions, knowledge questions, exam questions, scoring data and learning progress data for the entire distance education model, and achieve storage and transmission of these data. The whole structure of the distance education model that incorporates database technology is shown in Figure 2.

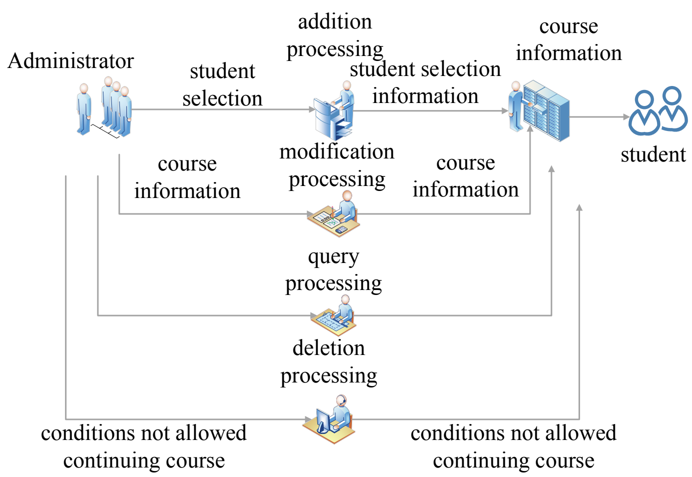

Fig. 2. Structure of the distance education model that incorporates database technology

Database technology for the entire distance education model includes different data tables, mainly stored in the form of memory. The entire process of memory storage runs mainly in accordance with the order of time to calculate the memory storage location. The calculation process is shown in Formula (1) below:

$$tm - ti = \nabla t \quad (1)$$

tm is the time for the entry of the mth data table; ti is the time for the entry of the ith data table; ∇t is the time difference between the two data tables. After determining the time difference between the data tables, it is necessary to decide the length L of the stored data table. The length of the entire data table is the sum of the length of each data table. The length of each data table is calculated in Formula (2) below.

$$IR = LT - LH \tag{2}$$

IR is the length of a single datum; LT is the tail location of a single data table; and LH is the header location of a single data table.

After determining the time difference between different data tables and the length of a single data table, it is possible to determine the relative position of its storage in memory. The distribution of locations of the entire database data memory is shown in Formula (3). Location is the location of data storage; RAM is the location of memory; i is the data sequence.

$$Location = \frac{RAM \times \sum_{i=1}^{m} (1 + IR)^{t_m - t_i}}{(1 + IR)^{t_m - t_0}} \tag{3}$$

3.3 Integrating micro-video real-time transmission algorithm into the teaching of Cross Talk

In the whole process of micro-video transmission, it is necessary to ensure the corresponding real-time and high transmission quality requirements, and the transmission efficiency must be guaranteed under limited bandwidth resources. Therefore, AIMD Algorithm was used in this study to optimize the entire data stream transmission. Specifically, AIMD algorithm can be represented by Formula (4).

$$X(i+1) = \begin{cases} X(i) \times A & T(i) > k2 \quad (0 \le A \le 1) \\ X(i) + B & T(i) \le k1 \quad (0 \le B) \end{cases} \tag{4}$$

$X(i+1)$ and $X(i)$ are the transmission rates of the data streams at different times. A and B are the corresponding algorithm calculation factors. T (i) is the packet loss rate during the entire data stream transmission process. k1 and k2 are limiting critical values.

At the beginning of the entire data stream transmission process, the multiplication factor is set as a constant and the addition factor as the transmission rate of the previous period, where C and Z are respectively set within (1, + ∞) and (0, 1), as shown in Formula (5).

$$A = Z \qquad B = C \times X(i) \tag{5}$$

At the same time, the beginning of the data stream transmission is decided according to the requirements in Formula (6). The micro-video data stream can be transmitted only when it meets the formula.

$$X(i) < \frac{X}{2} \qquad X(i) + Z < X \tag{6}$$

During the whole transmission process, the transmission rate of the data stream shows a corresponding slow growth state. The algorithm of A and B in the whole transmission implementation algorithm is determined as shown in Formula (7).

$$A = a \times (X - X(i)) \qquad B = C(0 < a < 1) \tag{7}$$

If the growth rate is too fast in the entire video data stream transmission process, which results in a large proportion of the transmission channel and bandwidth resources, the value of B needs to be increased in the entire transmission algorithm as shown in Formula (8).

$$A = a \times (X - X(i)) \qquad B = C \times X(i)(0 < a < 1) \tag{8}$$

3.4 Integrating new distance education information technology into the teaching of Cross Talk

Cross Talk, belong to art courses, was chosen as the main teaching experiment course of the distance education model proposed in this study. The preceding part has stated that the failure to vividly express the main teaching content of the whole course is the main problem in the teaching of art courses and leads to the low interest and enthusiasm of distance education learners. In this distance education model, a good learning condition is created for users mainly in the form of micro-video, with vivid, lively and diversified presentation methods. This is the most important part of the multimedia module of the entire education model. Sufficient courseware resources are provided in the entire distance education model provides, and students have access to the corresponding Q&A module. The framework and idea of the entire distance education model are shown in Figure 3 and Figure 4.

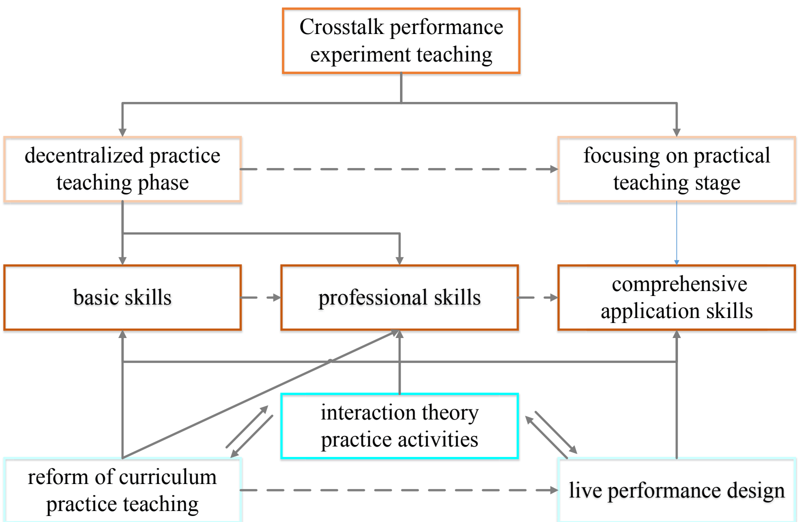

Fig. 3. Chart of the teaching content reform idea

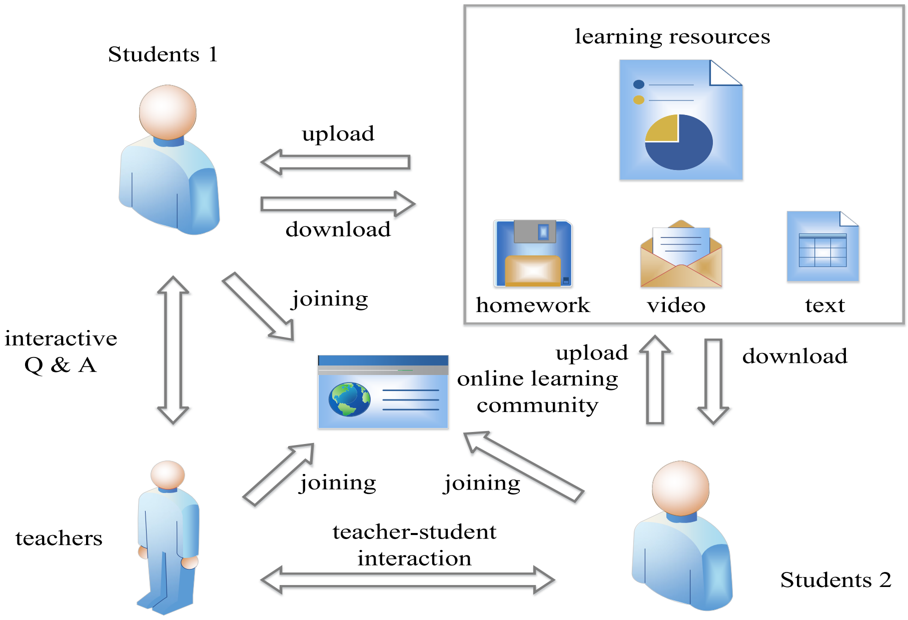

Fig. 4. Flow chart of the teaching reform idea

4 Teaching Case and Teaching Effect

4.1 Teaching case

Teaching resources throughout the course include micro-video resources and course resources, which are stored in the system database in the form of data packets. The physical form of the system database is memory. The entire teaching resource module includes two parts: course information and assignment information.

