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Short Papers

Technological Competences: A Systematic Review of the Literature in 22 Years of Study

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Abstract—In this Systematic Review of the Literature (SRL) the term "technological competence" is analyzed. The analysis is conducted within the areas of knowledge in which the term has been studied, considering the definitions that have been associated to the term, the approaches proposed by the authors that make use of the term, the transformation of the concept throughout the time, and the boundaries of application with other similar terms, such as technological capability and technological skill. A total of 140 publications focused on technological competences are analyzed. The publications correspond to a time span ranging from 1994 to 2016, and include research articles from recognized databases and, to a lesser extent, gray literature articles. Finally, the term technological competence applied in the productive sector is redefined such as it allows focusing on projects for technological absorption or training in industry.

Keywords—Technological competences, e-competences, technological capability, e-skills.

1 Introduction

The term *technological competence* represents the central focus of the SRL, which is intended to define a particular concept applied to the productive/industrial sector.

A first discussion related to the term technological competence in industry within the context of the Information, Communication and Collaboration Technologies (ICCT), is about the specialization in knowledge management. Technological competences can be understood as specific performance applied to different professional fields. From this perspective, two types of competences are required when it comes to professional performance: technological competences and professional field's specific competences. Therefore, when a professional task that requires a technological com-

petence is performed, actually both types of competences are being used, each with its own operational logic.

Secondly, technological competences are articulated with specific knowledge of the different professional fields. Hence, the technological competences would act transversally for processing information, knowledge, communication and intelligence in any professional field. Related to the performance, it is expected that the technological competence operates *symbiotically* with other field-specific competences, this is, one competence type cannot be separated from another. In this sense, technological competences would appear as a "modelers" of the professional competences.

The conceptualization of technological competence and the identification of its significant features for designing suitable training and evaluation proposals for enterprises (companies) are obtained by analyzing and comparing all the definitions associated with it, from multiple approaches in the professional field, along with its transformation throughout the time.

The present study is divided into six sections. The first section is devoted to justify the SRL and the objectives and research questions are pointed out. The second section addresses the SRL method by describing the search parameters, discrimination process, coding and every aspect related to the identification and classification of the information. In the third section, the graphical results of the SRL are provided and briefly analyzed in order to point out the main findings. The fourth section presents the discussion of the findings as well as the conclusions, where the research questions are clearly resolved. Fifth and sixth sections correspond to references and authors information, respectively.

1.1 Objective of the review

To analyze the concept of technological competence and its relationship with capability and technological skill as conceived from the seminal origin of the term, the transformation of its meaning throughout the time, the field of knowledge of its creation, conceptualization and correlation among the terms related, and the re-definition of the technological competence applied to the industrial sector.

1.2 Research questions

This investigation is focused on a deep understanding of the technological competence concept. Furthermore, it is intended to provide insightful responses to the following research questions:

- Which are the elements that best describe the characteristics of a technological competence?
- What are the approaches and their conceptual relationship associated to the technological competence term?
- How the concept of technological competence has changed throughout the time?
- Which terms are relevant to the concept of technological competence?

2 Review Method

The SRL is presented from a theoretical-conceptual perspective about the term technological competence with the respect to an epistemic construction.

The analysis is based on the review of research works that have been published between 1994 and 2016, considering the exploration of the term technological competence and the difference between capability and technological skill. The analyzed papers are classified into three approaches: enterprise, educational and economical. Throughout this paper, the term "data" is regarded to the results obtained from the SRL.

2.1 Reference framework for information search

The first step towards the integration of the SRL was to establish the conditions necessary for collecting the data that would guide the search of published papers. An important aspect was to consider only research works focused on the conceptualization of the term from a theoretical perspective.

The search was conducted in the databases of the Association for Computing Machinery (ACM), EBSCO Host, ELSEVIER, Institute of Electrical and Electronics Engineers (IEEE), JSTOR, SCOPUS and ScienceDirect.

Also, gray literature was considered as long as it belongs to international organizations, government institutions and doctoral dissertations. It is worth mentioning that grey literature is mostly obtained from citations included in the primary sources of information analyzed.

2.2 Search criteria

The search was conducted using the terms *competence*, *capability* and *skill*, considering a theoretical-conceptual perspective, intersected with the word *technology*. Boolean operators were used for applying these search criteria.

The keywords considered during the search are: *ecompetence, technology competence, technological competencies, technological competence, ICT competence, digital competence, computing competence, technology capability, technology skill, e-skills, IT-Skills*.

The specific search criteria executed in the search engine of each database is: *"ecompetence" OR "technology* competence" OR "technological competence" OR "ICT Competence" OR "digital competence* OR "computing* competence*" OR "technology* capability" OR "technology skill**" OR "e-skills" OR "IR-Skills**".*

Once the search was conducted, the obtained data is sorted by *relevance* to the subject of study, in order to clearly identify which is the most convenient contribution of each work.

2.3 Screening of the literature

Screening of the literature consists in determining whether or not the papers comply with the following features and conditions:

- The paper provides a theoretical study or it contains a comprehensive empirical framework.
- The publication year is not constrained, since it is of interest to investigate how term technological competence has evolved over the years.
- Studies carried out within any area of knowledge can be considered.
- Studies published in English are preferred. However, works published in Spanish can be considered as long as they belong to publishers of recognized quality.
- Gray literature can be admitted given that it provides the perspective of international organisms about the technological competences. Also doctoral dissertations can be included provided that they are from recognized educational institutions.
- Papers must strictly consider the terms *competence*, *capability* or *technological skill* from a development of human potential point of view.
- The terms *competence*, *capability* and *skill* must be strictly referred to the *technology* ambit, papers that address these terms unrelated to technology would not be considered.

Preliminary results of the search, prior to screening and selection process, provided a total of 50,756 published works. Table 1 presents the number of papers corresponding to each of the considered databases.

Table 1. Number of publications per database

Database	Number of publications
Association for computing machinery (ACM)	38 707
EBSCO Host	729
ELSEVIER	5 045
Institute of Electrical and Electronics Engineers (IEEE)	1 285
JSTOR	1 617
SCOPUS	2 571
Science Direct	802

After the screening process, 140 papers were selected for the analysis. Selected papers are classified as articles for dissemination of science and gray literature, being 67% of the former and 33% of the latter. There is a significant different among the number of papers pre-selected during the search process and the number of selected papers after the screening process. However, this is something expected due to the application of the selection criteria, where the description and definition of the technological competence is considered only from a theoretical-conceptual perspective.

During the screening process, it was observed that the conditions with the highest exclusion ratio are: a) Papers must strictly consider the terms *competence*, *capability* or *technological skill* from a development of human potential point of view, and b) The terms *competence*, *capability* and *skill* must be strictly referred to the *technology*

ambit, papers that address these terms unrelated to technology would not be considered.

2.4 Codification and data selection

After the screening process, a codification system was established to classify the collected data according to specific terms. A total of five indexing terms were considered, defined as: technological learning, technological capability, technological skill, core/basic competence and technological competence. The latter is further classified into three categories according to the geographical region of the publisher, given the previously importance of this matter. Table 2 presents the classification of collected data by indexing terms.

Table 2. Classification of data by definition of terms

Classification by definition of terms		Scientific articles	Gray literature	Total publications	% by term
Technological learning		11	1	12	8.6%
Technological capability		17	0	17	12.1%
Technological skill		7	9	16	11.4%
Core/Basic competence		15	0	15	10.7%
Technological competence	Regional	2	1	3	2.1%
	National	5	8	13	9.3%
	International	36	28	64	45.7%

The definitions associated with the terms technological competence, technologic capability and technological skill were thoroughly analyzed in each paper, in order to determine how the concept was specifically applied and how it was related to other authors. This allows classifying each research work into one of the dimensions proposed in table 2.

Given that the technological competence is the focus of this research work, the 80 papers that fall into the technological competence dimension, which represent 57.1% out of the overall selected research works, have the most impact to re-define the concept of technological competence associated to the industry. Nevertheless, the rest of the research works that fall into the other dimensions constitute a reference framework and outline for the concept.

It was identified during the screening process that the terms technological capability and technological skill are intersected with the term technological competence. Therefore, as part of the results, the relationship and main differences between: a) technological competence and technological capability, and b) technological competence and technological skill, are concisely described.

With respect to the term technological learning, from the analysis of the studies provided by [1][2][3][4][5][6][7][8][9][10] we identified that it could be associated to the lifelong education in matter of technology. Hence, it has no similarities, from a conceptual perspective, with the technological competence. On the other hand, based on the studies carried out in [11][12][13][14][15][16][17], the term core/basic competence corresponds to a more general concept related to technical, administrative and

professional knowledge, that is not limited to the technological aspects, in consequence there is no need to compare it to the technological competence term.

3 Results of the Review

The results obtained from the SRL are divided into two dimensions:

- **Individually:** Conceptual analysis of the technological competence, how the concept has been transformed throughout the time and how other authors relate the concept, nomenclature and application approaches
- **Collectively:** conceptual comparatives of the technological competence with respect to technological capability and technological skill terms. The general structure of the achieved results is depicted in Figure 1.

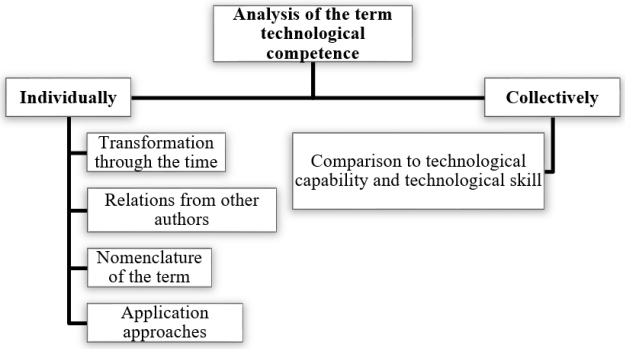

Fig. 1. General structure of achieved results

Collected data are referred to research works conducted by universities, research and development centers, public and private organizations, located in several countries. Figure 2 provides the representativeness of each publication country as observed in the selected data.

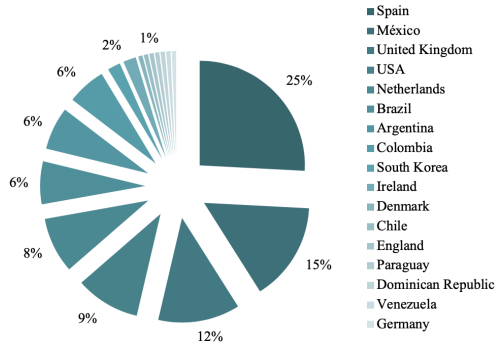

Fig. 2. Representativeness of publication countries according to databases

The information provided in figure 2 corresponds to the percentage of journals registered in each listed country, where the topic technological competence figures as part of its publication scope. For the pie chart depicted in figure 2, considering 100% of all selected publications in the SRL. Countries are listed in decreasing order of its percent value, being Spain, Mexico, United Kingdom, USA and the Netherlands the countries with the highest percent value, having 25%, 15%, 12%, 9%, and 8% respectively for each one. Brazil, Argentina and Colombia are represented with 6%; and with minimum representation are South Korea and Ireland with 2%, and Denmark, Chile, England, Paraguay, Dominican Republic, Venezuela and Germany with 1% each.

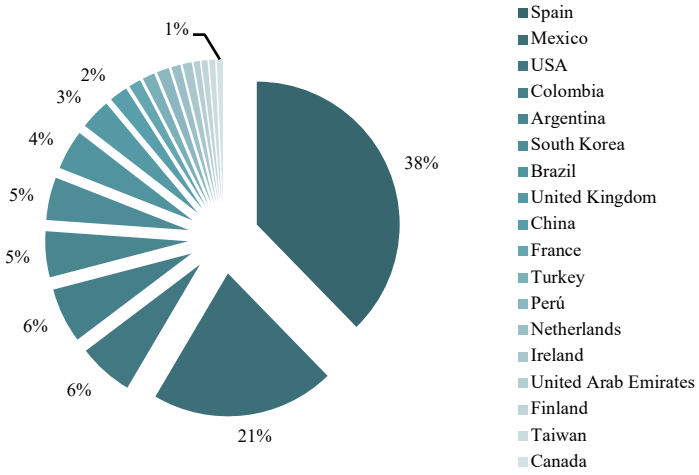

Fig. 3. Percentage of authors per country that have studied the term technological competence

The pie chart shown in figure 3 represents the percentage of research works per country conducted in higher education institutions or research centers that periodically publish studies related to the technological competences subject. Among the listed countries, Spain, México, USA and Colombia figure with 38%, 21%, 6%, and 6%, respectively. With moderate to low participation are Argentina, South Korea, Brazil, United Kingdom and China having 5%, 5%, 4%, 3% and 2% each. Finally, with minimum participation are France, Turkey, Peru, Netherlands, Ireland, United Arab Emirates, Finland, Taiwan and Canada.

3.1 Technological competence–conceptual analysis

Transformation of the term throughout the time: The analysis of the term technological competence was carried out based on the comparison among the perspective of different authors and considering various approaches proposed within the field of application of the term. The papers selected to conduct the analysis were those that specifically studied the technological competence from a conceptual point of view, and, from them, it is determined if the concept has undergone any change over time.

From the analysis, it was observed that most of changes identified in the concept of technological competence correspond to the addition of elements that diversify the definition of the term, although they do not modify the foundations of the basic structure. The scope of the study contemplates the analysis of papers published along a period of 22 years. The number of published papers per year is summarized in figure 4 together with a reference map.

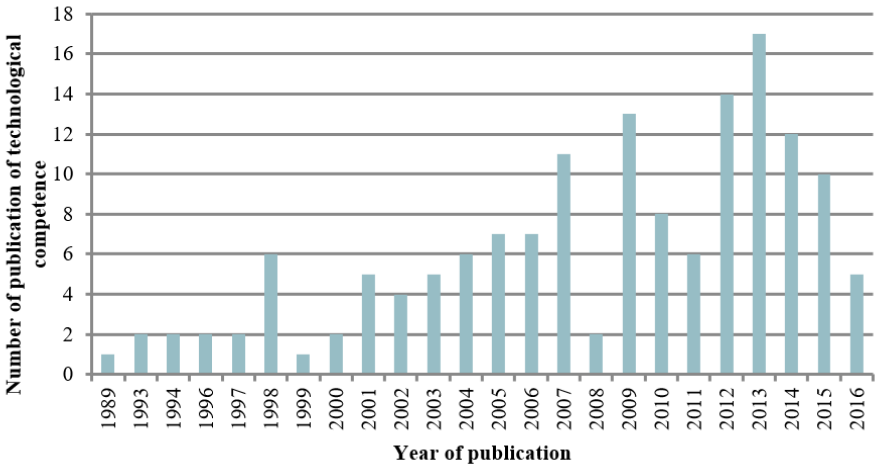

Fig. 4. Number of publications per year

Authors list: The procedure for data analysis is based on a researchers' triangulation approach. The approach is characterized by the comparison of several interdisciplinary contributions, proposed in multiple areas of knowledge.

The references selected for conducting the conceptual study of the technological competence are listed in table 3. Here, the references are classified according to their nomenclature, focus, and cross-references. Cross-references are those references included in the reviewed papers, which contribute to the construction of the theoretical basis of the research work, and to the conceptual construction of the term. Furthermore, a diversity of nomenclatures for the technological competence term is described, and similar conception and application patters are found within the different approaches explored in each area of knowledge.

From the results is observed that 56% of the papers are related to an industrial (enterprise) approach, 37% to educational approach, and 2% to the economical one. Likewise, cross-references that include a specific definition for the technological competence are identified in their corresponding reference.

In the educational ambit, the concept of technological competence is oriented to the specialized teacher training. There is evidence of studies where universities are designing strategies for teachers training and for integrating technological elements within the classroom. Also, administrative processes designed as a response to the demands of a national development plan focused on innovation provide significant

information regarding the concept of technological competence. In general, the key elements of such studies are teachers and students.

In the enterprise approach, the term technological competence is defined from a broader context. In this field, technology is particularly required by the urge for update along with the problems caused by the growing digital gap in industry, which is alarming. In [19] learning in industrial environments is addressed and the need for the development of technological competences is analyzed. The work is carried out within the electrical sector, but it can easily be extended to consider multiple productive fields. In [22] the results of the integration of three elements – vision, resources and capabilities – are presented. This integration is provided by the development of individual or collective learning processes. The learning processes incorporate different technological flows of the enterprise, envisioning the necessity of collaboration in order to embrace the technological development and the construction of new paradigms of innovation in an industry [20].