Course Information. This part of the learning module offers an overview of the course of Cross Talk, including course objectives, teaching plans, course arrangements, experiment arrangements, etc. In the online course module, students can fully understand relevant information and notifications of the course. At the same time, teachers can publish related preview materials before class so that students can synchronize with the class content in the class.

Assignment Information. This part covers the release of assignment information, uploading of students' assignment, and teachers' online correction of the assignment. Before the deadline for the assignment, students can upload their assignment at any time, and teachers can check online at any time. Besides, students can upload related multimedia audio and video works through this platform. With the teaching resource module, the platform can store video performance information recorded by students, so that teachers can trace students' learning situation in many aspects by using the distance teaching model. Figure 5 and 6 illustrate the application of micro video in the new distance education model.

Fig. 5. Screenshot I of application of micro video in the new distance education model

Fig. 6. Screenshot II of application of micro video in the new distance education model

The focus of the entire multimedia teaching module is learning based on video resources. In the video learning process, dichotomy can be found on all video learning interfaces. The upper part is the video playing interface with the width-height ratio of 800: 600. Meanwhile, the lower part of the entire learning interface offers the video title, learning duration and introduction of the main content, so that students can have a more in-depth understanding of the corresponding learning content. The existing excellent video resources of Cross Talk are also available. Teaching resources can be displayed for students in the form of text and video. The entire playing interface is simple and beautiful, facilitating students' operation in the learning process. The video learning interface of the entire system is shown in Figure 7.

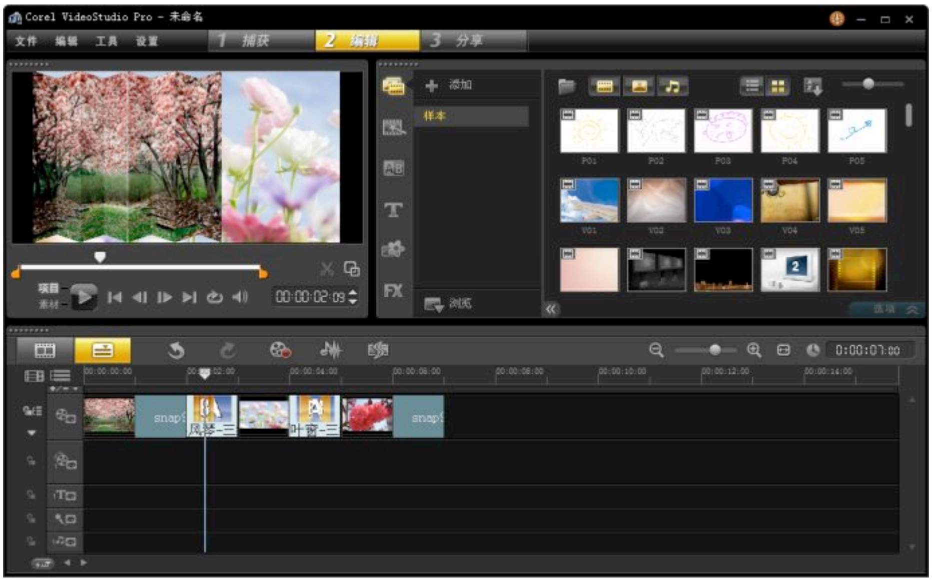

Fig. 7. On-site learning of Cross Talk in the new distance education mode

The interaction module of the entire distance education model is mainly divided into three parts: student-learning resource interaction, student-student interaction, and student-teacher interaction.

Student-learning resource interaction. Learning resources and the course content should be integrated first for students to engage in the interaction with learning resources. Due to the short playing time of the micro-video teaching content, micro-video resources should be designed in accordance with learners' cognitive development in order to ensure that the whole teaching video is lively and interesting, to convey knowledge within the effective time while making sure that the learning content is rich and complete.

Student-student Interaction. Course discussions and course performances were mainly set in this study to promote the sharing of experience and emotional communication between students. The use of discussion community is helpful for the completion of student-student communications. In addition, a collaborative video conferencing system was developed to enhance the exchange of video learning experience among students, in order to enhance the communication and interaction among students, enhance their experience and create an attractive atmosphere.

Student-teacher interaction. Teachers, as the guiders and facilitators in distance education, produce influence in the learning process and learning activities mainly through learning media, learning guidance and other forms. Students ask teachers questions concerning Cross Talk, and teachers pass the processed knowledge in a scientific way to students through micro-video or text. This is a way for teachers to act on students.

4.2 Teaching effect

Cross Talk is a course for undergraduates majoring in Quyi (Chinese folk art forms). A total of 327 users of the distance education model in 2017 as the research object to investigate the effect of using the new distance teaching model. The 327 respondent were randomly divided into two groups: 167 in the experimental group and 160 in the control group. The control group used the traditional distance education model. 327 copies of the questionnaire were sent out and 327 copies were collected, meaning that the recovery rate is 100%. 325 copies are valid, suggesting an effective questionnaire rate of 99.4%. Invalid copies are those with some omitted questions. SPSS was used in this study to analyze the research results. Table 2 demonstrates how the users scored their own learning attitude before using this new distance education model.

Table 3 shows the scores of different learning attitudes of the respondents in different dimensions after using the distance education model.

Table 1. Top 5 and bottom 5 items in the scoring of platform users' learning attitude ($\bar{x} \pm s$)

Order	No.	Item	Scores
Top 5	12	Passing the exam is enough, and there is no need to study hard	4.5±1.33
	8	Cross Talk is closely related to engagement in art work	4.4±1.31
	7	Having a welcomed show of Cross Talk gives me a sense of accomplishment	4.2±0.83
	16	Cross Talk has no technologic element and I can practice it after watching look	4.1±1.02
	12	Engagement in Cross Talk related work gives me a sense of accomplishment	4.0±0.96
Bottom 5	3	I often search Cross Talk information online	2.5±0.74
	9	I often take a variety of ways to obtain Cross Talk skills	2.9±1.23
	4	I will ask the teacher when encountering a problem I do not understand	3.0±0.53
	2	I review the learning content only before the exam	3.2±1.44
	18	I will preview before each class	3.3±1.13

Table 2. Comparison of scores of the two groups' learning attitude in each dimension ($\bar{x} \pm s$)

Item	Leaning interest	Learning experience	Personal learning habit	Knowledge of Cross Talk	Mean
Experimental group (n=165)	4.89±0.63	4.54±0.57	4.57±0.52	4.47±0.33	4.76±0.56
Control group (n=160)	4.1±0.32	3.79±0.34	3.96±0.53	3.19±0.23	3.68±0.62
T	0.775	0.865	0.689	1.345	1.187
P	0.274	0.075	0.001	0.513	0.063

From the students' evaluation of their learning experience in the whole course, it can be observed that there is a gap in the course learning experience between those who used the new distance education model and those who used the traditional distance education model. Compared with the latter, the former could gain more control over the whole course, and obtain more in-depth understanding and comprehension of the corresponding Cross Talk knowledge. As for the students who used the traditional distance education model, it was concluded from the respondents' feedbacks that the corresponding theoretical knowledge of Cross Talk is rather complicated and the traditional learning way does not assist the users to have a clear understanding of the entire course, leading to the poor learning experience of these students in the course of Cross Talk.

Judging from the personal learning habit and understanding of Cross Talk among the respondent after learning the course, it can be seen that there is still gap between the experiment group and the control group in relevant scores. The average score of those students who used the new distance teaching model in personal learning habit and knowledge of crosstalk is higher than that of those who used the traditional distance education model. From the single level of learning effect, we can see that the new distance education model brings more obvious improvement to students.

5 Conclusions

By comparing the traditional teaching model and the reformed teaching mode, it was found that the Cross Talk teaching model based on the new distance education information technology can make up for the deficiencies of the traditional teaching model and improve students' learning attitude, concretely manifested is the following aspects:

1. The distance education model effectively combines the usual learning of theoretical knowledge with actual cross talk, efficaciously enhancing students' learning effect in the art course of Cross Talk.
2. Using the reformed interactive teaching model, teachers can trace students' learning progress at any time, and adjust the teaching content according to students' understanding and comprehension of new knowledge. At the same time, the model can improve students' ability to innovate and solve problems, and correspondingly expand teachers' understanding of students in order to better "teach students according to their aptitudes."
3. The use of the teaching model put forward in this study reinforces students' cognition of their major, enables them to more intuitively recognize the art charm of Cross Talk, and leads them to meet the social needs for graduates of art performance.

In conclusion, this reform of the teaching model for Cross Talk has been approved by teachers and students, and the teaching effect shows that this teaching model can be promoted in the teaching of other majors.

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The Augmented Reality for Teaching Thai Students about the Human Heart

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Abstract—Biology is a science about living organisms. Organisms have complex systems consisting of complex organs. Focusing on the human body, if the organ or its structure is visually presented, the learners are more likely to understand it and its function. This research aims to explore the bilingual (Thai and English language), development of an augmented reality tool for use in teaching students about the human heart. The augmented reality application was evaluated by five experts, who analyzed its content consistency by using the Index of Item Objective Congruence (IOC), Diffusion of Innovation (DOI), and the content validity index (CVI), indicating that the augmented reality can be used for publicizing. A sample of 30 subjects were evaluated after AR training. It was determined that the learning result post AR obtained higher ratings when compared with the ratings prior to the use of augmented reality tool. The before and after augmented reality learning results were analyzed for statistical significance at p value < 0.001 with the use of a T-Test. Afterwards, the effectiveness of the tool was evaluated by users focusing on the acceptance of the augmented reality tool to teach the anatomy of the heart; the evaluation of which was based on the theory of Unified Theory Acceptance and Use of Technology (UTAUT) in which the results of the arithmetic mean and the standard deviation were 4.65 and 0.48, respectively. This demonstrated that the users generally accepted the augmented reality tool to teach about the heart at the highest level.

Keywords—Augmented Reality, Human Heart, Teaching, Biology

1 Introduction

The educational management or the lesson planning for students in this era rely on modern tools instructors to attract the attention of the learners and give the best knowledge and learning experience to the learners. With the help of modern technology, the production of media must consider the major objective of using media which is to develop the learners' proficiency in all aspects [1]). The learners tend to understand the content via memorization of pictures and gain visual perception and real understanding. This means less of a burden on the teachers while reducing the difference between the learners [2].

Biology is a science that studies about living. The study of morphology, physiology, growth, behavior, evolution, ecology, and so on, concerning the living organisms at the cellular and organic levels, contain a wide range of content and detail which can lead the learners to have a negative attitude towards the subject. Moreover, the teachers might use media that does not promote learning. That tends to affect their understanding about biological principles. There is a lot of knowledge content, but the fundamental principle of biology (which is the closest to us) is the human body, and in particular the 'heart'. Humans are multicellular living organisms. It consists of multiple cells in the form of tissues. The organs and their systems are complex. Furthermore, the heart is an important organ which plays a huge role in continuously circulating blood to other organs in the body. The human heart is located in the chest span and slightly to the left. It is divided into four chambers: two on the top and the other two at the bottom. If there is some abnormality happening within the heart, it can be fatal. Heart disease is one of the main causes of death among Thai people as the average death rate is one person in seven, with the trend increasing annually. Due to its importance, the heart as well as its structural characteristics and functions should be well studied for better understanding about its function in order to protect and maintain it. In biology class, focusing on the human body, if the organ or its structure is visually presented, the learners tend to understand it and its function better [3]. However, for the internal organs, it is difficult to see their shapes, sizes, structures, and functions; even though there are figures and descriptions in textbooks, related documents or on the internet, as most of them are presented in the form of two dimensional images in which their characteristics or functions cannot be clearly seen [4]. In other words, this potentially affects the proficiency of the learners. In fact, the appropriate form of instructional media is the ability to effectively enhance learners' perception towards the use of computers. Computer Software should be developed to promote higher efficiency, facilitate the data processing system, and effectively present information, pictures, sound, and messages. For example, the virtual technology (Augmented Reality) is one of the innovations that can be applied to the area of education to stimulate, support, and promote learning experiences [5]. Barsom et al. did a systematic review on the effectiveness of augmented reality applications in medical training. They reported that augmented reality applications support blended learning in medical training and have gained public and scientific interest. In order to be of value, applications must be able to transfer information to the user. While promising, supporting evidence to date is lacking [6]. Wee et al. presented augmented and virtual reality in surgery the digital surgical environment including applications, limitations and legal pitfalls. A head mounted display (HMD) with either VR or AR (virtual or augmented reality respectively), will have great potential in the field of surgery. Their functionality has the potential for benefit in a range of clinical settings across the MDT and in medical education. First generation devices like GG have given us a glimpse of what AR can provide and despite its demise our appetite for new head mounted devices has not diminished [7]. New innovations like the Microsoft HoloLens and the emerging mass market of VR headsets would indicate that these technologies will become familiar to surgeons and inevitability we will find a way to integrate them into our day to day practice. The challenge of identifying compelling and valuable experiences for these modalities now begins along with validation of their benefits in all aspects of surgical care. The digital surgical environment is about to drastically change. Joyce reported that augmented reality magnetically tracked scalpels reduce tool switching though limitations in today's augmented reality technology fall short of creating an ideal immersive workflow by requiring the use of a monitor [8]. While this technology catches up, we recommend focusing efforts on enabling the easy creation of layered, complex reports, linking, and viewing information across systems. Reflecting upon our results, we argue for digitalization to focus not only on how to record increasing amounts of data but also how these data can be accessed in a more thoughtful way that draws upon the expertise and creativity of pathology professionals using the systems. There are also many companies that have developed augmented reality to teach students about the human body. There are no research studies on the development of augmented reality as a tool to teach the human body using Thai language.

The research had developed the augmented reality tool to teach the human body, especially the functioning of the heart in a bilingual setting (Thai and English language), with the use of the Android operational system which is available on smartphones and tablets. It can assist the students and interested people in studying about the human body with visual aids and without limitations in location. The tool can enable the students to gain more knowledge and understanding, and ultimately increase their interest in the subject. This study also aims to increase the learning potential for learners to catch up with the digital era. In addition, it can reduce the long term expenses and contribute to the learning society that stimulates, supports, and promotes education through media. It may also further expand the proficiency of the learners.

2 Methodology

The research methods for studying the development of the augmented reality tool to teach students about the heart, include the following steps:

2.1 Documentary Research

The analysis and data collection on human heart function was performed by the research by reviewing related theories and previous studies on human heart function to utilize data in developing the augmented reality tool. The human heart is comprised of four chambers [9, 16]: 1) The chamber on the top right (Right Atrium) 2) The chamber at the bottom right (Right Ventricle) 3) The chamber on the top left (Left Atrium) 4) The chamber at the bottom left (Left Ventricle).

2.2 The Design of the Augmented Reality for Teaching Thai Students about the Human Heart

Based on collected information about human heart function, the heart components, heartbeat, and the blood circulation, the augmented reality model was constructed and installed in the system. The subjects were able to use their smartphones or tablets with the scanning application to scan the images used for enhancing the memorization process on heart structure. After scanning, the heart structure showed up in the form of three dimensional pictures.

2.3 The Development of the Augmented Reality for Teaching Thai Students about the Human Heart

Based on the design of the augmented reality tool for teaching about the heart, the information about the heart components, the heartbeat, and the blood circulation in each chamber were used for constructing the model of the augmented reality tool to teach heart anatomy. Subsequently, there was a construction of the contents promoting memorization skills by linking pictures together into the model of a heart. The users could use the augmented reality via smartphones or tablets with a scanning application to scan the heart pictures for virtual memorization of the structure, the heartbeat in each chamber, the blood circulation, and other functions of each chamber. The subjects had a choice in displaying the Thai or English language. Augmented Reality displays the blood flow with each heartbeat in each chamber as shown Figure 1 to Figure 3.