Marc Giget was a pioneer in the definition and representation of the term technological competence within the industry. Back in the 80's decade, Giget was analyzing the Japanese industry and its potentialities. He explained, in an original and symbolic way, the function of technology in industry by means of a tree structure [72] and by 1997, he conceptualized the term technological competence, which has been the benchmark for over 70 research works [21]. The definition provided by Giget in [21] integrates three main edges named as *knowledges*. The edges describe knowing how to conceive, how to produce and how to sell, and also includes the entire administrative cycle of an industry, not only the use of technology as an element external to the processes and activities of the industry. As a result of the analysis, it is stated that Marc Giget is the seminal author of the concept given its contribution to the administrative approach with the paper L'Innovation dans l'enterprise in 1996 [20].

Table 3.

Ref	Nomenclature	Focus	Definition / Cross Ref
[18]	Technological competences	Educational	"Knowing how to make use of new technologies, especially informatics technologies, in two senses, as sources of information and as tools for processing, ordering and analyzing data"
[19]	Technological competences	Business	"It is used to define a new strategic core of the company, through a broad connotation that includes not only the proficiency of the technologies themselves, but also all the elements of knowledge accumulated by the company. In particular: Know how to conceive, due to the technological proficiency and the ability to identify markets. Know how to produce, due to the knowledge of processes and costs, the ability to organize production, internally or externally. Know how to sell, for the domination of distribution networks and communication" [20][21] "It is the result of the integration of three elements: vision, resources and capabilities, which is eased by the development of feedback processes of learning, individually or collectively originated, that incorporate the different technological trends of the company." [22]
[23]	Technological competences	Educational	"Finite system of cognitive dispositions that allow us to do infinite actions to successfully perform into an environment mediated by artifacts and cultural tools"
[24]	Technological competencies	Business	"They are the technical assets of a company. Competences are a subset of the capabilities in a company"

[25]	Technological competences	Business	"Is the result of the integration of three elements defined and controlled by the company: the strategic challenge, technological resources and dynamic capabilities, which implies knowing how to conceive, produce and sell." [20][26]
[27]	Technological competence	Business	"Organization and technical capacity involved in achieving a certain level of production performance with technological effects" [28] "Collective learning in the organization, especially how to coordinate the different production techniques and integrate multiple technologies flows."[29]
[30]	Technological competence ICT Competence	Business	"Potentiate the curricular integration of information technologies"[31]
[32]	Technological distinctive competencies	Business	"Process of technological innovation, being a flow magnitude that allows describing processes for the generation of technological knowledge" [33] "Unique combination of knowledge and capabilities that allow generating a number of profitable innovations" [34][35]
[36]	Technological competence Technological specialization	Business	"National technological competences determine the technological specialization of a country"
[37]	Technological competence Technological capability	Economic	"They are expressions of the knowledge assets of a company, operating in different levels of the productive apparatus" [28][38] "It considers having the knowledge and skills to understand, make use and make decisions about technology" [39]
[40]	Technology/Technological Competences Technology Management Competence	Business	"Include basic technical skills that involve knowledge of techniques designed to carry out business processes, and the use of tools and equipment necessary to perform an operational activity"
[41]	Computer competence Technological competence Digital competence	Educational	Informatics competence "Set of capabilities acquired in the informatics field that enable the possibility to proficiently interact with the computer, in addition to recognizing and identifying its elements, for personal, academic and /or professional purposes, by using specific software in order to manage information, communication and to solve problems" [42] "Set of knowledge, skills, dispositions and behaviors that train the individuals to know how the ICT work, what they are used for, and how they can be used to achieve specific objects." [43] Technological competence "Knowledge of the possibilities brought out from the new technologies for improving teaching. Making use of the ICT in educational field, as for example, in the organization of the teaching-learning processes that take place in the classroom. Select, use, design and produce ICT-based teaching materials that promote acquiring meaningful learning y that turn the classroom into a lab where student's responsibility and prominence are encouraged" [44] Digital competence "It involves the safe and critical use of Information Society Technologies (IST) for work, leisure and communication. It is based on the core competences of TSI: the use of computers to obtain, evaluate, store, produce, present and exchange information, communicate and participate in collaboration networks through the Internet" [45] Informative competences "It is the set of knowledge, skills, dispositions and behaviors that enable individuals to recognize when they need information, where to find it, how to assess their suitability, and use it accordingly to a given problem. It is common to all disciplines, to all learning environments, to all levels of education. It allows apprentices to master the content and expand their research, to be more autonomous and take more control of their own learning"

			[43] ICT competences or ICT use competences "Use ICT as a tool for expression and communication, for providing access to sources of information, as a mean for documents and data storage, for presentation tasks, research learning and collaborative work" [46]
[47]	Technological/Electronics competence e-Competence/e-skills/IT-skills	Business	"The knowledge, skills, abilities and attitudes of taking advantage of the new information technologies, used for education or for work, and, in general, for any process of knowledge generation. It involves the ability to apply specific knowledge and use the know-how to solve cognitive and practical problems"
[48]	Technological competence	Business	"Finite system of cognitive dispositions that allow us to do infinite actions to successfully perform into an environment mediated by artifacts and cultural tools" [23]
[49]	Technological distinctive competencies	Business	"They are identified by the current state and progress of science and relevant technologies, also by generating advanced technological processes, assimilating new technologies and useful innovations, attracting and retaining qualified scientific-technical personnel, and mastering, generating or absorbing basic and fundamental commercial technologies." "The experience of the organization in the mobilization of diverse scientific and technical resources, through a series of routines and procedures that allow new products and production processes to be developed and designed." [50][51]
[52]	Technological competence	Business	"Resources needed to generate and manage improvements in investments, processes and organization of production, products and equipment. These resources are accumulated and incorporated into individuals (experience, skills and tacit knowledge) and organizational systems." [53]
[54]	Technological distinctive competencies	Business	"It refers to the capability for obtaining information about the status and progress of science and technology. Capability to generate advanced technological processes, to assimilate new technologies and useful innovations, to attract and retain their qualified technical-scientific personnel, to master, generate or absorb technology. Efficiency in the creation of programs aimed to the development of competences or the absorption of technology, either from TR&D centers, or suppliers and customers" (definition obtained from the description of the evaluation instrument)
[55]	Technological competence /digital/ICT	Business	"Capability, knowledge and attitude about the use of ICT over its various functions and application contexts"
[56]	Technological competence Technological specialization	Business	"It represents the regularity of the technological activity of a country in the different technical or knowledge fields, this is, the technical areas in which the country develops technological entrepreneurships, among all the technological possibilities" [57]
[58]	Technological competence	Business	"The ability to identify, accumulate, codify and apply different types of knowledge. It determines, to an important extent, the capacity of a company to undertake processes of learning, both internal and external. The more advanced the competences, the greater the capacity to codify the tacit knowledge that circulates within the company and to absorb external knowledge."
[59]	Digital competence	Economic	"The ability to search, obtain and process information, as well as to use it in a critical and systematic way, evaluating its relevance and identifying the differences and links between real and virtual information. People must be able to use tools to produce, present and understand complex information, and have the necessary skills to access, search for and use Internet-based services, but they must also know how to use information society technologies to support the critical thinking, creativity and innovation" [45]
[60]	Digital competence ICT Competence Computer competence	Educational	"The necessity to acquire knowledge, skills and attitudes that enable people to interact with ICT as the acquisition of other skills such as teamwork, learning to learn, etc., is facilitated. Technology not only stimulates creativity and innovation, but also contributes to intercultural dialogue and plays an important role to overcome individual learning problems." [42][43][45][61][62]

[63]	Technological competence Digital competence e-skills	Business	"Concept that includes different types of dynamic competences and levels, particularly in those jobs that require highly specialized technical knowledge. It is increasingly necessary that any employee has some degree of digital competences that allows him to perform his work exploiting ICT."
[64]	ICT competence	Educational	"Those referred to the knowledge and use of different telematics tools" [65]
[66]	e-Competence/ICT skill/e-skill/digital skills/ICT Professional	Business	"Skills needed by citizens to face their social, personal and professional life. The ICT skills of the end users are at the level of digital literacy and are required by all those who live in the information society."
[67]	Digital competence	Educational	"Secure, critical and creative use of ICT to achieves the objectives related to work, employability, learning, leisure, inclusion and/or society participation" [68] "Combination of knowledge, abilities and attitudes related to the ICT, developed by people in real situations, in order to effectively and efficiently achieve specific goals." [69]
[70]	Technological competence	Business	"Organization's ability to efficiently manage its technological processes, in such a way that it can competitively develop its production processes" [71]

Theoretical basis of the former definition of the technological competence term are the studies related to the core competences [11][12][13][14][15][16][17][26][29][34] within the management field of knowledge, where the capabilities and skills necessary to train industry leaders are defined, in order to increase their competitiveness and move up in their careers. Core competences are generally considered as activities or techniques for technical incorporation in addition to multiple action lines. That is the main reason why authors that usually study this term, end up being part of the theoretical timeline of the technological competence term, even though they do not literally belong to the construction of the concept. The concept of technological competence represents a whole set of elements taken from the core competences area.

Nomenclatures given to the term technological competence: The data obtained from the analysis related to the description and classification of the term technological competence according the nomenclature assigned to it is summarized in figure 5. From these results, it can be observed that 51% of the works employed the name technological competence, which represents the majority of the analyzed papers. The second place goes to the name digital competence which is observed in 14% of the papers, followed by ICT competence – where ICT stands for Information and Communication Technologies – with 8%, and at last are computer competence and technology management, with 6% and 3%, respectively. It is worth mentioning that this nomenclature list corresponds only to the specific names used by authors, but the definitions managed for each name present similar features.

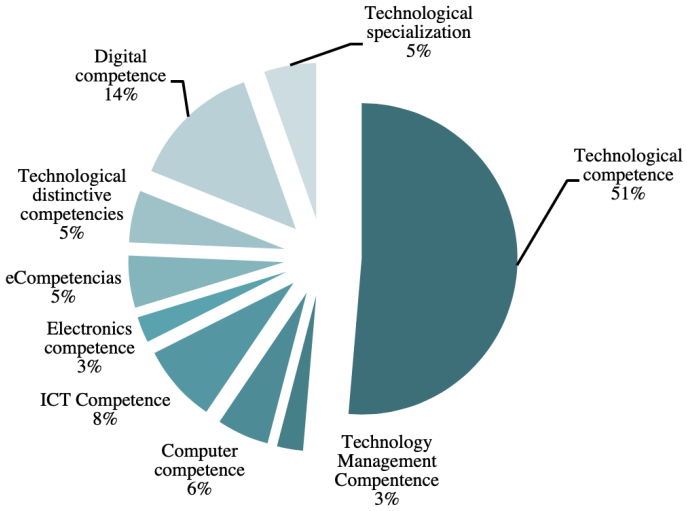

Fig. 5. Use of the term of technological competence

Application approaches associated to the terms – conceptual relationship diagram: It is interesting to dive into the research proposal of each author and how are they related. This is, it is necessary to analyze and classify the authors that include a reference framework in the resulting papers of their studies. In figure 6, the relationship among authors, with respect to their citations, is presented. The diagram is organized by blocks according to the approach, or to the area of knowledge. The citation from an author to another is marked by a line, with the arrow indicating the direction of the relationship – from the author who cites to the cited author –. Also, the nomenclature assigned by each author to the term and the year of publication are indicated.

In the relationship diagram can be clearly observed the evolution of the term technological competence along each of the approaches. From this relationship is possible to state the following results:

- The authors Barroso & Morales [52] manifest an intersection between the technological competence and technological capability terms. Therefore, they are recognized as the authors that formally connects both terms within the boundaries of the definition.
- Several authors that conduct research about core competences [26][28][29][33][34], which represent a broader level of professional competences, remark the importance of technological skills. In [22][25] Morcillo establishes a conceptual relationship between the works of the seminal author [20] and [19], as well as the relationship with the core competence concept, as provided in [26][29].

3.2 Conceptual comparative with respect to the technological competences

Concepts like technological competence, capability, or skill, are historically used without distinction in the literature. However, it is necessary to precise the terms in order to clarify the approaches and their political, administrative, training and strategic implications.

Technological capability: The concept of technological capability has been studied during the history of the development of industry. The term is pointed out and adapted by multiple authors inside the industrial approach. Some of the related works can be found in [53][73][74][75][76][77][78][79][80][81][82][83][84][85][86][87][88][89][90][91][92][93][94][95][96][97][98][99]. The aforementioned publications try to reconsider the trends of the worldwide productive sector by integrating ICCT to daily activities, by conducting descriptive analysis inside the companies, and by promoting new progress trends.

The relationship between the technological competence and capability is carried out based on the analysis of the verbs, actions and elements names as representative features of each concept.

Table 4 presents a list of the specific elements identified repetitively and relevant to the description of the technological competence and technological capability terms. It is also observed that some representative features are common to both terms, but the term technological competence adds some specific features, which are remarked in the table. The definition of the technological competence concept implies a more extensive description, with more actions, as compared to the technological capability.

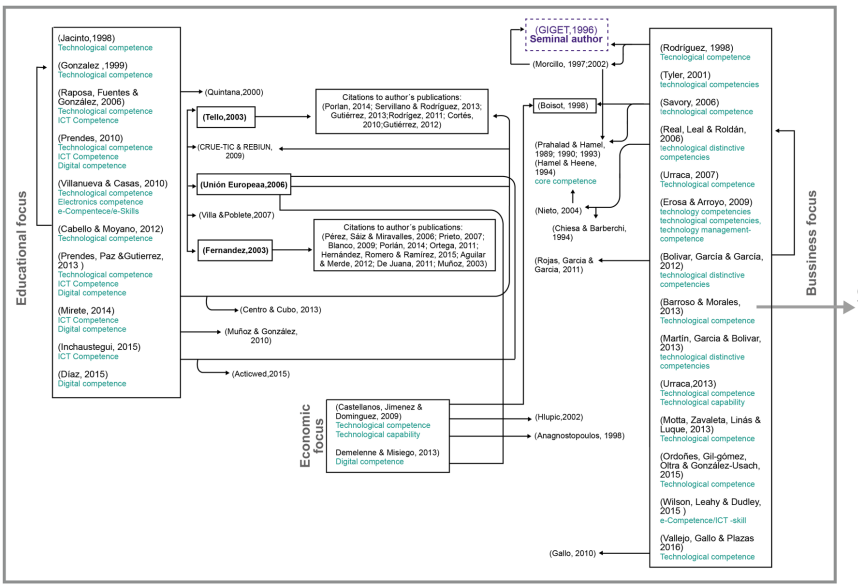

Fig. 6. Authors of publications and their research relationships

Table 4. Conceptual differences between competence and technological capacity

Term	Representative feature of the concept
Technological competence	**Expertise,** aptitude, **suitability** Know how to conceive, technological domain**, market capacity** **Vision**, resources, capabilities **Strategic challenge,** technological resources, dynamic capabilities Knowledge and skills (understand, make use**, decision making)** Knowledge-skill-ability-**attitude** To solve **cognitive** and practical **problems**
Technological capability	Generate resources, manage resources Organization, production and equipment Skill, efficient use Use, adopt, change, create new technology Appropriating, transferring, developing (technology)

Technological skill: The term technological skill, within the area of interest, is defined and treated as a resource or tool associated to characteristics of human capital, described as an important foundation of the technological competences acquired by a company's personnel. The concept of technological skill is further analyzed from an administrative, economic or marketing point of view. Therefore, it is applied to the industry evolution and personnel development [100][101][102][103][104][105] [106][107] [108][109][110][111][112].

The relationship between technological competences and e-skills is easier to break down because the role of each term in the study context is delimited by the etymology of the concepts. In [101], the positioning of the e-skills inside of an organization is studied. In this work, besides describing the importance of the e-skills, the boundaries existing with the concept of e-competence, defined by the European e-Commerce Framework [113], are stated. In [113], the technological competences and skills for the industry in Europe are described. They state that the set of skills form a competence, and backwards, the set of competences define a profile or level of knowledge.

4 Discussion and Conclusion

4.1 Elements that characterize the technological competence term

The technological competences are characterized by the technological domain. This is represented by the coincidences identified in the definitions assigned by the reviewed authors.

From an enterprise approach, it implies the capacity of identifying markets, producing new products or services, efficient data management, skills to manage the technical assets of the company, as well as the capability to face strategical and dynamic challenges in the current globalization trends [19][20][21][22][23][24][25][26] [27][28][29][32][33][35][36][40][49][51][52][54][56][58][63][66][70][71][72].

From an economical approach, it is identified that the decisions made based on technology and the use of critical thinking for innovation, represent important features for the concept [39][59].

From an educational approach, the speech diverges, and the definition is oriented to the use of technological artifacts and services, the relationship with computers and software, the improvement of teaching, meaningful learning provided from technological mediation, and to the generation of learning control [18][23][30][41][42][43][44][45] [46][47][48][60][62][64][65][67][69].