Fig. 1. Interface of the augmented reality for teaching Thai students about the human heart

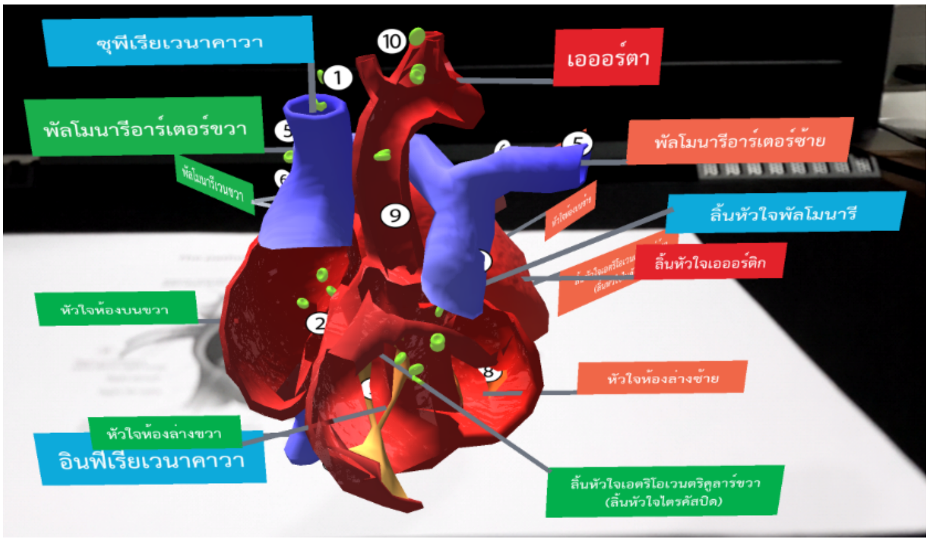

Fig. 2. Display Thai language in the augmented reality for teaching Thai students about the human heart

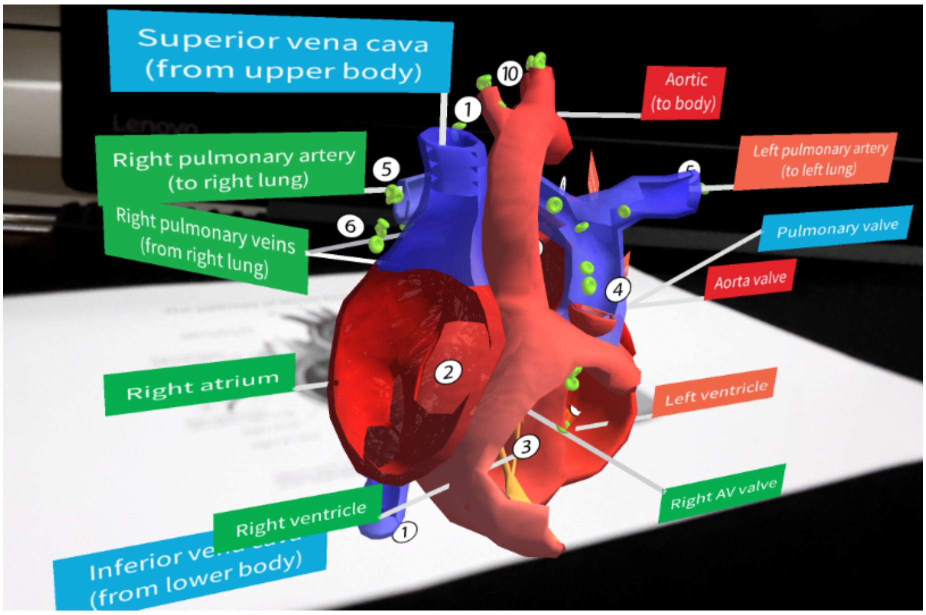

Fig. 3. Display English language in the augmented reality for teaching Thai students about the human heart

2.4 Evaluation of the Effectiveness of the Augmented Reality for Teaching Thai Students about the Human Heart

The effectiveness of the augmented reality was evaluated by five experts who were specialized in the field of information technology and biology. The evaluation used the analysis of content consistency (Index of Item Objective Congruence: IOC) [10] by which the experts to provide scores. If the criteria determined by the IOC value of each indicator was higher than 0.5 (the highest IOC value is 1), it means the augmented reality tool met the objective, possessed content suitable for education purposes, and that the augmented reality tool worked effectively. The IOC value of each indicator was 0.8, indicating that the developed augmented reality tool met the objective and in content consistency and is suitable for use in education about the heart.

Subsequently, the experts also used the Diffusion of Innovation theory (DOI) to evaluate five parameters [11]), being 1) more advantageous or have better performance 2) usability, 3) noticeability, 4) consistency with the demand or experiences of the learners who would potentially adopt the innovation, and 5) the result of which could be shown in advance [12]. It is necessary to see if the innovation could be adopted by the sample group. The data was analyzed to find the mean value and the standard deviation value in order to assess the innovation dissemination of the augmented reality tool to teach about the heart. The evaluation results of the DOI in all five aspects evaluated by the experts were 1) the arithmetic mean and the standard deviation of "more advantages or better performance" were 4.40 and 0.55, respectively. It showed that this criterion was rated at a high level. 2) The arithmetic mean and the standard deviation of "usability" were 4.40 and 0.55, respectively. It showed that this criterion was also rated at a high level. 3) The arithmetic mean and the standard deviation of "noticeability" were 4.40 and 0.55, respectively. It showed that this criterion was rated at a high level. 4) The arithmetic mean and the standard deviation of "the consistency with the demand or experience of the subjects who would potentially adopt the innovation" were 4.20 and 0.45, respectively. It showed that this criterion was rated at a high level. 5) The arithmetic mean and the standard deviation of "the result which could be shown in advance" were 4.40 and 0.55, respectively. It showed that this criterion was rated at a high level. The arithmetic mean and the standard deviation of the overall image of the innovation dissemination were 4.36 and 0.49, respectively. It showed that the augmented reality tool to teach about the heart was accepted to be used at a high level.

2.5 The Dissemination of the Augmented Reality for Teaching Thai Students about the Human Heart

The researcher tested the augmented reality to teach 30 subjects about the heart. The subjects were students at elementary level. Permission to conduct the study was obtained prior to the study the sample group was randomly selected from volunteers. Training was provided via a lecture and workshop demonstrating how to use the augmented reality tool to teach about heart function [13] as shown Figure 4.

Fig. 4. Workshop demonstrating how to use the augmented reality tool to teach about the heart

2.6 The Learning Results of the Sample Group after Learning with the Augmented Reality Tool to Teach about the Heart

The research had developed the pre-test and post-test to obtain learning results. The tests had passed the Content Validity Index (CVI), evaluated by the five experts [15]. From the assessment of the Content Validity Index evaluated by all the experts, it was determined that the CVI value was 0.83 as there were ten questions out of twelve questions receiving the scores at 3 or 4. As the result was higher than 0.8 (the highest CVI value was 1), the ten questions had passed the CVI. Before being trained, the sample group had to finish the ten questions pre-test. Subsequently, they would enter the training session with the augmented reality tool. It took three hours. After the training, the subjects did the post-test which had the same questions as the pre-test, but the order of questions and the answers were changed. After collecting the post-test, the trainers provided the subjects with the correct answers. Completed tests were assessed, scores recorded, and data analysis was performed by using the T-Test to find comparisons between the pre-test and post-test learning results.

2.7 Evaluating the Effectiveness of the Augmented Reality for Teaching Thai Students about the Human Heart Based on the Unified Theory of Acceptance and Use of Technology *(*UTAUT*)*

To evaluate the effectiveness of the augmented reality for teaching Thai students about the human heart based on the UTAUT [14], the research developed a questionnaire on the acceptance of the augmented reality tool to teach the sample group about the heart and evaluate the four aspects of the tool which are 1) anticipation on performance, 2) anticipation on effort, 3) social influence, and 4) the condition of facilities during the application. There were two questions for each aspect in the test. Subsequently, the data was analyzed to find the mean and the standard deviation values to determine the assessment effectiveness on the acceptance of the augmented reality tool.

3 Results

The results of the development of the augmented reality to teach Thai students about the human heart, include the following.

3.1 The Test Results of the Augmented Reality for Teaching Thai Students about the Human Heart

The pre-test and post-test results after the augmented reality training from thirty subjects revealed that the post-test results of the sample group after training was better than their pre-test results. The results were analyzed by comparing the number of the subjects who could answer the questions correctly with their individual results. The learning results showed that the subjects had more correct answers after the training. From the comparative test results collected before and after the training, according to the statistical test of the following hypothesis:

The hypothesis was assumed as followed:

H0: The learning result before and after using the augmented reality tool were not different.

H1: The learning result before and after using the augmented reality tool was different.

Statistically tested by T-Test, the main hypothesis (H0) was rejected because the significance value was lower than the significance level (α) which was previously determined. In this study in which $\alpha = 0.05$, the H0 was rejected and the H1 was accepted. The efficiency of the developed model was different in their methods. From the Table of Pair Sample Testing, the significance value was analyzed to consider whether the mean values of the two groups were different. In fact, it was found that the significance value was lower than the predetermined significance level. Therefore, the mean values of the two groups were different. Considering the comparative differences of the learning results both before and after the use of the augmented reality, it was found that there were differences at the statistical significance p value < 0.001.