Two relevant features for the definition of technological competence are identified in [40][65], cited mainly as conduct dispositions that train the individuals [58][60], cognitive problems solving [64], and in second plane, the consideration of the context of learning and the interculturality, which represent important variables for the analysis of the term [72][77].

There are two determinant elements of the technological competence definition that evolve along with the concept and differentiate it from other term. In the former, it is referred to the mastery of distribution, communication and collaboration networks, collective work and learning, and the statement of team work [20][21][22][29][45][46]. In the latter, the development of qualified personnel, technological absorption for generating technological development and innovation centers, the development of technological entrepreneurship centers, and the establishment of processes for start new companies [54][56][58][114].

Another group of authors write about the technological competence term within the framework of action proposals. This is, the term is addressed from government sources, or private training institutions, putting aside the conceptual approach. They are focused on the analysis of indicators and considerations for establishing models oriented to the development of technological competences. With international coverage, are the studies proposed in [115][116][117][118][119][120][121][122][123][124][125][126][127][128][128][130][131][132][133][134][135][136]. In the national extent, the works [137][138] are considered. Meanwhile, in the regional coverage, where the region is regarded as the Mexican's north border state of Baja California, the studies of [139] and [140] are identified. The last 26 mentioned studies differentiate from the rest of the rest of the references of this work because of the application approach. While the first data mainly consider conceptual and theoretical values, the final data is focused on proposals for technology incursion, which point out the direction of the term and the future work.

4.2 Approaches of the technological competence term

As stated in the section 4.1, the technological competence concept is located within three main approaches, represented by the area of knowledge in which the concept is studied:

- **Industrial approach**, representing the research oriented to case studies in industry and productive sector, with the administrative sciences, marketing and enterprise development concepts involved
- **Educational approach**, the studies are carried out in a psychological education level, directed to the development of teaching-learning strategies, where most of research is pointed to improve the level of technological knowledge in teachers

- **Economical approach**, it apparently can be linked to the industrial approach, but it is a novel research trend distinguished by the fact that technology is considered as an exclusively financial growth strategy for organizations.

Giget is identified as the seminal author for contributing the technological competence term in 1996, which was applied to the industry. Giget has been cited by numerous authors, starting in 1997 to the most recent works. He envisions a changing environment inside companies achieved through training and continuous improvement of its personnel, while an economical approach is also considered [20].

Authors build the term based on core theoretical considerations. The selected approach for the technological competence term is defined by citations and by previous reviews made by theoretical researchers from the administrative, economic and educational areas. In general, tight collaboration between industry and economical approaches is expected. In the industry approach, only the trend related to the work area is envisioned. Meanwhile, for the educational approach, authors analyze the term strictly limited by its profile, and they hardly make references to the proposals made in different areas.

4.3 Terms associated to the technological competences.

The term technological competence is directly linked to the meanings technological capability and technological skill. Therefore, it is straightforward to identify the necessity of analyzing those concepts and the intersection of their definitions. Each term is individually analyzed and thereafter the relationship existing among the terms is collectively reviewed. Moreover, the key features that serve as links among the terms are identified.

Figure 7 provides a graphical representation of the terms' relationship. It is pointed out that the technological competence is a result from the development of specific technical skills and innovation. Therefore, technological skills figure as the theoretical basis for the technological competences. Also, it would not be possible to develop technological competences without the capability for applying the knowledge provided by them. In this case, technological capability is referred as the necessary resources for generating and managing improvements for products, services and processes, including human capital. Technological capability resources are gradually incorporated to individuals by continuous learning, this is, they can be accumulated.

For the purpose of this investigation, the correlation's middle point is set for the terms. In order to determine this middle point, the definitions made in [23][45][69] are considered, and the technological concept for industry is reframed.

The evaluation of technological competences can be based on the term's correlation, given that the principles for generating measurement instruments, markers and metrics are identified for each plane.

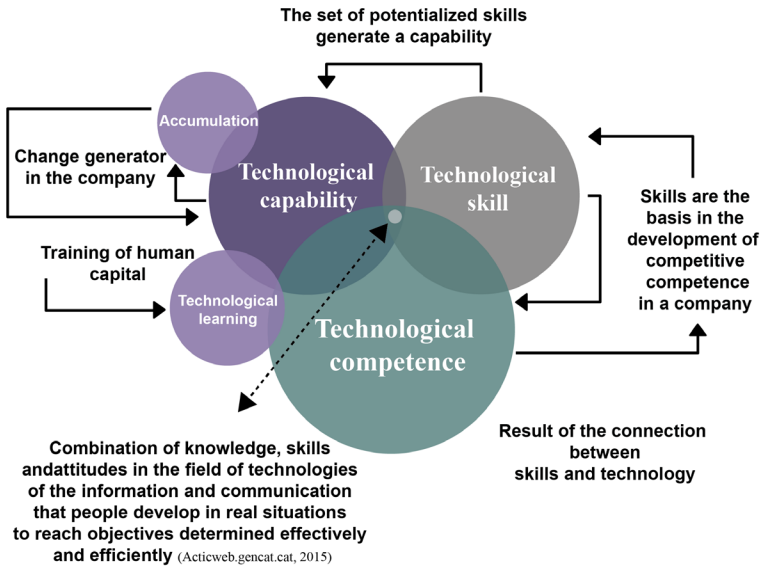

Fig. 7. Conceptual correlation between competence, capacity and technological skill

4.4 Reconsideration of the technological competence term related to the industry

From the SRL and data analysis, a definition for the term technological competence is constructed, convenient for its application to the productive sector. The conceptualization of the technological competence is drawn from an integral and systematic vision, and considers a corporative and industrial perspective:

Set of cognitive, attitudinal and value dispositions that allows developing human capital inside of an organization, to interact and master the conscious or unconscious use of Information, Communication and Collaboration Technologies, as referred to the technological appropriation and incubation for innovation in services, processes or products that provide benefits and business growth, strictly based on the collaborative work of the personnel.

This conceptual construction is structured with the objective of defining the term technological competence oriented to the organizational analysis, centered on human capital, aiming to the corporate development, both social and economic, visualizing technological expertise from a "conscious" state, but more important, considering the "unconscious" state, because it represents the ideal state in which individuals do not perceive ICT incorporation as an instrumental element, but as a transparent, day-to-day and spontaneous relationship with technology. It is relevant to assume collaborative work as a main feature because learning and skills development is generated by the organization's collective experience, personal experiences and the context.

4.5 Future work

The rationale for conducting a conceptual analysis of the technological competences and related terms is the future necessity for constructing a technological competence profile that considers all the criteria derived from a broad concept oriented to the industry. It is necessary to weight and describe evaluation criteria in order to identify the level of technological competence of human capital in the productive sector. This would be impossible without the background provided by the theoretical information assigned to the term, concepts relationship, identification of authors that study the term and the analysis of the main international, national and regional application projects.

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Mapping Algorithm Design and Maturity Model Construction of Online Learning Process Goals

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Abstract—In order to solve the problems of resource storage, resource delivery delay and other issues in the online learning process, it is studied and analyzed from the perspective of process goals. Firstly, a measurable e-learning process capability maturity model (EPCMM) is established. Then, based on the analysis of workflows in EPCMM's five process areas, a mapping relationship between major activities and key objectives is established in the process area. Finally, the mapping algorithm of online learning process features to process goals and the mapping algorithm of online learning metrics to process features are given. The practical results show that compared with the classical algorithm, this algorithm can effectively reduce the average transmission delay of online learning resources and improve the load balance of the system.

Keywords—Online learning, mapping algorithm, process, model

1 Introduction

The advancement of network technology and the characteristics of media have given learning a new carrier. A standardized online learning concept is becoming a new thing that enterprises, educational institutions and government agencies take seriously. The global trend and commercialization of online learning will be an important educational change in the 21st century. Whether online learning has achieved success or whether educational investment has achieved the desired educational benefits requires evaluation. Evaluation is the basis for conducting online teaching activities. With the increasing popularity of multimedia technology and the Internet, information technology is changing the way people produce, work, live and learn in human society, and this change is increasing. In recent years, the development of the network industry has deeply affected people's lives from all levels. In today's world, online media has become a mass media that can't be ignored and is becoming more and more important.

With the development of modern information technology, it has had a profound impact on the way people learn, and this has led to tremendous changes in the field of education and teaching. Today, the form of education has extended from traditional stage school education to on-the-job training and lifelong education, and the demand for learning has reached an unprecedented level. In the past, various forms of

traditional education have been unable to meet the rapidly updated requirements of social knowledge and skills. As online learning becomes more and more accepted by the public, many companies specializing in online learning have emerged. The services provided are basically divided into three categories: the first category provides a technology learning management platform, the second category provides content, and the third category provides specialized services. Generally speaking, online learning evaluation belongs to the sub-category of educational evaluation, and has the three meanings of educational evaluation, namely value judgment, evaluation development and reference standards. However, online learning has its own unique personality compared with traditional learning. For example, the separation of teaching and learning activities in time and space, the realization of teaching requires a reliable and secure network transmission system, and the learning of learners is mainly self-learning. Therefore, online learning evaluation also shows its unique characteristics.

Online learning is not simply a copy of the traditional full-time education model, which relies on high-speed information technology and networks. Traditional textbooks and classroom face-to-face teaching have been replaced by autonomous learning models that combine unbounded and shared online learning resources with self-study and face-to-face tutoring. The traditional teaching model centered on textbooks and teachers is being challenged as never before. Online learning is a new education mode, which runs through the education concept of cultivating people with comprehensive development and advocates new concepts of learning, teaching, and management. The learning and teaching activities of online learning are mainly realized with the Internet. It makes full use of the learning environment provided by modern information technology with new communication mechanism and rich resources to realize a new learning method. Whether online learning has achieved results and whether educational investment has achieved the desired educational benefits requires an evaluation. Evaluation is the basis for conducting online teaching activities.

2 Literature Review

Acostagallegos et al. (2015) pointed out in the study that there are four components in the analysis of learning essence, namely learning subject, learning conditions, learning outcomes and learning process. Human learning is a social phenomenon that is constrained by the development of social history and the physical and mental characteristics of people. Learning is the means by which individuals adapt to the environment. Learners interact with the environment and constantly change their behaviors to adapt to survival and acquire their own needs [1]. Wilcox et al. (2015) pointed out in the study that learning is the activity of acquiring skills in terms of purpose and result. From the perspective of pathways and processes, the objective things of perception, reflection and change are all learning. From the content and the harvest, learning is an activity that acquires information knowledge, forms skills, improves intelligence, and optimizes quality. As long as people live in the

environment, as long as they perceive, think and change the environment, they are learning [2]. Wren et al. (2014) pointed out in the study that learning is the process of obtaining information, processing information and applying information. Acquiring information is the prerequisite, processing information is the key, and applying information is the purpose. The process of processing information includes identifying the attributes of the information, the function and value of developing the information [3]. Bozzano et al. (2014) pointed out that learning is a process of planning, purposefully acquiring, processing, and applying information to form skills, improve intelligence, and improve diathesis [4]. Ferralis et al. (2015) proposed an Agent-based model in the study that combines learning models, balanced scorecards, and option pricing to provide a dynamic, flexible framework for evaluating the implementation of online learning projects [5]. Bartocci et al. (2015) pointed out in the study that ordinary online learning systems focus on the management of learning objects and learning outcomes, but it ignores the learning process. Workflow-based instructional activities can help support, manage, and monitor the learning process. In their papers, the application of work communication learning in online learning environment and the construction idea of teaching environment based on workflow management system are discussed [6]. Duc et al. (2015) pointed out in the study that the evaluation of online learners' reading ability should be based on the analysis of reading materials, the evaluation of learners themselves, the evaluation of reading details and the reading scores. In this way, the potential of learners can be stimulated to the maximum extent and the teaching can be promoted [7]. Sentelhas et al. (2015) introduced Internet-based distance learning evaluation standards in research. This standard includes architecture, curriculum development, teaching and learning, curriculum structure, student support system, teacher support system, evaluation system. These aspects are further refined into several necessary core indicator items and several non-essential optional indicator items. At the same time, the report also introduced a case study on the evaluation of the college's online courses with this standard [8].

The first part introduces the research background, explains the importance and necessity of this topic. The second part summarizes the research on E-learning. The third part constructs the E-learning Process Capability Maturity Model, introduces the key indicators of E-learning process domain, and describes the mapping relationship and algorithm between E-learning process and measurement. The fourth part introduces E-learning Process Capability Maturity Model and describes the characteristics of this model. The fifth part gives the conclusion.

This study introduces the process management evaluation framework into the field of E-learning, and its feasibility and practical significance are obvious. The proposed EPCMM model can be regarded as an exploratory step in this research direction. However, there are still some limitations in this study and no perfect model has been proposed. Therefore, the complete E-learning process evaluation system still needs further research and development.

3 Methodology

3.1 Construction of online learning process maturity model

As a process-based online learning maturity model, E-learning maturity model (EMM) plays an active role in evaluating the organization's ability and level of online learning activities. However, the EMM model itself uses the method of color block labeling to indicate the maturity and level of the organization's activities in the various process areas of online learning. It has inherent defects in effectively controlling and improving the online learning process. Therefore, the analysis and evaluation methods of high maturity ability in the Capability Maturity Model (CMM) are used for reference, and a new online learning process capability maturity model is established with the quantitative method, which is EPCMM.

The key of the EMM dimension concept is to embody the overall phased capabilities of the organization, rather than a gradual horizontal measurement model. It describes the capabilities of the process from a collaborative point of view. For an organization, if it develops in all dimensions of all processes, it will be better than those that do not. Higher level capabilities will not produce the desired results without the support of lower level capabilities. Without the support of higher-level capabilities, lower-level capabilities become very special, unsustainable, and unable to respond to the needs of changing organizations and learners. In the process of online learning, the relationship between abilities at all levels can be studied, as shown in Figure 1:

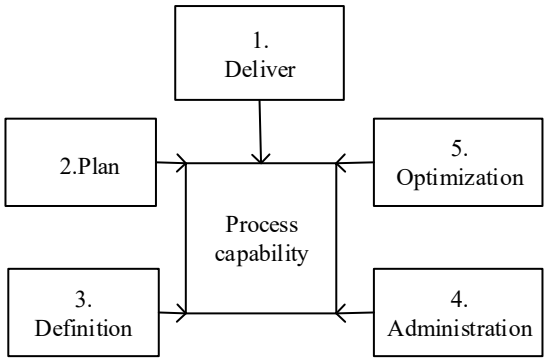

Fig. 1. Measurement dimension of online learning process

Take Marshall's model as a prototype and refer to all the key indicators in the five process domains of EMM. First, quantify each process activity. The previous section discusses the metrics of the online learning process, including five dimensions of delivery, planning, definition, management, and optimization. Estimated value V_i of each process behavior is respectively set on the above five dimensions, i = {1, 2, 3, 4, 5}. And the estimated value is set according to the four performances: insufficient, 0 points; partially sufficient, 2 points; most sufficient, 4 points; fully adequate, 6 points;

that is, V = {0, 2, 4, 6}. Then, the estimated value of the five dimensions are averaged by weighting, and the obtained estimated value of the process behavior is a, that is:

$$a = \sum_{i=1}^{5} W_i * V_i \quad . \tag{1}$$

In the above formula, W represents the weight of the process behavior in each dimension. For the sake of simplicity, it is assumed that the influence of a process behavior in five dimensions is equal, so all the above five weights are set to 0.2. Taking the learning process in Marshall's model as an example, there are 10 process behaviors, and the estimated value of each process behavior is obtained by weighted average of its 5 dimensions. If all processes are full scores in each of their dimensions, then all values of a are 6 and the total score is 60 points. In this way, the full score of the five process categories in the Marshall model can be calculated. The learning process is 60 points; the development process is 36 points; the collaboration and support process are 66 points; the evaluation process is 42 points; and the organizational process is 54 points.

Next, the EPCMM process metamodel is built. The model is a two-dimensional structure, as shown in Figure 2:

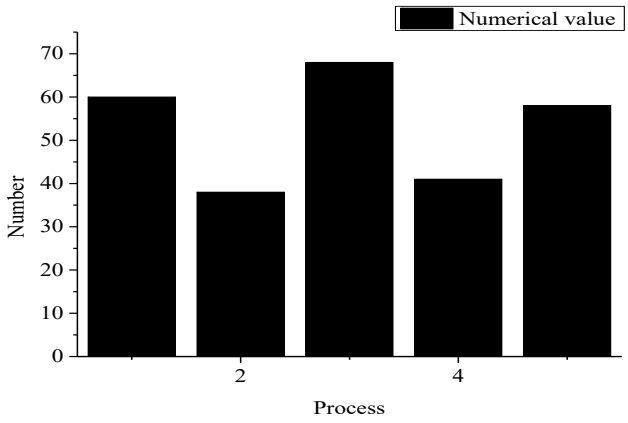

Fig. 2. EPCMM Process metamodel

The above diagram represents the structural framework for development, learning, cooperation, evaluation, and organization. The process categories defined in each EPCMM are evaluated according to Marshall's model, which shows that all process behaviors are rated as full scores. The above process metamodel can be expressed as a continuous model or as a phased model. As a continuous model, the process behavior on each process category is changeable, and the estimated value of its process categories reflected in the model is also variable. As a phased model, when the process behavior of each process category is fixed at a certain stage, the model shows

the stage level and ability of an educational institution to implement online learning. In actual work, each online learning organization can define its own online learning process metamodel according to its own organizational standards.

The EPCMM phased model provides a predefined roadmap for organizational-level improvements based on relationships at the process level, represented by a series of stages called maturity. Each maturity level covers all online learning process domains, each of which is described by key metrics that meet its objectives, the metrics are determined by values in each dimension (Equation 1). Process improvement progress is achieved through all process domain objectives in a particular maturity level. The EPCMM's phased model is defined as 6 maturity levels (MLs). ML0: initial level; ML1: delivery level; ML2: planning level; ML3: definition level; ML4: management level; ML5: optimization level. The definition of maturity level of online learning process is shown in table 1.

The maturity level is a stepped model, as shown in Figure 3.

Table 1. Maturity level definition

Maturity level	Describe
5	Continuous improvement in all aspects of the online learning process.
4	Ensuring online learning resources and quality of learning.
3	Developing and supporting the definition process for online learning.
2	An online learning project has a clear and measurable goal.
1	Create an online learning process and produce process results.
0	No process is defined.

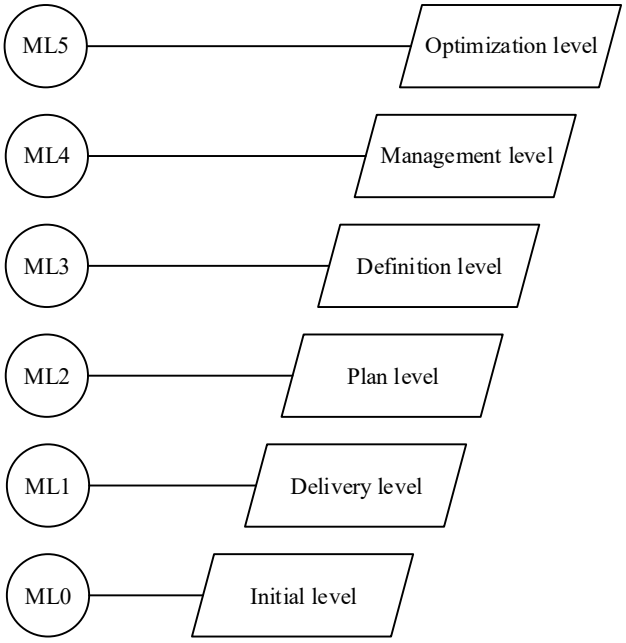

Fig. 3. Phase model

The online learning phased model has two advantages: first, the phased model provides a process platform for supporting the organization's online learning process improvement. For organizations looking to improve the maturity of the online learning process, the phased model provides a clear, effective and progressive approach to development. In the six online learning maturity levels of the organization described in the phased model, each time a level crossing is achieved, the organization is committed to solving a problem in a certain dimension in all online learning process domains; second, the staged model can define an online learning process maturity level for the organization, facilitating horizontal comparison across organizations. The expected range and application of the process domain is very clear in the online learning maturity level based on the phased model.

There are two disadvantages in the online learning phased model: first, the phased model divides the online learning process domain into six levels. In general, an organization must meet all of the process domains of the level and its low level in order to reach a certain level, thus lacking flexibility; second, each level of the staged model has more process improvement work that needs to be performed at the same time, so the workload is large and the cost is also large.

Online learning continuous models are not clearly defined in the order in which improvements are made. There are no discrete phases associated with organizational-level maturity, nor a definition of the overall ability classification of the organization, but a different capability distribution CL for any process. The continuous model of online learning is defined as six capability levels (CLs). CL0: incomplete level; CL1: executed level; CL2: planning level; CL3: definition level; CL4: management level; CL5: optimization level. Organizations can choose to perform the appropriate processes as needed, without being limited by the stage model's limitations on the process domain. Like the online learning phased model, the online learning continuous model also has a process domain with time. Similarly, each process domain is described by key metrics that meet its objectives, and its metrics are determined by values in each dimension (Equation 1). The difference is that the practice of the process domain in the online learning continuous model is the way to support the improvement of a single process domain. In a continuous evaluation, each process domain is rated by capability level. The different process domains of the two organizations are rated as different capability levels. It is described with key metrics that meet its objectives, and its metric is determined by the values in each dimension (Equation 1). It is a superimposed model and can't be gapped between levels.

The online learning continuous model also has the following two advantages: first, the online learning continuous model provides users with greater freedom to improve the online learning process. It allows users to select the order of process improvement activities based on the business purpose of the organization. In a continuous model, the user can choose to define the order of the process domains that are more suitable for their business environment; second, based on the continuous model, the organization's online learning process is evaluated, and the organization can make vertical comparisons with previous capabilities in the same process domain. In a continuous model, multiple capability levels can be defined for different process domains, which can enhance the understanding of strengths and weaknesses in

process improvement. The continuous model also has two shortcomings: first, since the online learning continuous model does not specify the order of the process domains, the organization's online learning process improvement requires the guidance of the online learning process improvement experts to determine the process domains and improvement priorities that the organization needs to improve; second, although the organization has made process improvements with the online learning continuous model, it is difficult to compare the inter-organizational process capabilities with other organizations.

3.2 Key indicators on the online learning process domain

In the learning process domain, a total of seven process indicators are defined;

The practical activities on key indicator 1 need to meet the following requirements: learning outcomes are primarily derived from educational intent or learning objectives, which clearly describe the learning content, the actions or performances to be taken, and the evaluation method. High-quality learning objectives are clearly reflected in teaching methods and content, along with flexible and diverse teaching attitudes, learning processes and styles. A formal assessment is given, which protects the interests of the learner. Learning objectives are well documented, teaching strategies, ideals, values are defined, and the learning process is explored rather than just testing knowledge.

The practical activities on key indicator 2 need to meet the following requirements: in this process activity, its process capability is reflected in encouraging students to use various communication methods or channels to participate in communication between classmates and teaching staff. In fact, providing tools alone is not enough. It is also necessary to dynamically encourage and support the use of tools and participation in communication. It should provide students with information on how to access and use different communication channels. It should give students a clear explanation of why channels or models are included in the curriculum and how they will help achieve learning goals. In particular, when many students are not familiar with online learning, it is necessary for them to get clear information on how to use communication channels effectively and appropriately.

The practical activities on key indicator 3 need to meet the following requirements: the ability of students to effectively carry out an activity is reflected in the skills of the learners they possess and the ability to effectively utilize the various sources of information and the technology provided by the institution. It can be assumed that students have some level of technical ability and experience, but this does not mean that students are doing effective online learning. When designing instructional elements, it must consider how to ensure clear guidance to students and how technology should be used to support student learning. Technology and pedagogy must be clearly reflected in the curriculum and programs designed and provided.

The practical activities on key indicator 4 need to meet the following requirements: effective interaction requires careful planning and thoughtful management to ensure that responses to students meet their expectations while being clear. Under this requirement, the type of classification reaction is very effective for online learning

environments with complex needs. It is also necessary to train students to use communication tools and provide strong technical support.

The practical activities on key indicator 5 need to meet the following requirements: provide a variety of communication channels, supplemented by a formal evaluation feedback process. Timely and useful feedback on policies should be required to improve students' relevant abilities, not just to meet current goals. Teaching staff should provide guidance and assistance for more effective feedback. Students receive feedback from teachers and other students that can be used to compare the gap between actual performance and expectations. Timely and constructive feedback affects student participation, curriculum performance and learning outcomes.

The practical activities on key indicator 6 need to meet the following requirements: link the content of the resource search and other information to the appropriate database by providing resources and guiding research to indicate where to find the appropriate reference material. Support the skills of using a variety of information to develop students' skills to effectively access useful resources. More comprehensive research skills should also be reflected in the assessment tasks and related feedback. The development of information literacy and skills should be reflected in the learning objectives. Provide teaching staff and students with templates, examples, training and support to use existing information resources to support student learning. Clear guidance and support on policy and intellectual property issues should be provided to teaching staff and students.

The practical activities on key indicator 7 need to meet the following requirements: teaching design should reflect diversity. Diversity encompasses coherent themes that involve accessibility and learning preferences. Inclusive support theory improves accessibility and all beneficial learning styles. This includes differences in the required respect ability and learning style. At the same time, it is required to respect values, guidelines, language factors, cultural and national traditions, and learners of special requirements. Inclusiveness also involves gender issues. In short, inclusive design benefits all learners.

3.3 Mapping relationship and algorithm of online learning process and metrics

Online learning organizational goals and objectives related to cost, quality or time can be mapped to appropriate online learning processes through quantitative indicators, so that online learning process objectives can be developed. In order to ensure the effectiveness of the measurement activities, a reasonable method must be used to select the metrics. Indicators are both a quantification of goals and a basis for process metrics. To achieve the goal of the evaluation process, a set of effective indicators should be used to measure process quality and performance.

Figure 4 shows the mapping relationship between the goals and characteristics of the online learning process. Here, based on this definition, the mapping relationship between the online learning process objectives and the process domain key indicators needs to be analyzed, so that the metrics about these key indicators can be effectively

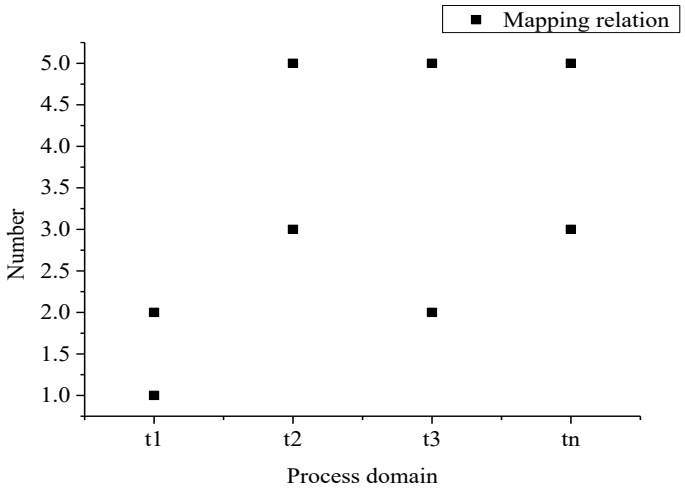

Fig. 4. Mapping relation function diagram

integrated into different processes. The online learning process goal is achieved by mapping key metrics to the appropriate online learning process. The determined organizational goals are measured by a range of key indicators. When the key indicators meet the requirements, the organizational goals can be achieved. The achievement of these key indicators is achieved by implementing activities in the relevant process domains.

The function of the online learning goal process is:

$$\theta(pg) = P_{Goal}, P_{Goal} \subseteq P \quad . \tag{2}$$

The mapping algorithm steps of the online learning process target are as follows:
Mapping algorithm from online learning features to process objectives: Mtg

Input: any feature t
Output: process / objective pair set (PnGT)
Steps:
PnGT=θ, P=process ensemble // initialization
Loop1:
Break if process set P = θ
P=P-p//take process
Loop2:
Break if P=θ
If t belongs to P
PnGT = PnGT+<P,Pgt>
End Loop 2
End Loop 1

Any given process has one or more specific characteristics that can collect data. It is the metrics corresponding to these characteristics that can be used to measure process performance. In turn, the indicator measurement of the process performance can quantitatively measure and improve the quality characteristics. In any case, it is necessary to map a process goal with process activity and its indicator metrics. In online learning practices, workflow analysis provides an effective way for practitioners to effectively map process activities to process goals.

4 Results

EPCMM is an effective model for evaluating process capability maturity for organizations conducting online learning activities. Control methods can effectively help organizations monitor the implementation of the process. According to the process improvement guidelines and plans formulated by the organization, it is possible to effectively control a process so that the online learning process activities can be established at a stable level to achieve the organization's strategic goals. EPCMM staged model can be used to make horizontal comparison of maturity across organizations, while the EPCMM continuous model can be compared longitudinally against the previous capabilities of the organization on the same process domain.

The formal definition of online learning process modeling is based on software engineering. Accordingly, the definition of process metrics is combined with process definitions as an extension of the process definition. This approach better eliminates the ambiguity between the process definition and the process metric definition, making the implementation of the metric plan consistent with its definition. Based on the organization's standard online learning process, an online learning project executable process is generated. Based on the online learning process capability baseline, an online learning project plan control benchmark is established. At the same time, relevant responsible persons are assigned to the online learning process activities, and online learning process guidelines and criterions are established to ensure the effective implementation of the online learning process.

After establishing a series of workflows based on the EPCMM process model, it is necessary to ensure that the main activities in those workflows cover all the key indicators in each process domain of the model, with reference to the key indicators listed in the paper. At the same time, activities in the workflow on each particular process domain are necessary to ensure that key metrics are only mapped to this activity in a particular process domain.

5 Conclusion

The formal definition of online learning process modeling and the generation algorithm of online learning project execution process lay the foundation for the definition of the organization standard online learning process. It also provides an effective theoretical basis and practical method for developing automated tools that use online learning process definition and process control. The organization’s online

learning goals are measured by a set of key indicators. When the key indicators meet the requirements, the organizational goals can be achieved. The achievement of these key indicators is achieved by implementing activities in the relevant process domains. A mapping relationship between main activities and key indicators is established on the online learning process domain.

The online learning process capability baseline consists of a process eigenvalue and an upper bound deviation control limit. If the actual metric value at the time of the process execution falls within the upper and lower control limits, the process is stable. The Statistical Process Control (SPC) method can effectively help the organization to monitor the implementation of the process. According to the process improvement guidelines and plans formulated by the organization, the online learning process can be effectively controlled, and the online learning process activities can be established at a stable level to achieve the strategic goals of the organization. When the sample range is stable, the corresponding practice activities are included in the new online learning process improvement plan, and the key indicator list is refreshed. The current CL can serve as a reference point on the baseline of new online learning process capabilities.

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Developing BacaBicara: An Indonesian Lipreading System as an Independent Communication Learning for the Deaf and Hard-of-Hearing

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Abstract—Deaf and hard-of-hearing people have limitations in communication, especially on aspects of language, intelligence, and social adjustment. To communicate, deaf people use sign language or lipreading. For normal people, it is very difficult to use sign language. They have to memorize many hand signs. Therefore, lipreading is a necessary for communication between normal and deaf people. In Indonesia, there is still few education media for deaf people to learn lipreading. To overcome this challenge, we develop a lipreading educational media to help deaf and hard-of-hearing to learn Bahasa Indonesia, called BacaBicara. User-Centered Design (UCD) is implemented to design the application and to analyze the constraints and conceptual models for the needs of users. This conceptual model uses the picture, lipreading video, text, and sign language to help the users understand the contents. The High fidelity prototype was implemented for evaluating usability testing. Based on the evaluation of the application, the results show that the prototype matches the usability goals and the user experience.

Keywords—Deaf and hard of hearing, lipreading, user-centered design prototype, Interaction.

1 Introduction

Persons with disabilities are the largest minority group in the world, one of which is hearing and speech disability. The person who has the imperfection is called the deaf people. There are about two millions deaf people in Indonesia [1]. In the city of Semarang, the number of people with hearing impairment is increasing. The number of deaf people in the city of Semarang in 2012 was 527 children, increasing rapidly from previous years.

One of the consequences of hearing and speech limitations, people with hearing impairment have difficulties in communication, especially on aspects of language, intelligence and social adjustment [2]. Although there are many technologies to help people with speech impairments such as hearing aids and cochlear implants, these

technologies will not work in a noisy environment. Futhermore, not all normal people understand the sign languange so that the message is not conveyed properly and will lead to misunderstandings [3]. Therefore, an interactive media is needed to bridge the communication between normal and deaf people. Lipreading is one method that can be used to train deaf people to communicate with normal people. This technique uses the lip shape reading ability to analyze the word being spoken by the interlocutor [2] [4] [5].

Indonesia is a country that has implemented various technologies into the education sector. With the advancement of this technology, it is encouraging us to develop the application that can be used to facilitate the communication learning by using lipreading techniques for both deaf and normal people. Based on these issues, we create BacaBicara, which provides language learning through lip reader using interactive website-based technology that adopts e-learning systems. BacaBicara can be used for all ages, both normal humans and deaf people. This application provides lipreading videos as learning materials, texts, images (visualization) and exercises, so people with hearing impairments can use this application as an independent teaching material that can be accessed easily anywhere and anytime and easily understood by all people. This application is equipped with a teacher's page, as a means for a teacher to know the development of his students.