3.2 The Evaluation Results of the Acceptance and the Use of the Augmented Reality for Teaching Thai Students about the Human Heart

The results of the acceptance and the use of the augmented reality were evaluated in four aspects which are: 1) the anticipation of the performance; its arithmetic mean was 4.65 and the standard deviation was 0.48. It showed that the acceptance of the performance was rated at the highest level; 2) the anticipation of the effort; the arithmetic mean was 4.63 and the standard deviation was 0.49. It showed the anticipation of the effort was rated at the highest level; 3) the arithmetic mean and the standard deviation of the social influence were 4.67 and 0.48, respectively. It showed that the social influence was accepted at the highest level. 4) The arithmetic mean and the standard deviation of the condition of facilities for the application were 4.63 and 0.49, respectively. So, the acceptance of facilities in application was rated at the highest level. The overall image of the evaluation effectiveness results on the acceptance of the users in regard to the augmented reality tool had the arithmetic mean value of 4.65, and its standard deviation was 0.48. It showed that the users accepted the augmented reality as a tool to teach about the heart at the highest level as shown in Table 1.

Table 1. The Evaluation Results of the Acceptance and the Use of the Augmented Reality for Teaching Thai Students about the Human Heart

Items	Mean	SD	Decision
1. The anticipation of the performance	4.65	0.48	The highest level
2. The anticipation of the effort	4.63	0.49	The highest level
3. The social influence	4.67	0.48	The highest level
4. The acceptance of facilities in application	4.63	0.49	The highest level
Total	4.65	0.48	The highest level

4 Conclusion

This paper presents the development of the augmented reality tool to teach about the human heart in a bilingual setting (Thai and English language). It was evaluated by the five experts who had the experiences in teaching and researching about the virtual biological technology using the content consistency analysis (Index of Item Objective Congruence: IOC). The IOC value of each content was 0.8. The results indicated that the constructed AR was consistent with the objective and correspondent with the anatomy of the heart and evaluated by using the Diffusion of Innovation theory (DOI) in order to find out whether this innovation can be adopted by the sampling group. The assessment results were the arithmetic mean valued at 4.04 while the standard deviation was 0.35. This shows that the augmented reality as a tool to teach about the heart was accepted for the dissemination at a high level. The system was tested with a group of 30 subjects who learned from the system and an experiment with a pre-test was conducted. The results of the study showed that the subjects who used the augmented reality got better results for learning. Correspondingly, there are four aspects of the effectiveness evaluation focusing on the acceptance of the augmented reality as a tool to teach about the heart measured by the theory of Unified Theory Acceptance and Use of Technology (UTAUT). The overall image of the effectiveness assessment results on the acceptance of the users was rated at the highest level as it the arithmetic mean and the standard deviation were 4.65 and 0.48, respectively. To conclude, the development of the augmented reality as a tool to teach about the human heart can contribute to the effective learning and better results in understanding.

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In MOOCs we Trust: Learner Perceptions of MOOC Quality via Trust and Credibility

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Abstract—In this study we sought to examine MOOC learners' levels of trust in the platforms, institutions, and instructors involved in MOOC design and delivery. We sought to examine what influenced learners' conceptualizations of trust in MOOCs and how this might influence their future intentions towards the related MOOC providers. To this end we examined whether an increase in perceived source credibility of the MOOC increased trusting beliefs of the MOOC learner. Furthermore, we examined whether increases in trusting beliefs of the MOOC learner would lead to an increase in their future trusting intentions. This second question has implications for whether a learner persists in their learning or decides to commit to further study pathways such as paid certificates. In addition to testing these two hypotheses we sought to determine the most significant underlying drivers that learners reported as affecting their trust in MOOCs they undertook. Drawing on concepts of trust from the literature, we adapted and developed a survey instrument and recruited MOOC learners to respond. Following analysis of 76 responses we found a positive correlation between source credibility and learner trust in MOOCs. Further there was also a positive correlation found between trust in MOOCs and learners' professed future intentions. Finally, we determined several component factors of MOOC trust drivers as reported by MOOC learners. Our work holds potential implications for MOOC platform developers, instructors, and designers in signposting areas where MOOC learners have positive and negative experiences of MOOCs, which can in turn influence their future relationship with the MOOC providers.

Keywords—MOOCs, Trust, Credibility, Online Learning, Quality

1 Introduction

The phenomenon of the MOOC has marched steadily along, continuing to rise despite cycles of hype and hysteria. Reports show that MOOCs continue to grow both in terms of numbers of courses being offered and the total number of learners enrolled on all MOOCs For instance, the increase in the total number of courses has been estimated at 6,850 from over 700 universities in 2016 which would put the total number of people who have enrolled in at least one MOOC at 58 million [1]. The cMOOC and xMOOC classifications, and other derivatives, show that this is a contested area and not a uniform phenomenon. This is evidenced, for example, by two systematic literature reviews of the research into MOOCs that show the breath of this research landscape, and highlight its diversity during the period between 2008 and 2015 [2][3]. In spite of some uncertainty and concern about their true role in education and viable business models, MOOCs appear now to be a mainstay feature of the higher educational landscape. Indeed, the business model and case for MOOCs [4] has gained increasing attention with the arrival of MOOCs for credits, as tasters to fully online degrees, or as freemium services whereby participants pay for extras such as certificates. In this context it is important to examine how MOOC learners may or may not decide to deepen their relationships with MOOC providers. It is important to explore how learners trust or distrust MOOCs and how this might impact on their future intentions towards the providers including in contexts where they may be required to pay for content, services, or certificates. Some research has examined how MOOCS might engender attitudinal change in learners towards specific issues, such as animal welfare [5] or human trafficking [6]. However, no research has been conducted to date on attitudinal change that is not directly related to course objectives. This study sought to address this gap.

Researchers have examined trust and credibility in online environments in a variety of domains, such as trust in ecommerce websites and trust in online medical information. In general, this research aims to model the user's beliefs in some way, usually based on how their pre-existing beliefs are changed through their online interactions and how this may affect their future beliefs and ultimately actions [7][8][9].

Little if any research has been undertaken to date using the well-developed concept of trust in online learning environments, or more specifically to informal online learning such as takes place in MOOCs. This is significant as certain issues that dominate MOOC research would seem to be impacted by the belief model of the learner. The first of these issues is determining how learners might better persist and complete MOOCs. A second question, whether a MOOC learner may be persuaded to engage in a longer, more formal study route or pay for certification, may also be seen as potentially being impacted by learner trust in the MOOC provider.

An important component of trust is credibility, which can be seen as a perceived quality in that it does not reside in an object, person or piece of information [7]. Source credibility has been defined as a two-dimensional concept comprised of perceived expertise (skill) and perceived trustworthiness (morality, goodness). To make a judgement of an item or a person, people tend to evaluate these two elements first and then combine them to make an overall assessment of that item or person's credibility. The research explicated in Ref. [8] extends this model to include a third component, dynamism. Dynamism describes the extent to which a source is "fast, energetic, bold, colourful and confident". It references the *way* in which a message is delivered [9]. These three components of credibility can be used to examine how a person determines their trust in an entity. This study hence sought to examine the credibility of MOOCs according to the following research question: RQ1: Does perceived credibility of the MOOC increase trusting beliefs of the MOOC learner?

A second question relates to the impact on future behaviour arising from trust levels in the MOOC. In trust based research this impact is known as trusting intentions i.e. what will the person do next? Will they buy a product, recommend an item to their friends, disclose information or otherwise make some decision based on the trust beliefs they hold? This led us to the second research question: RQ2: Do trusting beliefs of the MOOC learner increase their trusting intentions towards MOOC providers?

In the methodology section below, we show how we adapted pre-existing research instruments to gather data and analyze constructs relating to trust and intentions. Because this domain is quite different from those in which trust has been examined to date we also wished to more broadly examine trust in MOOCs by asking MOOC learners themselves what affected their trust in MOOCs. To this end we developed the following research question: RQ3: What are key trust drivers according to MOOC learners? The development and use of the instruments to answer the above three research questions will next be outlined.