The design method used in designing the user interface of BacaBicara is User-Centered Design (UCD). The development of the application is based on the user needs [6]. This method serves to build a good interaction and interface so that it meets the needs of the hearing impaired blind. The paradigm in this method places the needs, desires, and limits of the user as the main focus in each stage of the design. The paradigm is applied to various well-known methods and techniques for analyzing, designing, and evaluating [7].

2 Literature Review

Deaf people can be grouped into two categories: prelingual and postlingual. Prellingual child included in the category of heavy deaf, while postlingual group has hearing loss from birth. Because this limitedness, deaf people tends to have speech disorders. The development of the language learning for the deaf people may not only rely on the sense of hearing, but they need to optimize the visual abilities [8]. Deaf people rely heavily on visual media to understand a language such as cues, text, images, videos, and animation [9]. In the process of speaking and language learning, people who are deaf need a long time and intensive coaching. There are 3 main methods of deaf people learning languages: sign language, hearing from cochlea implant, and lipreading. Nearly 80% of non-verbal communication is the media most often used by people with speech deafness to learn languages [8]. Several studies [8] [9] [10] [11] [12] have applied the use of lipreading in the form of an interactive application to increase interest in speech and deaf speech learning.

Lipreading is often analogous to “third ear”, because we listen to someone through lip movements, speech patterns, and expressions of the other person (lipreading.org).

Lipreading requires the development of certain skills that make the process easier and more effective [2]. When we perform the language learning method using lipreading, the appearance of images or videos is the main key in understanding the letters and words that the narrator says [13]. Fig. 1 is a description of the pattern of lip movements that are grouped according to pronunciation. So, we propose BacaBicara web based application. The application is complemented by non-verbal communication; lipreading videos, narrator faces, and animations of each material. The application is presented in the educational games so as to provide some of the latest innovations to attract students' interest in learning by combining fun ideas with some learning material [14].

Based on [6] [15], the interfaces design of educational software must pay attention to the way students learn and must also provide good use so as to provide synergy between student interaction and software can run naturally. BacaBicara application uses an elearning system so that it can train users' skills and gain knowledge about new domains. Not only the elearning system, but also the development of learning through educational games is also implemented in the system. This research was conducted to investigate whether website interaction is easy to understand or not.

Table 1. The pronunciation of Indonesian Phoneme [12]

Viseme Class	Phoneme Handle	Example Pronunciation
Vocal	a	Like a in *"father"*
	i	Like *ee* in "t*ree*"
	u	Like *oo* in "*boot*"
	e taling	Like *e* in "*exact*"
	e pepet	Like *e* in "*dress*"
	o	Like *o* in "o*wner*"
Bilabial	p	Like *p* in "*pencil*"
	b	Like *b* in "*banana*"
	m	Like *m* in "*main*"
Labiodental	f	Like *f* in "*fun*"
Dental	t	Like *t* in "*ten*"
	d	Like *d* in "*dig*"
Alveolar	s	Like *s* in "*small*"
	l	Like *l* in "*look"*
	r	Like *r* in "*rich*"
	n	Like *n* in "*name*"
Plato alveolar	c	like *c* in "*chesee*"
Palatal	v	Like *v* in "*vase*"
Velar	k	Like *k* in "*kind*"
Glotal	h	Like *h* in "*hungry*"

Refer to Fig. 1, the movement of lip are influenced by Indonesian phoneme which is described by the BacaBicara narator. The process of text recognition consists of preprocessing familiar words, identification of words (word boundaries, lexicons), identification of phrases and accent of positions. the example of pronunciation Indonesia phoneme will be shown in Table 1.

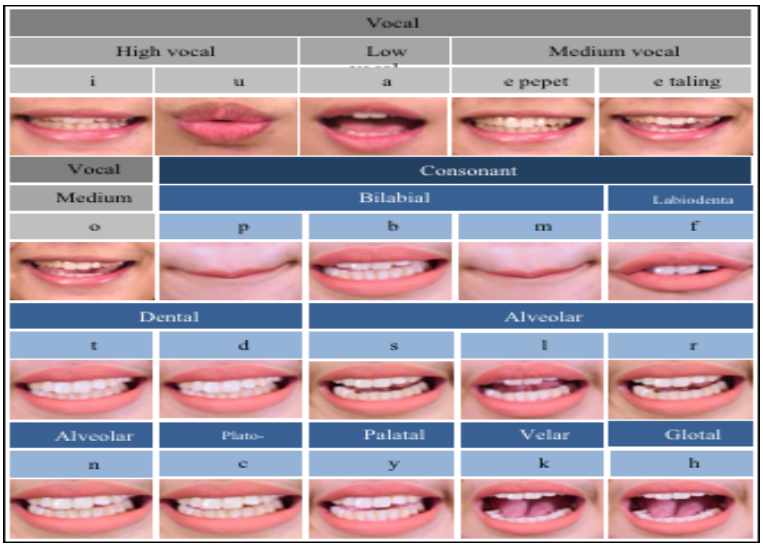

Fig. 1. The pattern of Indonesian lip movement

In this study, we use the UCD interface development method. The users are given a BacaBicara application prototype, then they are asked to do some interaction in the form of classroom management for mentoring teachers, lipreading exercises for people with speech and normal people.

3 Methodology

This study aims to develop a web based application that meets the usability goal and user experience for BacaBicara application as an independent communication learning to assist the deaf people. We use UCD approach to develop BacaBicara because people with hearing impairments have special characteristics that is different from the normal people. This approach is also effectively used for developing elearning systems to find out what the users need [6]. UCD is a development method in building user interfaces that are designed according to user information needs. In UCD, users participate in the development process [16].

3.1 Specify contect of use

At this stage, we conduct interviews and observations to the teachers and deaf people in inclusive schools to explore the needs and problems faced by them during the process of speaking and language learning. There are two types of personality catheteristics in this study, the first is the deaf person who often communicates with normal people (without using sign language). The second is deaf people who rarely communicate with normal people and use sign language media. We focus on the first personality characteristic to implement the system.

Table 2. The purpose and tasks of the users

User Goals	User Task
Build user interest in learning language independently using Lipreading	Easy to use and accessible to the public
	Using video visual and animation media
	The teacher can find out the progress of each class and each student
	Presented in the form of quiz games to attract the users
Recognizing forms of sylabels, words and grammar (Indonesian)	Learn the shapes of the vocal and consonant letters
	Recognize the tapped words of a combination of vocal and consonant letters.
	Identify grammar
Understanding the forms of sylabels, words and grammar (Indonesian)	Periodic training to improve the ability of users in language
Users are accustomed to using Lipreading as a language learning aid	

3.2 Identify User Goals and User Task

This research proposes a learning media that provides solutions for users, especially those with deaf speech to learn language independently. The goal of the user is to make users accustomed to using this application to train their speaking skills and language, especially Indonesian. Some of the tasks that must be performed to achieve this goal include: the user must have an interest in learning language using the method of lipreading learning, users can identify differences in syllabel, new words and grammar, and the last is the user can understand what the narrator is saying so that it can hone their ability to learn lipreading. The objectives and tasks of the users are presented in Table 2.

3.3 Produce Design Solution

Based on several requirements analysis that has been carried out in the previous stage, we design a user interface that contains some features. The design stages are divided into several phases.

Information architecture: Information architecture is the structure of software used by users to find information based on user position. BacaBicara have 7 features, which are:

- **Welcome page:** This feature is the start page of BacaBicara. Display of this interface is made to provide such information as a description of the application.
- **Register page:** This feature enables user to register their BacaBicara account. Users can register as students or teachers. If they register as a teacher, the system will automatically give the class code that the teacher will teach. There are five parts that the users have to fill, which are: usename, email, password, a choice to register as teacher or student, and teacher code.
- **Login page:** After registering, the user will enter BacaBicara by entering the username and password.

- **Lesson page:** This feature allows novice users to try the offered lesson before entering the main question page. Lesson pages are divided into 11 lessons: high vocal (i, u), moderate vocal (e pepet, e taling, o), low vocal (a), bilabial consonant (p, b, m), laiodental sonan (f), dental consonants (t, d), alveolar consonants (s. l, r, n), plato-alveolar consonants (c), palatal consonants (y), velar (k) consonants, and glottal consonants (h) [17] [18].
- **Guideline page:** This feature allows users to get detailed user guide information in accessing the system. The information is provided in the text and video tutorials that are easily understood by the user.
- **Teacher page:** This feature allows the teacher to maintain the progress of his students. The teacher can see the list of students who enter the class through the student page list and see the progress of each student through a statistics page.
- **Student page:** This feature allows students to choose the topic of lipreading exercises which are divided into 15 topics. Each topic has 3 levels, namely easy, medium, and difficult. After selecting the topic presented by the system, the user will enter the question page. Question page is presented in the interactive quiz that enhances user learning interest.

Workflow: Workflow is used to find out what processes users can do in software. Workflows are designed to represent information architecture, interface design, visual design, and navigation design. Each design is analyzed with the right design elements. Fig. 2 shows the workflow diagram of the BacaBicara application. From the welcome page, users can register as teacher or student. The login page is used for users who have already done in the previous registration and page guidelines.

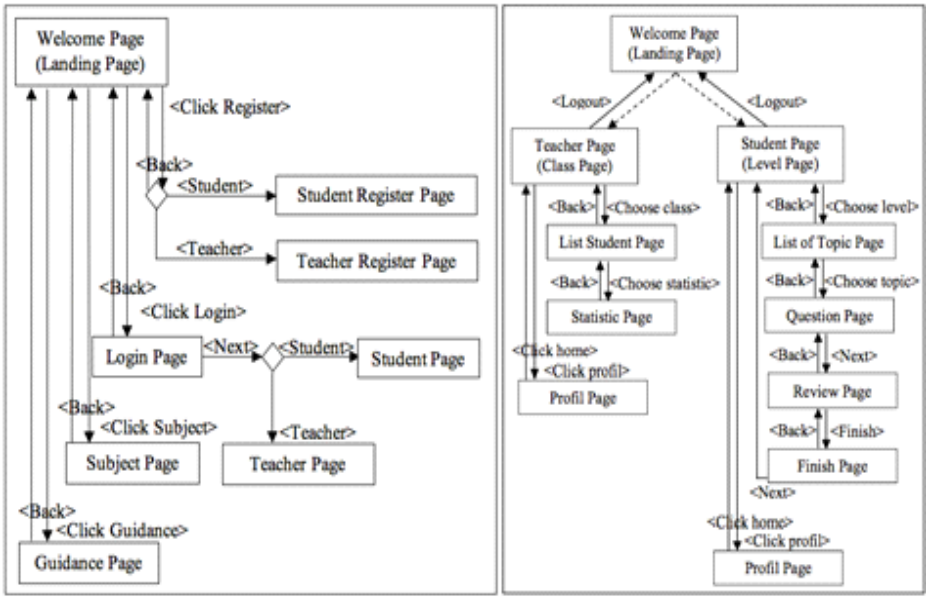

Fig. 2. The workflow of BacaBicara

Implementation: In this paper, a high-fidelity prototype was built using an approach. This prototype represents software and has interaction between users and prototypes [7]. This prototype was developed using web technology: HTML5, CSS, Javascript and PHP.

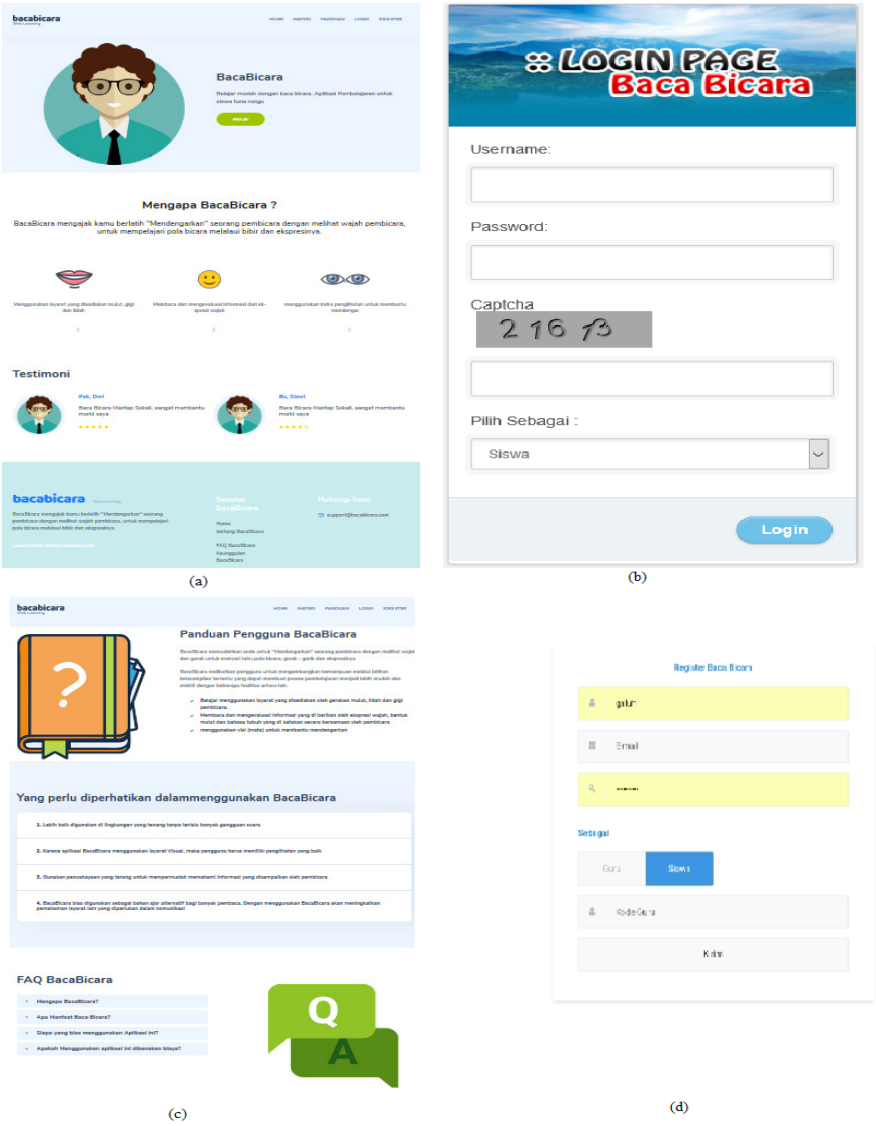

Fig. 3. High-fidelity prototype of BacaBicara

High-fidelity prototypes are implemented with the UCD model. Design principles are used to create user-friendly applications. Visual design is made taking into ac-

count the visual hierarchy and its components designed to achieve usefulness and user experience goals. The design of the BacaBicara system refers to the 8 golden rules coined by Ben Shneiderman. The Golder rules were first implemented in 1986, including [19]:

- **Strive for consistency:** Consistency in BacaBicara lies in color. We use white and blue for the color in the system.
- **Cater to universal usability:** Users in BacaBicara include students, teachers, and administrators. Each user has their own main page according to their tasks and needs.
- **Offer informative feedback:** A visual presentation of an interesting object provides an environment that is really good for displaying changes explicitly. The feedback that is implemented is in the login process, if the username and password are not in the database, the system will issue a notification of error
- **Design dialogs to yield closure:** Informative feedback on the completion of a group of actions gives users satisfaction of achievement, a sense of relief, a signal to stop contingency plans from their minds, and indicators to prepare for the next action. For example, the system gives appreciation if the students answer questions correctly and give notice if the students answer the questions incorrectly.
- **Prevent errors:** As much as possible, design a system so that users cannot make serious errors, for example, marking the right menu items and not allowing alphabetical characters in numeric field entries. For example, giving placeholders (writing in the input) and information under the input.
- **Permit easy reversal of actions:** As much as possible, the action must be reversible. This feature reduces anxiety, because users know that mistakes can be canceled, and encourage exploration of foreign choices. For example, in the data deletion process there is a confirmation dialog. Users can choose to cancel so that the data is not deleted.
- **Support internal locus control:** Users want what is in the interface and the interface responds to user actions. For example, if the user presses the register button, the register process will appear, not another process.
- **Reduce short-term memory load:** Humans have limited capacity for processing information in short-term memory. Therefore, designers avoid interfaces where users must remember information from one screen and then use that information on another screen. Examples for student list pages do not display student numbers, but student names and photos because student numbers are difficult to memorize.

The pop quiz metaphor is applied to learning media. Users will be given a short question with multiple-choice answers, this aims to develop new vocabulary or new sentences. This quiz has a maximum score of 100 points. Every user who can answer the question correctly, there will be an additional score for each question. Conversely, if each trial answer is wrong, 20 points will be deducted. At the end of each topic, there is a review page to repeat the content. The review page is designed similar to "looking for some items in the room" game.

4 Results and Evaluation

4.1 BacaBicara: An online Indonesian lipreading system

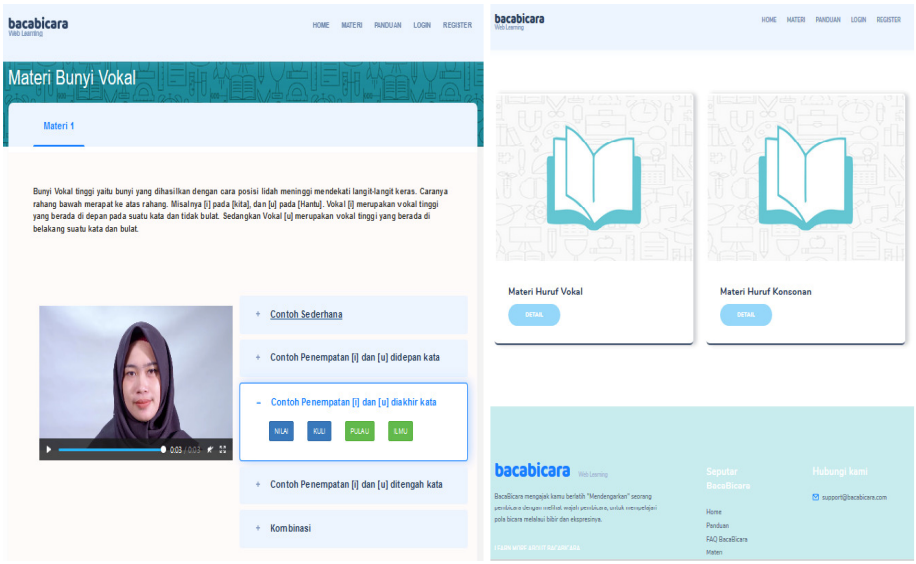

Fig. 4. Lesson Page

BacaBicara is an independent learning media that can be used by users (deaf speakers and normal people) to learn the language and talk using the lipreading method. This application utilizes the visual user ability to pay attention to the lips of the other person so that we can understand the speaker's intentions and conduct brief communication. This application uses Indonesian as a learning material so that users can implement their abilities in their daily lives. Pronounce learning is one of the most important components to make users accustomed to seeing Indonesian pronunciation from lip reading. This learning uses videos to help visualize lipreading. Fig. 4 displays an interesting view of the BacaBicara application.

The BacaBicara presents the material in the form of a simple example, examples of placement of letters that have been divided by categories referring to the lesson page in the chapter 3 and the combination of words based on previous syllables. This material is used as a teaching material for students before starting the lipreadig training so that they can adapt to the narrator in the Bacabicara application.

BacaBicara shows the exercises that are packaged through pop quizzes as educaional media. This quiz shows lipreading videos and students must read the video footage in the multiple choice provided by the system. Students can also see a review of the exercises they have done through a review page. Fig. 5 shows the type of pop quiz provided by the system.

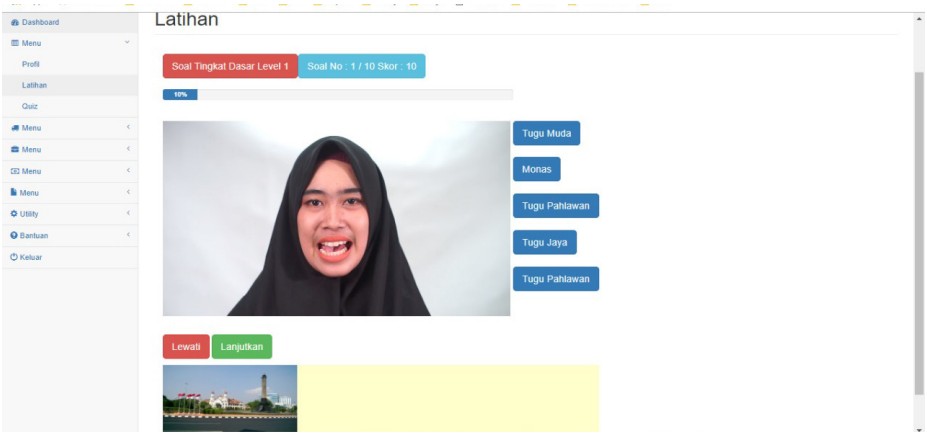

Fig. 5. Quiz Page

Users will be given several new vocabulary words or sentences in the video, then the user is required to answer each of these videos by selecting several answer choices in the quiz. BacaBicara will repeat the questions that cannot be answered by the user so that the user can better understand and learn from the error. In addition, BacaBicara always provides notifications sent by the user's cellphone to remind the training schedule that was previously agreed upon between the user and BacaBicara. This innovation is used so that users consistently practice lipreading to improve lip reading skills and also to improve scores. Teachers as instructors can monitor students' abilities through the teacher's dashboard. Teachers can also provide special assistance to students who have difficulty learning this lipreading.

4.2 Interview

Testing the research using five respondents was enough if the results show more than 75% [16]. Interviews and observations of this study were conducted on 5 students and 5 teachers. Interview begins with user identity questions including name, age, gender, contact, and hobbies. Followed by questions about how to communicate both to the deaf and normal people. Examples of questions include “How is your hearing condition? (Range 1 to 7, from no interference to severe hearing loss)”, “How do you communicate with deaf people?”, “How do you communicate with normal people?”, and “What are the obstacles when communicating with deaf people and normal people?”

The interview results show that the deaf in the Inclusive School communicate using sign language and writing. When dealing with deaf people, they only use sign language. When dealing with normal people, they use sign language coupled with lip movements that reflect the sentence or by writing. While the communication of normal people with hearing impairments uses direct sign language. For normal people who do not understand sign language, they can use lip movements or writing.

4.3 Exploration

After completing the interview, the user perform some explorations on the system for a few minutes. These explorations aim to find out how understanding users understand the system without instructions. The results show that the user is able to explore the system without difficulty.

4.4 Task completion

Users get tasks that must be completed from the system. Task completion aims to evaluate whether the user understands how the system works. There are 5 tasks that must be done, including: user register, user login, view profile, change profile, and complete one material. The result show that all users can assign the given tasks without difficulty. Users also understand the flow of the system.

4.5 Question and answer

Question and answer aims to get user understanding about the system. Answers are written on paper. These questions include:

- What do you think about this system?
- What is your expectation of this system?
- What experience did you get when using this system?
- Mention 3 things you like about this system!
- Mention 3 things you don't like about this system!
- What do you think about the whole system? (Interface, convenience, interaction, etc.)
- If you can contribute to the development. What do you want to add and change?

The result of question and answer shows that the application is simple, easy to use and easy to understand. The expectations of the user have been met from the application and the user feels comfortable when using the application.

4.6 Questionnaire

Questionnaire aims to get quantitative data from users. Questionnaire uses a rating of 1 to 5. A rating of 1 represents poor and a rating of 5 represents excelent. Questions are based on the usability goal and the user experience (UX).

Based on the questionare, the results show that 100% of users agree that the prototype is useful, easy to learn, easy to remember, help, and interesting, while 90% of users agree that prototype is effective, and 70% of users agree that the prototype has the good UX.

Table 3. Questionnaire Results

Parameters	Achievements		Response				
	Usability Goal	***User Experience***	***5***	***4***	***3***	***2***	***1***
General option		Engaging	3	2			
User interface		Engaging	2	2	1		
User experience	Good UX		3	1	1		
Task completion	Effective		2	3			
Prototype usability	Useful		3	2			
Ease of use	Learnable			4	1		
Information understanding	Memorable		2	2	1		
Information usability		Helpful	4	1			
User engagement		Engaging	3	2			

5 Conclusion and Future Work

In this paper, we develop a lipreading educational media to help deaf and hard-of-hearing people learn Bahasa Indonesia. The application is suitable for deaf users, since the application is useful, effective, easy to remember and easy to learn,.Design of the application highlights content consistency, clearness of user interface design, and information security.

The prototype of the application meets all the objectives specified for deaf users. The results show that 100% of users agree that prototype fulfill useful, learnable, memorable, helpful and interesting goals, 90% of users agree that prototype meets effective goals, and 70% of users agree that prototype meets good UX goals. For future development, this application will be developed into a mobile application. So that users can learn more easily in their free time. The research area can be improved to find out the best design principles that are suitable for novice users.

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A Distributed Distribution and Scheduling Algorithm of Educational Resources Based on Vector Space Model

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Abstract—To explore the distributed dispatching and scheduling algorithm of educational resources, based on the vector space model, the user and resource description model is built. In addition, the user interest representation method based on the background and tense vector space model (BTVSM) is proposed, and the distributed architecture based on the scheduling server is used to provide the personalized distribution service to the resource users. At the same time, the task scheduling model and algorithm are analyzed. The task scheduling optimization based on ant colony algorithm is mainly used in the scheduling server, and the simulation experiment is designed to verify the effectiveness of distributed dispatching and task scheduling algorithm for educational resources. The experimental results prove the validity of the application of distributed dispatching and scheduling algorithm based on VSM in specific systems, and it can effectively solve the allocation problem between the resource user group and the distributed dispatching center.

Keywords—Vector space model, distributed dispatching of educational resources, task scheduling.

1 Introduction

With the continuous accumulation of new resources and the increasing number of resource users, there is an obvious problem in the construction of educational resources: new resources cannot be updated to the user side of resources in time and the resource users are in urgent need of new resources. How to realize effective resource distribution has become an urgent problem in the current educational resources construction, which is the bottleneck of restricting the development of educational resources and the further development of educational information. In view of the problems existing in the distribution of existing resources, the distributed delivery and scheduling problem of educational resources is studied, focusing on the research of its delivery and scheduling algorithms. In the distribution of educational resources, the emphasis is put on the personalized needs of the resources users. In the process of personalized distribution of resources, the user interest representation method based on the background and tense vector space model (BTVSM) is put forward. In addition, the task scheduling optimization based on ant colony algorithm is adopted in the

scheduling server, which effectively solves the allocation problem between the resource user group and the distributed distribution center.

2 Literature Review

Chen et al. (2014) indicated that users could submit tasks on the host for processing. The demand for load allocation occurred in such an environment. Because of the random arrival of the task and the time requirements of their random CPU service, several computers are very likely to be idle or light load, and some other computers are heavy in load, which reduces the performance. In practical applications, there is always a server or system waiting on the other server for idle tasks [1]. Liu (2017) took educational resources distribution as the research object, selected 96 universities in the United States as the actual cases, and analyzed how to achieve a more equitable distribution of educational resources [2]. Gang (2013) focused on the study of free resources based on Internet. The research showed that this kind of resource service was provided only by a few sites, and the variety and quantity of resources were limited and were often the resources of some courseware and journal publications [3].

Because of the difference between economic and social development, there is a great difference in the degree of education information at home and abroad. As a result, it leads to a great difference in the construction of educational resources and the service of resources. In foreign countries, the information technology level of school teachers is very high. Educational resources are generally developed by school teachers themselves, with only a small number of teaching aids. Chakraborty (2013) analyzed the work of load allocation algorithm, and pointed out that it distributed and redistributed tasks between all participating nodes, thus maximizing the overall performance of the whole system. He focused on the details of the load allocation algorithm and its applicability in various load sensors [4]. Bouguerra et al. (2014) studied the fault-tolerant scheduling of parallel systems with non-memory failure distribution, and focused on the analysis of error handling that may occur during resource scheduling [5]. Purdy et al. (2015) studied the scheduling and allocation of medical education resources, mainly to improve the energy consumption efficiency of Core processors. Compared with the latest techniques, the proposed method had significantly lower energy consumption at both low parallel processing speed and higher parallel processing speed [6]. Wan et al. (2014) studied the user-centered resource service, and pointed out that most of the forms were based on the portal as the basic presentation, and friendly interface and convenient access to resources could provide timely services, such as information search and common problem solutions. Multiple portals could correspond to a resource database to provide different functional interfaces [7]. Roumasset and Wada (2011) studied online ordering resources, which mainly transferred resources by mail or express delivery. They also pointed out that the content of educational resources was not only K12 resources for basic education, but also a variety of professional resources. The resources were mainly displayed in the form of literature, and there were a large number of curriculum plans and programs, while audio and video resources were relative less [8].

To sum up, the distribution of educational resources requires not only a larger operating environment, but also needs a fair distribution mechanism. The load allocation of educational resources and the optimization of scheduling algorithm can maximize the overall performance of the system, reduce the efficiency of energy consumption, and diversify the variety of resources, thus further providing users with timely service and convenient access to resources. Therefore, by introducing the vector space model, the personalized needs of the resource users are focused on, and the allocation problem between the resource user group and the distributed distribution center is solved.

The first part introduces the research background and explains the importance of Background and Tense Vector Space Model (BTVSM) for the representation of user interest. The second part summarizes various researches on resource scheduling and allocation. The third part constructs the user interest model based on BTVSM, analyzes the recommendation process of personalized resources, and introduces the recommendation method of personalized services, task scheduling model and algorithm, as well as the experimental environment. The fourth part takes a user u_1 as an example to select personalized resources for Chinese subjects in grade 4 of primary school and carries out personalized service experiment and task scheduling service experiment. The fifth part gives the conclusion.

This study confirms the effectiveness of education resource distributed distribution and scheduling algorithm based on VSM in the application of specific systems, and it can effectively solve the distribution problem between the resource user group and the distributed distribution center. The specific example is studied, so the results have certain validity. However, the study is only focused on one area, and the findings may not be applicable to other areas. Therefore, it is necessary to conduct further research in other fields.

3 Method and Technology

3.1 User personalized resource recommendation

The premise of personalized resource recommendation is that the user and resource description should be characterized by the modeling, and then the personalized service can be realized by the matching calculation. As a result, user modeling and resource modeling are very important contents, which will be focused on.

First of all, it is necessary to build user interest model based on BTVSM.

For a user's interest in a particular field, the interest and preference of the user shows the characteristics of stability and variability, so the user interest model should have strong adaptability and robustness. In the description of the user interest model, the following two factors should be considered: first, the user will have different understandings for different background knowledge expressed in a key word; second, the interests of users will change over time.

In order to reflect the user's interest more truly, the user interest model is represented by the BTVSM. In the model, the subject and study section are introduced as

the background restriction, and the interest weighting function $w_n(\overline{T_n})$ based on temporal change is introduced into the vector space to calculate the attenuation and update of the user's interest weight. At some point t, the user interest model is expressed as:

$$Ul = \{s, g, K\} \tag{1}$$

In Formula (1), there are

$s \in S, g \in G$, $K = \{(k_1, w_1(\overline{T_1})), (k_2, w_2(\overline{T_2})), ..(k_n, w_n(\overline{T_n}))\}$, and $\overline{T_n} = \{t_{n1}, t_{n2}, ...t_{nm}\}$.

In Formula (1), S represents a collection of disciplines (such as mathematics, language, and biology); G indicates a collection of learning segments (primary school first year, primary school second year, and primary school third year); K suggests the user interest keyword vector space; k_n is the key word for nth describing interest; $\overline{T_n}$ refers to the time set submitted by keyword k_n each time; t_{nm} is the time for mth submission of the keyword k_n; $w_n(\overline{T_n})$ is the weighting function of time for keyword k_n.

For the attenuation and update of user interest, the time window mechanism is used to calculate, that is, if the keyword is submitted, the weight increases in a certain time window Δt; otherwise the weight will be attenuated.

Supposing that:

For each time window Δt, each time the key weight k_n is submitted, then the weight of interest is increased by the unit of a;

For each time window Δt, if the key word k_n is not submitted, then the weight is attenuated by the unit of b;

Then, at some moment t, the interest weight function of the keyword k_n is expressed as:

$$w_n(\overline{T_n}) = \begin{Bmatrix} \sum_{i=1}^{f(t_{nl}, t)} (f(t_{nl} + (i-1) \bullet \Delta t) \bullet a - c \bullet b), w_n(\overline{T_n}) > 0 \\ 0 \end{Bmatrix} \tag{2}$$

Otherwise,

$$c = \begin{Bmatrix} 0, f(t_{nl} + (i-1) \bullet \Delta t > 0 \\ l \end{Bmatrix}$$

In Formula (2), $f(t_{nl} + (i-1)$ indicates the number of time window Δt in the time interval of $[t_{n1}, t]$; $f(t_{nl} + (i-1) \bullet \Delta t$ denotes the times of keyword submitted in the time window of $[t_{nl} + (i-1) \bullet \Delta t, t_{nl} + i \bullet \Delta t]$.

The user interest model is described by tree structure as shown in Figure 1.