2 Methodology

This current study adopted a similar procedure to that which was performed in Ref. [9]. It framed the MOOC website itself as the message being communicated. The source of the message was the MOOC provider (and also the education institution that provided the course), the receiver of the message was the MOOC learner, and the desired outcome of the providers (i.e. the intended persuasion) was that the learner maintained trusting beliefs, and eventually would intend to further engage with the provider, for example by finishing the course or taking a paid certificate (i.e. would have trusting intentions that lead to behavioural follow-through).

To examine *Source Credibility* (RQ1) we asked participants to indicate how they felt about the course provider on a scale related to items in three categories: *Expertise*; *Dynamism*; and *Trustworthiness*. Here we followed the scale developed by Ref. [8]. For *Expertise* participants rated the course provider according to the items: *Trained*; *Experienced*; *Authoritative*; *Skilled*; *Informed*; *Competent*; *Knowledgeable*; *Capable*; *Successful*; *Effective*; *Efficient*; *Strong*; and *Orderly* (13 items). For *Dynamism* ratings were of: *Fast*; *Bold*; *Active*; *Aggressive*; *Decisive*; and *Confident* (6 items). For *Trustworthiness* ratings were made of the items: *Safe*; *Just*; *Honest*; *Reasonable*; *Trustworthy*; *Good*; *Sympathetic*; *Stable*; *Kind*; *Rational*; *Reliable*; *Reputable*; *Dependable*; *Friendly*; *Sensible*; *Responsible*; and *Consistent* (17 items). In addition, we asked participants about their *Trusting Beliefs* relating to course providers according to the constructs of *Benevolence*, *Integrity* and *Competence*, as developed by [4], and used questions adapted from their survey instrument. To solicit information on how leaner trust might influence future behaviour (*Trusting Intentions* - RQ2) we used the constructs *Willingness to Depend* (i.e. on a MOOC or MOOC supplied information), to *Follow Advice*, and *Willingness to Make Purchases* (i.e. to buy a MOOC certificate or enrol in a fee-paying degree with a MOOC providing institution). The three constructs used are detailed in Table 1:

Table 1. Trust constructs

Scale	Subscale	Source
Source Credibility of MOOC	Expertise	Ref. [2]
	Dynamism	
	Trustworthiness	
Trusting Beliefs in MOOC Provider	Benevolence	Ref. [4]
	Integrity	
	Competence	
Trusting Intentions towards MOOCs	Willingness to depend	Ref. [2]
	Follow advice	
	Make purchases	

Finally, we posed open-ended, free-response questions to participants prompting them to share instances of where they felt high or low levels of trust as a MOOC learner. These questions sought to uncover MOOC specific trust drivers (RQ3). In their work to identify online trust drivers from the perspective of French online consumers, the authors of Ref. [11] identified 15 drivers of online trust categorised as brand equity, layout design, content, expertise, site navigation, cultural markers, trustworthy partnerships, security, ease of contact, personalisation, advice capabilities, community features, usefulness, fulfilment capabilities, and privacy protection. We sought to use categories from this framework to qualitatively code the free text responses that address RQ3.

3 Findings

Responses to the questionnaire were collected during May and June of 2017 and participants were recruited through social media (Facebook and Twitter). The questionnaire was attempted 74 times of which 61 provided admissible response data for the study.

The survey results corresponding to RQ1 and RQ1 were first analysed for internal reliability of the constructs and then for correlation via scatter plots and statistical tests. The results of the open-ended trust questions (RQ3) were coded manually by a researcher assigning them to one of the 15 categories of Trust Drivers developed in Ref. [11].

Reliability of the scales was checked by measuring the Cronbach Alpha value for each of the scale variable scores. As per Table 2 all Cronbach Alpha values were above 0.8 suggesting good internal consistency reliability of the scales.

Scatterplots were generated to determine the relationship between *Source Credibility* and *Trusting Beliefs* (RQ1) and the relationship between *Trusting Beliefs* and *Trusting Intentions* (RQ2). Both indicated a positive linear relationship and Pearson Correlation Coefficients were calculated. For RQ1, whether *Source Credibility* affects *Trusting Beliefs*, r was +.511, a positive correlation, suggesting support for the RQ1 hypothesis, i.e. perceived credibility of the MOOC was associated with trusting be-

Table 2. Scale reliability

Scale	Subscale	Cronbach's Value	Mean Inter Item Correlation	Number of items in the scale	No. of valid cases
Source Credibility of MOOC	Expertise	.978	.792	12	39
	Dynamism	.821	.456	6	39
	Trustworthiness	.977	.714	17	39
Trusting Beliefs in MOOC Provider	Benevolence	.800	.593	3	55
	Integrity	.858	.604	4	56
	Competence	.840	.566	4	54
Trusting Intentions towards MOOCs	Willingness to depend	.819	.533	4	56
	Follow advice	.900	.678	5	54
	Make purchases	.802	.576	3	56

liefs of the MOOC learner. For RQ2 a correlation coefficient value r of +.603 was found, indicating a positive relationship between the two variables i.e. trusting beliefs of the MOOC learner are associated with higher levels of trusting intentions towards MOOC providers.

3.1 Trust drivers

RQ3 attempted to uncover MOOC trust drivers from direct, unstructured user testimony. There were 30 responses to the question that asked users to describe things they felt made them trust or distrust a MOOC or its providers based on their experience. These responses were analyzed and coded to one of the 15 Trust Drivers identified in Ref. [5]. Two further categories were added that are specific to MOOCs: *Certification* and *Instructor Quality*. In addition, the category *Brand Equity* (*Quality*) was further subdivided into *Institution Brand Equity* and *Platform Brand Equity* to examine distinctions between learner trust in MOOC platforms and the university/institution to which the instructor(s) were affiliated. These are detailed in Table 3.

A count of each of the drivers detected and the results are summarized in Figure 1.

Table 3. MOOC Trust Drivers

Platform Brand Equity	Platform brand Awareness, Platform brand liking, Positive platform brand associates, Platform reputation
Institution Brand	Institution brand Awareness, Institution brand liking, Positive Institution
Equity	brand associates, Institution reputation
Layout Design	Quality of graphics and layout, Design elements, Graphical coherence
Content Quality	Course material content, Information quality, Relevance, Reliability, Transparency, Platform and institution information (e.g. "about us" section)
Providers' Expertise	Course quality, Description of the platform's or institution's competencies, Excellence awards, Professionalism, Long-term experience
Navigation	Logic of navigation and content presentation, Organisation of content, pages and menus, Disturbance through pop ups, "How to use" section, website ergonomics

Cultural Markers	National references, Recognition of local tradition and culture, Language translation facilities, Local phone numbers
Trustworthy	Institution and Platform partners, Links to partner sites, Partner logos,
Partnerships	Partner's network affiliations
Security	Security statements/symbols/seals, Payment procedures and options, Data encryption, Transparency of processes, "https" address
Ease of Contact	Availability of Institution and platform contact information, Page ranking in search engines, Respond to queries
Personalisation	Website feature personalisation, Personal space available, Personal recognition, Personalised choice options, Interactivity, Confirmation after email contact, Personalised during registration
Advice Capabilities	Virtual course advice, Hotline number, Online/offline help, FAQ section
Community Features	Quality and meaningfulness of membership features such as email account, Blogs, Forums, Availability of other learners' comments/reports, Social media tools and buttons
Usefulness	Efficiency, Search engine, Real time and up to date content, Useful for career and personal development
Fulfilment capabilities	Course guarantees, Cert delivery insurances, Learner rewards, Learner positive experiences
Privacy protection	Data protection, User control over personal data, Comprehensible privacy policy
Certification	Provision of certification on completion
Instructor quality	Quality of course instructor, Efficiency of instructor, Instructor's capability of engaging with learner

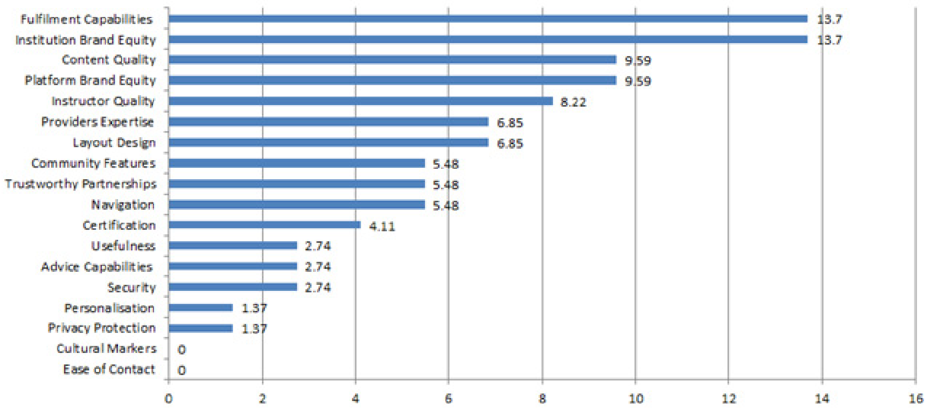

Fig. 1. Percentage of coded trust drivers reported by the respondents

As can be seen from Figure 1 *Fulfilment Capabilities* and *Institution Brand Equity* were identified as the most highly rated trust drivers by MOOC learners for MOOC websites and the educational institution that provided them. Both drivers scored 13.7%. These were followed by *Content Quality* and *Platform Brand Quality*, both scored 9.59%. *Cultural Markers*, *Ease of Contact*, *Privacy Protection* and *Personalisation* scored the least as trust drivers for the MOOC learners. Table 4 below includes example excerpts of learner responses and their coding for the main trust drivers found.