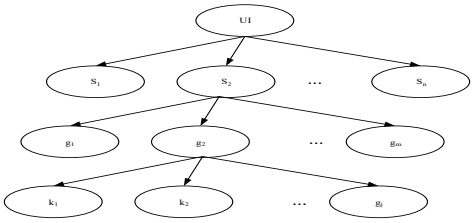

Fig. 1. User interest tree

Then, it needs to analyze the recommendation process of personalized resources.

The personalized service connotation includes two aspects: first, it refers to the selection of personalized initial resources for the new users based on the basic information of the resource users, and the second is to recommend the update resources that users are interested in according to the old users' interest in the information platform.

The flow chart of new user personalized initial resource recommendation is shown in Figure 2.

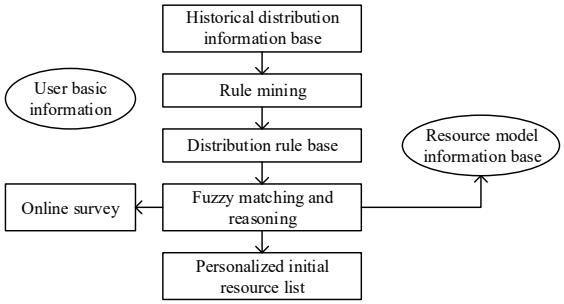

Fig. 2. The flow chart of new user personalized initial resource recommendation

The service flow of old user personalized update resource recommendation is shown in Figure 3.

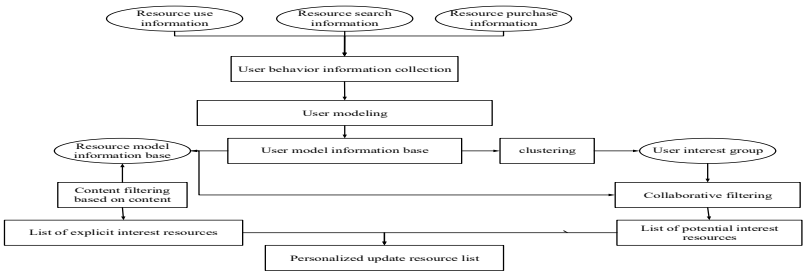

Fig. 3. The service flow of old user personalized update resource recommendation

3.2 Recommendation method of personalized service

When selecting the personalized initial resources for users, the information filtering technology is used to make personalized resource selection for users. In order to improve the performance of personalized recommendation service, the system combines content-based recommendation and collaborative recommendation based on information filtering technology to implement mixed recommendation.

The first is a rule-based recommendation method.

In order to accurately express the resource delivery rules based on user basic information, the weighted uncertainty representation with confidence is used, shown as follows:

R: If E_i (ω_i) Then H (CF (H, E), λ).

E_i is a prerequisite for rules. It can be a simple condition or a combination condition composed of multiple simple conditions connected by AND. H is a conclusion that can be a single conclusion or a combination conclusion formed by linking AND. CF (H, E) is the credibility of the rule, which is called the Certainty Factor or the rule intensity. Credibility is a quantitative representation of the degree of belief in things, and its initial value is determined by domain experts. λ is a threshold, and it provides a limit to the applicability of the corresponding rules. Only when the confidence level $CF(E_i)$ of the prerequisite condition E_i reaches or exceeds that limit, that is, CF (E_i)$\geq\lambda$, will the corresponding rules be applied. ω_i (i =1, 2,..., n) is a weighting factor and its value is given by domain experts. In order to obtain the characteristics of the user's choice of resources, it is necessary for the experienced experts to determine the influence factors and the importance of the user's satisfaction to the distribution resources from the user's basic information and the distribution of the resources. Then, according to the historical record information in the information base, it is used as a training example set and the user choice resource characteristics are obtained by data mining. These characteristics are processed through a series of steps, such as rule transformation, conflict resolution, synthesis, and updating.

In the selection of distribution rules, a target-oriented reverse reasoning is adopted, and fuzzy matching and fuzzy reasoning are adopted to achieve the selection of distribution rules. According to the basic information of the user, fuzzy matching is used to select the distribution rules for the users. If there are no matching rules, fuzzy reasoning theory can be used to produce new distribution rules to supplement the distribution rule base and enrich the distribution rule base continuously.

Then, the recommendation method based on content filtering mainly recommends resources by comparing resources and user models. An example is given to illustrate the implementation process of content filtering based on a user's recommendation of his interest resources.

Input: user interest tree User Interface (UI), resource set R, threshold n in TOPn principle.

Output: user interest resource (UIR) set.

Method:

/*Initialize the distance list L and user interest resource set UIR*/

For user interest tree, each interest branch UI_j do

Select the resource subset R having the same segment and subject as current user interest UI_j from the resource set R

For resource subset R'do

Calculate the distance between the keyword vector of current user interest UI_j and the keyword vector of current resource R_i'; store in the distance list L of current user interest UI_j

End For

Select the former n highly correlated resource storage user from the distance list L according to TOPn principle

Interest resource set UIR

End For

Return to the user interest resource set UIR.

From the above process, it can be seen that the key step is the similarity calculation of resources and user interests.

For vector space models, Euclidean distance, cosine distance and inner product are commonly used.

For any two vectors

$$X = (x_1, x_2, ...x_n), X^{`} = (x_1^{`}, x_2^{`}, ...x_n^{`}),$$

Euclidean distance is:

$$d(X, X^{`}) = (\sum_{i=1}^{n} (x_i - x_i^{`})^2)^{1/2} \tag{2}$$

Cosine distance is:

$$d(X, X^{`}) = \frac{\sum_{i=1}^{n} x_i x_i^{`}}{\sqrt{\sum_{i=1}^{n} x_i^2 \sum_{i=1}^{n} x_i^{`2}}} \tag{3}$$

Inner product is:

$$d(X, X^{`}) = \sum_{i=1}^{n} x_i x_i^{`} \tag{4}$$

The greater the distance between user interest keyword vector and resource description keyword vector is, the greater the similarity of them is; on the contrary, the smaller it is.

In addition, the determination of threshold n in input information is also very important. Too large or too small value affects the performance of the system. If n is too small, the recall rate will be reduced, and if n is too larger, the accuracy rate will be reduced. Therefore, the choice of n value is a question worthy of further study. In this system, the value of threshold n is associated with the total number of recommended resources, and the value of n is 3/5 of the total recommended resources.

Finally, it is a recommendation method based on collaborative filtering. It is different from the content-based filtering technology. It compares the user model, not the resource model or the user model. The key problem is to establish the user interest group, and it can realize the user clustering through some mature clustering algorithms.

3.3 Task scheduling model and algorithm

In the process of educational resources distribution, the essence of task scheduling is to deal with the matching between the user and the distribution center. The aim is to balance the system load of whole education resource distribution center. First, the task scheduling model should be built.

Combined with the actual situation of distributed distribution system of educational resources, the load balancing of distribution centers in the system is implemented by agent-based software. That is to say, a scheduling server is added between the distribution center and the user group, and the system realizes load balancing according to a certain task scheduling algorithm. Task scheduling services in the distributed distribution system of educational resources are composed of task receivers, task schedulers, task transponders, task monitors, as well as original task queues, optimized task queues, task logs and information bases, as shown in Figure 4.

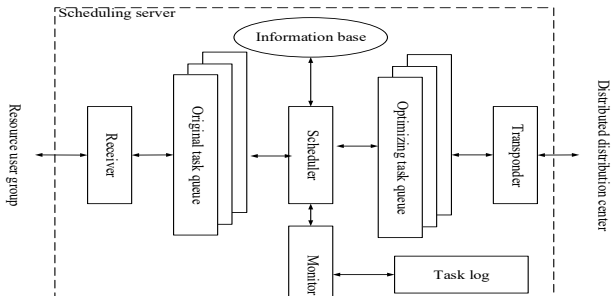

Fig. 4. Scheduling server model

From a macro point of view, the scheduling server balances the tasks of each resource distribution center, trying to avoid excessive requests to a single center, so as to balance the system load. On the microscopic level, it is possible to get a reasonable allocation scheme between distribution centers and resource users through optimization algorithm, so that the system performance is optimal. The early warning mechanism is set up for the prevention of abnormal problems. During the system operation, the health condition of the system is monitored in real time. When the abnormal situation occurs, the emergency processing program is automatically triggered to protect the normal operation of the system.

In the scheduling server, the task scheduler is the key component of the whole system. In the process of its operation and scheduling, the following two key problems

should be dealt with: the first is the load status evaluation of the distribution center server; and the second is the optimal scheduling algorithm that matches between the user and the distribution center.

For the load evaluation of the distribution center server, the system uses static evaluation method to evaluate the load of the distribution center in the initial stage. And it is evaluated by the statistical evaluation method after the system is running for a period of time. This can more effectively reflect the load capacity of the distribution center in the actual work.

In this system, different servers can respond to different users, and a typical combinatorial optimization problem is allocated among the two. According to the previous introduction, ant colony algorithm is a kind of optimization technique based on population operation. It can implicitly search multiple solutions in the solution space and can use the similarity between different solutions to improve the efficiency of the concurrency solution. In addition, ant colony algorithm is also very versatile and robust, so the ant colony algorithm is very suitable for combinatorial optimization problem. Therefore, ant colony algorithm is used to solve the optimal allocation between users and distribution centers. The optimal scheduling algorithm based on MAX-MIN ant colony algorithm is as follows:

The key of ant colony algorithm is to transform practical problems into ant colony networks. Here, the distribution center distribution process is regarded as c_j stages, and each stage assigns a distribution center to provide downloading service. Max_{cj} ants are set up, each ant transfers from c_j to $u_1 \sim u_n$, and the transfer probability is as follows:

$$P_{ij}(t)=\begin{cases}\dfrac{[\tau_{is}(t)^{\alpha}]\bullet[\eta_{is}(t)^{\beta}]}{\sum_{s\in allowed_k}[\tau_{is}(t)^{\alpha}]\bullet[\eta_{is}(t)^{\beta}]}, j\in allowed_k \\ 0, otherwise\end{cases} \tag{5}$$

In Formula (5), $allowed_k$ indicates the user set that the ant k can access to, and in each cycle, the users having been accessed are deleted from the list. $\tau_{is}(t)$ suggests the pheromone content between u_i and c_j at the moment of t, η_{is} is the inspiration degree from c_j to u_i, the parameter α means the weight of residual pheromone, and the parameter β denotes the weight of inspiration information. At the initial time, the pheromones of each path are equal. Set $\tau_{ij}(0)=C$ (C is a constant), and ijη is determined by a certain inspiration algorithm. The heuristic algorithm used is the reciprocal of download time at c_j for completing the user u_i task:

$$\eta_{ij}=\frac{1}{TM_{ui}} \tag{6}$$

Update of pheromone:

$$\tau_{ij}(t+\Delta t)-(1-p)\bullet\tau_{ij}(t)+\frac{Q}{E_b} \tag{7}$$

In Formula (7), p suggests the coefficient of volatilization, which is a constant in range of 0 to 1; Q is a constant; E_b indicates the global better solution.

The specific steps for algorithm: initializeα, β, p, Q, and C; oc ←0(oc is external cycle times); nc ←0(nc is built-in cycle times). Let out Max_{cj} ants at c_j (j=1, 2, …, m), and each ant chooses the next user according to the transfer probability. Require: ants in the same center cannot be transferred to the same user, and the number of ants at a user cannot exceed the upper limit Max_{uj} of the user connection distribution center. Modify allowed$_k$ list, calculate the value of all the objectives of this assignment, compare the better results, and put in the result set: nc←nc+1. If nc>the cycle times set, better results are used to update pheromone intensity according to update equation: oc←oc+1; otherwise, reset allowed$_k$ list and turn to the fourth step; if oc> the cycle times set, then output the current optimal solution or turn to the third step.

3.4 Experimental environment

In order to test the performance of distributed distribution and scheduling algorithm for educational resources designed, the task scheduling of personalized service and the user and the distribution center are simulated. As the task scheduling between the personalized service and the distribution center is implemented in the scheduling server, the scheduling server provides access interface to the resource users, the distribution center and the headquarters resource center in the form of Web Services in the actual system operation, and there is no visual interface. To observe the process and result of the system intuitively, a visual Windows program is used to carry out the simulation experiment. With the users language discipline of grade four in primary school as the simulation experiment object, the personalized resource selection based on the content filtering technology, the personalized resource selection based on the collaborative filtering technology and the task scheduling simulation experiment between the user and the distribution center are carried out, respectively.

This experiment takes 3 distribution centers to provide upgrade services for 20 users as an example to test the optimal scheduling results of the system. The server situation is as follows:

Three servers are respectively expressed as: C1, C2, and C3;

The maximum number of connections for server C1 is 5, the maximum number of connections for server C2 is 8 and the maximum number of connections for server C3 is 7;

20 users are represented as: U1, U2, ..., U20;

Assuming that the maximum number of server connections for 20 users is 1, the same resource packet is downloaded, and the file size is 50000K, then the download speed between each user and the server is limited to 100K/s~900K/s and generated randomly.

4 Results

4.1 Personalized service experiment

The personalized resource selection of language discipline of grade four in primary school is conducted.

Step 1: choose the resources with the academic subjects of Chinese language in grade four from the resources to be upgraded; step 2: choose the user u_1 and load his interest data; step 3: acquire the personalized resource recommendation list of the user u_1 through content filtering technology. Among the new resources to be upgraded, there are 30 resources belonging to the resources for language subject of grade four in primary school. According to the implementation process based on the content filtering technology discussed, the resource recommendation list is shown below based on the similarity calculation (cosine distance) between the resources and the user u_1 interest.

28, 29, 30, 26, 21, 17, 18, 20, 5, 7, 25, 23, 6, 13, 1, 10, 9, 8

Through the user u_1's direct feedback, it is known that 3 resources (5, 6, 13) are the resources that the user u_1 is not very interested in among the resources recommended by the system, and 4 of them (11, 24, 27, 31) are the resources that the user u_1 is interested in among the resources that are not recommended. According to the personalized evaluation method discussed above, the results are shown below:

Recall rate $=15/22\times100\%=68.21\%$

Accuracy rate $=15/18\times100\%=83.33\%$

Similarity $=2.7725/15=0.1848$

According to the above experimental process, 10 experiments were carried out, and the data of personalized service indicators were shown in Table 1.

Table 1. Personalized service index statistics table

Experiment order	Recall rate (%)	Accuracy rate (%)	Similarity (%)
1	68.21	83.33	0.1848
2	63.59	77.76	0.1835
3	60.86	77.77	0.1766
4	68.21	83.33	0.1848
5	63.59	77.76	0.1835
6	77.27	94.53	0.1923
7	75	83.33	0.1867
8	65	72.22	0.1755
9	75	83.33	0.1867
10	63.63	77.78	0.1834

From the above experimental data, it can be clearly seen that the personalized resource recommendation service based on content filtering technology in this system has relatively high accuracy rate, but the performance of the recall rate is slightly lower. The case reflected in the experimental data is consistent with the previous analyzed case. Therefore, users' potential interest resources based on collaborative filtering technology need to be supplemented.

The experimental results of personalized resource selection based on collaborative filtering technology are as follows:

Taking u_1 as the discussion object, collaborative resources are recommended. The user u_1, in the fourth class interest group, carries out content-based filtering resource recommendation to form a group interest resource list. Then, the resources not in the content-based interest resources of user u_1 are found as the potential interest resource recommended to user u_1.

From the above analysis, it can be seen that although collaborative filtering technology can improve the recall rate of personalized services, occasionally too many potential interest resources often reduce the accuracy and similarity.

4.2 Task scheduling service experiment

In order to prove the optimization performance based on ant colony algorithm task scheduling, the simulation experiments are carried out by using the fastest response method and the weighted rotation method, as well as the allocation between the distribution centers and the resources based on ant colony algorithm. The constant in the ant colony algorithm is initialized to: $\alpha = 2, \beta = 2, p = 0.1, Q = 11, C = 0.1$, and the number of iterations is 200.

The allocation scheme of fast response method is as follows:

- Users that server C1 provides services: U4, U7, U10, U11, and U12.
- Users that server C2 provides services: U1, U2, U5, U9, U17, U18, U19, and U20.
- Users that server C3 provides services: U3, U6, U8, U13, U14, U15, and U16.
- The allocation scheme of the weighted rotation method is as follows:
- Users that server C1 provides services: U6, U9, U12, U15, and U18.
- Users that server C2 provides services: U1, U2, U4, U7, U10, U13, U16, and U19.
- Users that server C3 provides services: U3, U5, U8, U11, U14, U17, and U20.
- The allocation scheme based on ant colony algorithm is as follows:
- Users that server C1 provides services: U4, U10, U12, U14, and U17.
- Users that server C2 provides services: U1, U2, U5, U7, U9, U16, U19, and U20.
- Users that server C3 provides services: U3, U6, U8, U11, U13, U15, and U18.

The detailed results of the contrastive experiment are shown in Table 2.