Table 4. Examples of participant responses and coding for the main trust factors found

	Platform Brand Equity	Institution Brand Equity	Content Quality	Provider Expertise	Fulfilment capabilities	Certification	Instructor Quality
"As for distrust, I would not feel comfortable acting on all the information given to me by the course since I know from my own first-hand experience that some pieces were one-sided histories."			*				
"trust NIHR site and course good education, distrust experience it has of primary care led research it's not mentioned so far"		*	*	*			
"Trust that Stanford has a reputation to maintain. So, I trust the entire program"		*					
"My certificate was mailed to me as promised"					*	*	
"I love the experience and commitment of my instructors, such humble and learned professionals. Thanks to Coursera"	*			*			*
"It was reliable, challenging and interesting topic. The only thing I didn't like was there was no option to get a honor code certificate."						*	
"I feel confident taking my new course as I have only had positive experiences with FutureLearn so far. The current educational provider is well established and regarded and I had no hesitation in signing up to the course"	*	*			*		

4 Discussion and conclusion

The main contribution of this research to the existing literature is that it has produced findings relating to the concept of learner trust in MOOCs, an area in which there is currently a paucity of research. The findings will guide further research in this field and also point MOOC stakeholders such as providers (designers, instructors, institutions, platforms) to possible ways their MOOC may be engendering or inhibiting development of learner trust in their MOOCs. This may have practical applications such as that known credibility indicators from the literature on web sources [7, 8] appear also to influence learner trust in MOOCs. Moreover, our findings indicate that trust will also affect future learner intentions, known as trusting intentions [8, 10]. This is important for analyzing, for instance, whether a learner is likely to purchase a certificate based on their learning. This will be important is determining whether MOOCs can overcome the challenges posed of them [12] and transition from 'innovation platforms' [13] to mainstream educational provision. This vein of research will help in determining people discuss and recommend MOOCs such as on social media for example [14].

A potential limitation of this study is that the literature does indicate that some trust constructs are not necessarily mutually exclusive and can overlap [7]. We sought to address this with the third of our research questions, which was pursued using qualitative analysis. In this case we used an existing tool from the literature but adapted it to the MOOC context. We make a contribution here by confirming the presence of the majority of trust drivers developed in Ref. [11], but also by identifying new drivers such as the importance of the instructor, institution, and platform. Moreover, our findings contrast with previous ones in domains such as e-commerce retail. For instance, we did not find any evidence of the importance of *Cultural Markers* nor *Ease of Contact*, as they are conceptualized in the existing trust literature [11]. Future research in this area could further explore issues suggested by the distribution of trust drivers here to ultimately improve MOOCs for learners.

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Factors affecting Successful Implementation of eLearning: Study of Colleges and Institutes Sector RCJ Saudi Arabia

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Abstract—The colleges and institutes sector Royal Commission Jubail (JCIS) represents four higher educational institutes namely, Jubail University College (JUC) for male and for female, Jubail Industrial College (JIC), and Jubail Technical Institute (JTI). All of the institutions are under one patronage General Manager of JCIS. Several courses are very similar in content and delivery offered at all institutes. ELearning is the ideal form of delivery for higher education students in JCIS. This study aims to explore the specific factors affecting successful implementation of eLearning as major barriers at JCIS. This research will extend the existing theoretical model Technology Acceptance Model (TAM) and develop an extended model of eLearning for successful implementation and adoption of eLearning solutions at colleges and institutes sector of Royal Commission Jubail. The study will attempt to investigate the various barriers those affect the successful implementation of eLearning in the sector. It is also expected that this research study will provide strategies for academicians in the development and implementation of online courses. In this research study, quantitative research approach would be applied which may utilize instrument survey questionnaire (for students, teachers, and management) from all colleges and institutes of the sector.

Keywords—eLearning, pedagogics, distance learning, learning management system

1 Introduction

Today, Information and Communication Technology (ICT) has changed higher education in the course of recent decades. Specifically, exploitation of advanced learning innovations like PDAs, smart phones, tablets with broadband network to web and social media have conveyed generous changes to the way higher education institutes, colleges, and universities give learning chances to students, the job responsibilities of educational institutes and trainers have changed as needs to be [1]. Learning and teaching by the use of internet, web applications, social media platforms, and mobile apps has made easier and informal for both students and teachers in today's eventful life routines [2]. Vigorous information and communication technologies has swapped traditional pedagogy and tutoring approaches with digital revolution in education sector by encouraging interactive learning and teaching novelties like other sectors of digital community [3]. Pedagogics is transformed from instructor-centred to student-centred approach with more tasks and choices for students for their learning [4]. E-learning concept refers to the use of various electronic equipment such as computers, CD (ROMs), recorded videos tapes, and other various tools in remote learning. However, in modern theories eLearning is an exploitation of advanced innovations like PDAs, smart phones, tablets with broadband network to web and social media with great mobility, plentiful resources have removed barriers of time, distance, place or people and provided affordable learning chances to students anywhere anytime.

As, in Saudi Arabia, gender based educational system vigorously needs adoption of eLearning system for educating boys and girls equally in institutes and colleges. Education Ministry of Saudi has also acknowledged the necessities of eLearning system in public universities of Saudi Arabia and invested massive resources for eLearning infrastructure to facilitate the substantial demand from on-job students to continue their studies [5]. Nonetheless, it has been seen that the achievement picked up in the eLearning framework implementation through many universities of Saudi Arabia are not specifically relative to the investment made [6]. This research study aims to investigate the possible barriers concerning effective adoption and execution of eLearning system in colleges and institutes sector of Royal Commission Jubail, which started as eLearning Project Committee in year 2015 by Director, eLearning center. First, this research study aims to achieve the reviews and analysis on potential barriers that restrict the full advantage of e-learning system in colleges and institutes sector of Royal Commission Jubail. Second, this research study would involve quantitative approach to conduct survey among the stakeholders mainly students, instructors, and staff members of JCIS. This study would aim to investigate each barrier related to students, instructors, infrastructure and technology, and management of colleges and institutes sector of Royal Commission Jubail Saudi Arabia.

2 Literature Review

2.1 Defining eLearning

Online learning began in the 1980s, while eLearning lacks a evidently recognizable beginning [1]. A typical eLearning definition refers to technological platform that facilitates learning environment for students at their own pace and time through network services like, live chats among groups of students and teachers, online assignments, online answers and questions method, discussion boards, and email support [7]. Oblinger and Hawkins [8] defined eLearning as modern learning solution in which all interactions among students and faculty members are online using internet medium. Similar view of [9], eLearning is technology based learning solely consuming private local network and internet technologies. ELearning term is well-defined as, "innovative approach to education delivery via electronic forms of information that enhance the students' skills, knowledge, or other learning performance" [10]. According to [11] eLearning is an improved and effective method learning by utilization of multimedia and hypermedia technologies. E-learning system can benefit learners over traditional head-on learning mechanism by facilitating students to learn at their own pace and time with the use of computer or mobile, and internet facility, it reduces the expenses as well by not driving to university or college and other stationary cost consumed by students every day in the classroom.

2.2 E-learning Committee Project at Colleges and Institutes Sector, Royal Commission Jubail (JCIS)

The eLearning Project Committee, led by Chairman of the eLearning centre took an initiative to encourage eLearning at JCIS. In the wake of distinguishing abilities holes that kept the JCIS teaching staff from instructing on the eLearning system most viably, the Chairman moved toward Northern Illinois University, College of Education's Department of Educational Technology, Research and Assessment (ETRA) office, about making an organization to dispense with those holes. The two associations worked together to distinguish the best preparing approach and the best time to conduct the preparation training. The ETRA gave a serious, two-week workshop to workforce and staff of the JCIS in Jubail Industrial City in the eastern part of Saudi Arabia on the Arabian Gulf. The program, "Online Teaching and Development," was intended to support self-confidence and sharpen abilities vital for JCIS faculty to effectively coordinate online innovation into their educating processes. The workshop was held at Jubail Industrial College. The participants were all faculty members from different departments of the JCIS institutions who were chosen to be trained to become master trainers of trainers. The two-week training program was organized into three main theme topics, instructional strategies, technology integration, and blended course delivery, to provide faculty participants with needed skills and knowledge on eLearning pedagogies, technology, and teaching strategies. These skills and knowledge aimed to make online teaching and course development more efficient and effective and to make learning more productive. The goal was to help these 30 faculty participants assume critical roles such as eLearning coordinators and trainers in the JCIS's online education initiative. Colleges and Institutes Sector Royal Commission has successfully implemented and run e-learning solutions in four institutions using licensed Blackboard learning management solution since semester 371, in year 2015. This research study aims to investigate the barriers effecting successful implementation of eLearning.

2.3 Barriers related to successful implementation of eLearning

Due to the influence of culture, social life, and living standard, it is somewhat challenging barriers to incorporate eLearning into traditional pedagogy in Saudi Arabian higher educational institutions. In the literature review, these barriers are categorized in three dimensions:

- Barriers associated to students
- Barriers associated to instructors
- Barriers associated to infrastructure and technology

3 Problem Description

Today, the practice of Information and Communication Technologies (ICT) in all forms of education is enforced and continuous technological advancement in use of ICT at has replaced traditional learning schemes with modern eLearning solutions with more flexibility and freedom for students to learn at their own pace and time with the use of computer, mobile, tablets, and internet facility. Colleges and Institutes Sector of Royal Commission Jubail has just proceeded to establish the provision of eLearning in four institutes of the sector. However, there are several barriers, discussed in literature review, for successful implementation of eLearning. It is right time to investigate and verify the critical factors affecting the successful implementation of eLearning in colleges and institutes sector of Royal Commission Jubail. The proposed study will provide the holistic view on such barriers to overcome the difficulties in implementing and obtaining optimal benefits from the modern eLearning solutions approved in colleges and institutes sector of Royal Commission Jubail. Additionally, the study will attempt whether the eLearning is an effective, easy-to-use, reliable, and cost-effective method of pedagogy in the sector.

4 Proposed Framework

This section elaborates the proposed research model composed of factors related to students, instructors, and management. TAM has been utilized in several studies to investigate the students and teachers' behavior using PU, PEU, and intention to use and adopt eLearning system [12]. Proposed model design is based on TAM theory to measure the influence of its main latent factors i.e. PU, PEU, BI on user acceptance of eLearning system in different faculties of CIS Royal Commission Jubail. This model design includes four additional constructs i.e. training, self-efficacy, compatibility, and facilitating conditions adopted from different research studies and literature. TAM has been applied as the most successful and common theory than any other theories in eLearning acceptance [13]. In figure 1, the proposed research framework supposed to be tested and analyzed that shows the constructs grouped into three categories to investigate the factors influencing students', teachers' and managerial behavior towards successful implementation of eLearning system. The existing research studies statistics e 2 shows that TAM is the most utilized as a part of existing investigation is student group, trailed by teachers, and management [13].

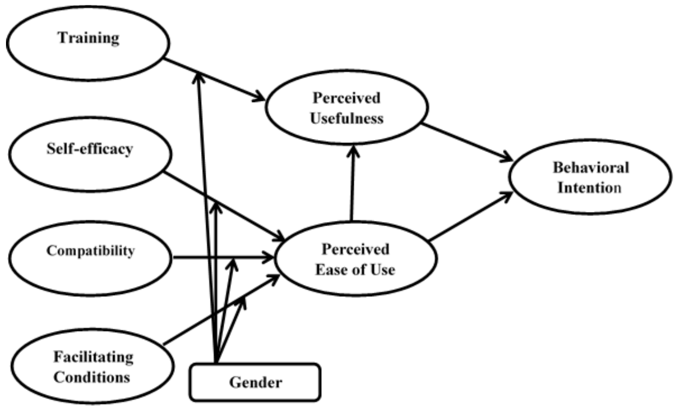

Fig. 1. Proposed Research Model

4.1 Student Factors

Self-Efficacy: The first factor is the student self-efficacy. Confidence of student from eLearning or web-based education is based on the student's personal capability to use information and communication technologies within the eLearning system. Self-efficacy is the self-belief of the students about their capacities that they workout to reach the assigned level of accomplishments in eLearning system [14]. If the student has positive perspective about eLearning then he would definitely participate in online course environment effectively. If the students' self-efficacy ranks high in information and communication technologies, his/her participation would be dynamic and positive towards use of the eLearning system courses. So, it is hypothesized as:

- Student Self-efficacy positively influence the perceived ease of use of an eLearning system

Compatibility: "The degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of potential adopters" [15]. In proposed research framework compatibility factor states the previous learning practice and knowledge of students and teachers in comparable learning system. Educational compatibility can viably encourage the learning events of students and enhance the learning accomplishments [16]. Hence, compatibility factor may support to implement an eLearning system successfully in JCIS. This factor is hypothesized as:

- Compatibility positively influence the perceived ease of use of eLearning system.

4.2 Instructor Factor

In any learning condition, instructors are primary performers to make successful lesson delivery [17]. Learning efficiency is reflected by self-efficacy of instructors as well [18]. The Instructor's uplifting performance, interactive pedagogics, and self-confidence toward utilization of innovation results learning adequacy [17].

Facilitating Conditions: ensure the convenience and accessibility of infrastructure supporting the utilization of proposed system [19]. Thus, facilitating conditions may support to measure the availability of technical and infrastructure support that provides smooth opportunity to students and teachers to successfully adopt the eLearning system at CIS Royal Commission Jubail. According to [19] facilitating conditions sprightly influence the perceived ease of use and perceived usefulness that impacts positively on use behavior. Thus it hypothesized as:

- Facilitating conditions positively influence the perceived ease of use of eLearning system.

Training: defines the profile of the teacher. This factor may help to measure access to technology, confidence, and attitudes of teachers [20]. Training factor may be utilized to know technical efficiency and experience of teachers in utilization of Internet in learning process, conducting online trainings, seminars/workshops, course administration and use of course management systems. It is hypothesized as:

- Training positively influence the perceived usefulness of eLearning system.

Gender: In Saudi Arabia there is gender segregation due practice of cultural and religious values. Due to dissimilar behavioral characteristics of males and females from each other both gender have diverse responsibilities in the social order [21]. Females are found passive compared to males in adoption of new technology [22], whereas males are more confident, vigorous, and diverse than females [23], [24]. Therefore, this study is supposed to study the impact of gender on successful implementation of eLearning system. Following hypotheses are formulated:

- Gender positively influence moderating role between training and PU.
- Gender positively influence moderating role between self-efficacy and PEU.
- Gender positively influence moderating role between compatibility and PEU.
- Gender positively influence moderating role between facilitating conditions and PEU.

5 Conclusion

Currently, the practice of Information and Communication Technologies (ICT) in all forms of education is enforced and continuous technological advancement in use of ICT at has replaced traditional learning schemes with modern eLearning solutions with more flexibility and freedom for students to learn at their own pace and time with the use of computer, mobile, tablets, and internet facility. Colleges and Institutes Sector of Royal Commission Jubail has just proceeded to develop the provision of eLearning in four institutes of the sector. Unless a proper scientific study is conducted to know the effect of certain barriers in implementation of eLearning system, it is not enough to develop a high-tech eLearning system only. However, there are several barriers, discussed in literature review, for successful implementation of eLearning. This paper has chosen TAM theory to utilize its latent factors along with four additional factors related to students, teachers and infrastructure. It is right time to investigate and verify the critical factors affecting the successful implementation of eLearning in colleges and institutes sector of Royal Commission Jubail. The proposed study will provide the holistic view on such barriers to overcome the difficulties in implementing and obtaining optimal benefits from the modern eLearning solutions approved in colleges and institutes sector of Royal Commission Jubail. More, it expected the results would support the evidence towards successful implementation and development of the eLearning system in JCIS.

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