The histogram for the comparison of algorithm results is shown in Figure 5.

The statistical map of the result of the objective function of above ant colony algorithm iterating 200 is shown in Figure 6.

It can be seen from the figure that the algorithm finds a better solution for 1383.5 seconds after the 106th generation cycle and has good convergence.

Table 2. Statistical table of comparative experimental results

Tasks	Fastest response method	Weighted rotation method	Ant colony optimization
U1	100	100	100
U2	55.6	55.6	55.6

U3	62.5	100	62.5
U4	71.4	83.3	71.4
U5	62.5	100	62.5
U6	55.6	500	55.6
U7	62.5	62.5	62.5
U8	55.6	55.6	55.6
U9	71.4	250	71.4
U10	62.5	500	62.5
U11	55.6	83.3	83.3
U12	62.5	62.5	62.5
U13	55.6	71.4	55.6
U14	100	100	83.3
U15	71.4	250	71.4
U16	55.6	71.4	71.4
U17	125	500	71.4
U18	166.7	100	100
U19	62.5	62.5	62.5
U20	62.5	166.7	62.5
Objective function	1477	3274.9	1383.5

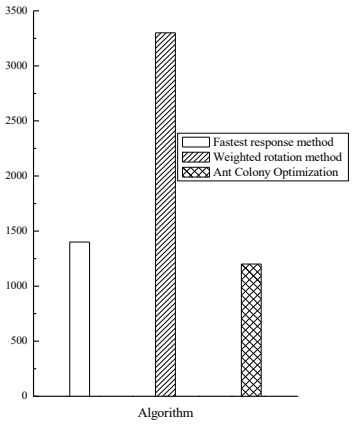

Fig. 5. The histogram for the comparison of algorithm results

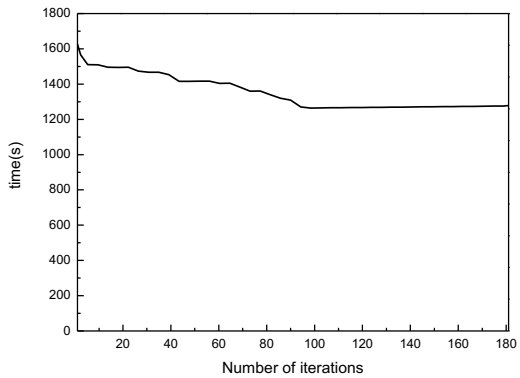

Fig. 6. The statistical map of the result of the objective function of ant colony algorithm

5 Conclusion

With the rapid development of science and technology and the increasing of marine transportation business, the communication of ship and automobile includes various kinds of services, such as analog voice, fax, business data, and video image. The communication equipment and information types between ship and shore are not unified. As a result, it brings about the problems like complicated operation, low end intelligence, and high communication cost. There is an urgent need for a unified communication platform to process and transmit multi-source data.

A ship data transmission system based on embedded technology is designed and implemented. The system can capture and store information types commonly used on ships (including sensor information, voice information, and picture information). At the same time, these different types of data are mixed processing, and the mixed data stream is transmitted to the modulated launching system. In addition, the Procurement Navigation (PRONAVI) technology is introduced, the Mesh-based PRONAVI network is constructed, which conform to the theme of future network security and intelligence and can better meet the future business and network development needs.

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Classification Method of Teaching Resources Based on Improved KNN Algorithm

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Abstract—In order to effectively utilize the network teaching resources, a teaching resource classification method based on the improved KNN (K-Nearest Neighbor) algorithm was proposed. Taking the text class primary and secondary school teaching resources as the research object, combined with the domain characteristics, the KNN algorithm was improved. By measuring the sample space density, the text of the high-density area was found. Different clipping methods were proposed for both intra-class and inter-class regions. The problem of cropping in the space of multiple class boundaries was considered. Results showed that the method ensured uniform distribution of samples and reduced the time of classification. Therefore, under the Weka platform, the improved KNN algorithm is effective.

Keywords—Text classification, KNN, primary and secondary school teaching resources, sample cutting.

1 Introduction

The development of Internet technology not only allows learners to receive the highest quality education anytime and anywhere, but also allows the dissemination of knowledge to be no longer limited to books. With the popularization and promotion of digital education, the construction of online education resources in China has become increasingly mature. Various types of educational resources are abundant and large. At the same time, network resources are also facing enormous challenges. Massive educational resources are still growing at geometric multiples, and the types are complex. There is no effective organization and management. Among the various types of resources, including video, audio, pictures, and text, the number of text-based resources is the largest. In this case, how to effectively classify the teaching resources in the network is an important problem that needs to be solved urgently. In the past, manual classification was usually used to allow professional personnel to complete the classification work. In the case of a small amount of resources, this classification results are very accurate. However, with the continuous increase of the number of resources, the problem of low manual classification efficiency and the decrease of classification accuracy with the increase of working hours has become increasingly prominent.

As a kind of machine learning technology, automatic text categorization can effectively organize and manage text information. Based on a given classification model, the text to be classified is subject to certain rules. Its degree of association with each category is calculated and automatically divided into corresponding categories. This technology has a wide range of applications in information retrieval, mail filtering, and digital libraries. Text automatic classification technology saves labor costs, classification is fast, and accuracy is high. Therefore, it is regarded as the main means of classifying teaching resources.

2 State Of The Art

In the late 1950s, Luhn H P, an expert in text mining, first proposed the concept of word frequency statistics. Chen et al. [1] considered this to be an epoch-making study in the field. Subsequently, Samanthula et al. [2] published the first paper on text categorization and proposed the "Bayesian hypothesis", which greatly promoted the progress of text classification related research. Li et al. [3] studied the performance modeling of manufacturing personnel based on the improved KNN (K-Nearest Neighbor) algorithm. Since then, many experts and scholars have achieved certain research results in this field of technology, such as the famous intelligence scientists Spark and Salton. Since the 1980s, traditional knowledge engineering techniques have been applied in this field. According to the knowledge provided by the experts, rules were formed and the classifier was manually established. This was a good classification in some corpora. However, in the face of large-scale data sets, the method was limited. After entering the 1990s, with the rise of machine learning technology, Hong et al. [4] began to try to apply it to text classification. This classification method automatically classifies the classified text by learning on the pre-classified text set and obtaining the classification rules. This method does not require expert participation. It has higher accuracy and shorter classification time. Meng et al. [5] described and designed every detail of the text categorization implementation method, and conducted relevant experiments on the data set Reuters22173 for testing. This article was later seen as a classic in the development of text categorization. Li et al. [6] proposed a support vector machine method (SVM) based on statistical theory. The basic idea was to find the optimal high-dimensional classification hyperplane. The method can be learned based on small samples. At the same time, the robustness and classification effect were good, which has been widely concerned by experts. In addition, Anthimopoulos et al. [7] used the deep convolutional neural network to classify Lung Patterns for interstitial lung disease.

In summary, at present, the general classification algorithm was mainly used for the teaching resources of primary and secondary schools. The research and design were not combined with the characteristics of the field, and the classification effect needs to be further improved. According to the characteristics of primary and secondary school teaching resources in text class, the related research on classification algorithm was carried out. First, the basic concept of the KNN (K-Nearest Neighbor) algorithm was introduced. Then, the experimental environment was built and experimental

data was collected. Finally, the teaching resource classification method based on the improved KNN algorithm was verified. Results showed that the method was effective.

3 Methodology

3.1 Introduction of KNN algorithm

KNN algorithm (also known as K-nearest neighbor algorithm) is one of the most commonly used classification algorithms at present. It is ideal for solving multi-category problems. The core idea is that in the feature space, if the K samples closest to the sample to be classified mostly belong to a certain category, the sample to be classified also belongs to this category.

For example, the training space contains two categories of blue squares and red triangles, and the green text is the sample to be classified. When K=3, in the three samples closest to the green sample, there are two red and one blue, and the green sample should be divided into red triangles. When K=5, in the three samples closest to the green sample to be classified, there are three blue and two red, and the green sample is divided into blue squares. From this, it can be seen that the selection of the K value directly affects the final result of the KNN classification.

Text similarity is used to measure the distance between two texts. Commonly used similarity calculation methods include the Euclidean distance method and the angle cosine method.

The Euclidean distance method is as follows:

$$D(d_i, d_j) = \sqrt{\sum_{k=1}^{n} (W_{ik} - W_{jk})^2} \tag{1}$$

In the formula, d_i and d_j represent any two texts i and j in the training set. n is the total dimension of the feature vector. W_{ik} and W_{jk} represent the corresponding feature item weights in the text vectors of the text d_i and d_j.

The smaller the value of the Euclidean distance D, the higher the similarity between the two texts. On the contrary, the similarity is low. The Euclidean distance method is a relatively simple method of calculating similarity. The amount of calculation is small, but the results are often not good enough.

The angle cosine method is as follows:

$$Sim(d_i, d_j) = \frac{\sum_{k=1}^{n} W_{ik} \times W_{jk}}{\sqrt{(\sum_{k=1}^{n} W_{ik}^2)(\sum_{k=1}^{n} W_{jk}^2)}} \tag{2}$$

The meaning of the parameters in formula (2) is the same as in the Euclidean distance formula (1).

The larger the angle cosine value Sim (d_i, d_j), the smaller the vector angle of the two texts, which indicates that the similarity of the two vectors is high. Conversely, the smaller the angle cosine value Sim (d_i, d_j), the larger the vector angle of the two texts, the lower the similarity. In addition, the range of the cosine of the included

angle should be [0, 1]. If it is not within the range, the calculation result is incorrect. When Sim=0, the two articles are completely unrelated; when Sim=1, the two articles are identical. At present, the similarity calculation in the text classification system generally adopts the angle cosine method.

The specific steps of the KNN algorithm are introduced, as shown in Figure 1.

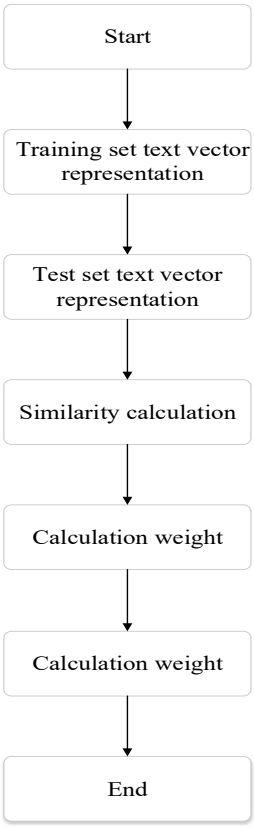

Fig. 1. Flow chart of KNN algorithm

First, the training set text is represented by a vector space model. The feature weight of each dimension is the result of the TF-IDF_ATC calculation.

Second, the test set text is also represented by a vector space model. The feature weight of each dimension is also the result of TF-IDF-ATC calculation.

Third, the spatial distance between the text to be classified in the test set and each text in the training set is calculated, that is, the text similarity. In the text similarity algorithm, the cosine similarity algorithm which is more suitable for KNN is selected, as shown in formula (3).

$$Sim(X, D_j) = \frac{\sum_{i=1}^{n} W_i \times W_{ji}}{\sqrt{(\sum_{i=1}^{n} W_i^2)(\sum_{i=1}^{n} W_{ji}^2)}} \tag{3}$$

In the formula, X is the text to be classified, and D_j is a text j in the training set. W_i represents the i-th feature item weight of the text vector X to be classified. W_{ji} represents the i-th feature weight of a text j in the training set. n is the total number of dimensions of the text feature vector.

Fourth, the Sim(X, D_j) values are arranged in descending order, and K training set texts having the highest similarity to the text X to be classified are selected. At present, there is no good way to directly determine the optimal K value. The K value can only be adjusted through experiments, and the appropriate K value is determined according to the test classification effect.

Fifth, the distribution of the selected K texts in each class should be counted, and the text to be classified should be classified into the category of most texts. There are many teaching resources in primary and secondary schools. It is easy to appear that several categories contain the same number of texts. Therefore, according to the category of the K most recent texts, the weight of the text to be classified belongs to each category, as shown in formula (4).

$$P(X, C_i) = \sum Sim(X, D_j) P(D_j, C_i) \tag{4}$$

Sim(X, D_j) is the similarity between the text to be classified and the text of the training set. P(D_j, C_i) is a category attribute function. When the text X belongs to the class Ci, P(D_j, C_i) = 1; otherwise, P(D_j, C_i) = 0. Finally, the text X to be classified is divided into categories with the largest P(X, C_i) value.

3.2 KNN algorithm analysis

According to the characteristics of the teaching resources in primary and secondary schools, two shortcomings of the traditional KNN algorithm are proposed:

First, when the number of training set texts is large, the computational overhead of the KNN algorithm is large.

Second, the sample distribution between the classes of primary school teaching resources in the text category is severely uneven. There is a misclassification phenomenon in the KNN algorithm classification.

Taking junior high school as an example, the distribution of resources in the resource pool of an ideal cloud platform is shown in Table 1.

Table 1. Distribution of platform resources

Subject name	Number of resources
Mathematics	1081
Physical	872
Chemistry	1408
Language and literature	5908
History	5266
Geography	1152

From the table, it can be clearly seen that the number of liberal arts resources is far greater than the number of science resources, especially between subjects with large

differences, such as mathematics and language, which can even reach 5-6 times. During the classification process, the samples between the various text classes of the training set are unevenly distributed. The effectiveness and efficiency of the KNN classification algorithm is greatly reduced. It can be clearly seen that the text to be classified should be classified into category 2. However, when k=10, since the density of category 1 is much larger than category 2, when using the KNN classification algorithm, 6 out of the 10 most recent samples selected belong to category 1, and 4 texts belong to category 2. The text to be classified is classified into category 1 to produce an incorrect classification result.

In the next section, in response to the above shortcomings, the corresponding improvement strategy for KNN algorithm is proposed, and the specific improvement strategy is deeply studied.

3.3 Design of KNN improved algorithm based on density cutting scheme

At present, there are two main ways to reduce the computational complexity of the KNN classification method: one is to reduce the time to find the nearest neighbor of the sample to be classified by optimizing the retrieval algorithm. The other is to select some representative samples in the original training sample set as new training samples, or delete some samples in the sample set. Then, the remaining samples are taken as new training samples, and the training sample set is reduced. As a result, the calculation work is reduced.

This study chose the second method. An improved KNN algorithm for applying density tailoring scheme is proposed. The time complexity of the KNN algorithm is reduced. At the same time, the problem of the classification accuracy rate due to the uneven distribution of sample density is solved in the training concentration.

The following basic concepts are defined, which facilitate the measurement of the density distribution of the training sample space. Finally, the clipping of the sample space is implemented.

A training sample set S is given. The definition is as follows:

Assuming that X and Y are two samples in the sample set S, Dist (X, Y) is used to represent the distance between X and Y. For any X∈S, its ε neighborhood is as shown in equation (5).

$$N_{\varepsilon} = \{Y \mid Dist(X,Y) \le \varepsilon, Y \in D\} \tag{5}$$

The circle X with the text X as the center and Dist (X, Y) as the radius is the ε neighborhood of X. Supposing that the ε neighborhood of X contains the number of samples of Nεx, and the ε neighborhood of X contains the minimum number of samples of MinPts, then:

When Nεx=Minpts, the ε neighborhood of X is a uniform density region;
When Nεx>Minpts, the ε neighborhood of X is a high-density region;
When Nεx < Minpts, the ε neighborhood of X is called a high density region.

Supposing that the sample set S contains {C1, C2, C3, Cn} for a total of n sample categories, and the classes and classes do not intersect each other. For any X∈Ci, if all text in the ε neighborhood of X belongs to the Ci class, X is in the intra-class region. Otherwise, if there are other categories of samples in the ε neighborhood of X in addition to the Ci-type text, X is in the junction area.

The high density area is divided into two cases. Among them, the red circle represents the inner region, and the blue circle represents the boundary region. The high-density cropping method for both cases is illustrated:

First, intra class region clipping (red): First, supposing that Y is in a high-density text area, and any other text in the ε neighborhood of Y is sequentially determined, such as whether the ε neighborhood of Z is at a high density. If it is at a high density, the text is cropped and N-- until the Y neighborhood N = Minpts, thereby making the Y neighborhood density uniform.

As can be seen from the above method, for the text Y in the high-density region, the text in the high-density region in the ε neighborhood of Y is removed as much as possible. This not only makes the density of Y relatively uniform, but also makes the text in the vicinity thereof more uniform. Minpts=3, Z is a text with a high density in the ε neighborhood of Y, so Z will be cut off. Similarly, there will be 5 texts in the ε neighborhood of Y that will be cropped, and N=3.

Second, border area clipping (blue): Assuming that the total number of categories of the ε neighborhood of X is C, an integer Hpts is selected as the minimum number of samples of the boundary region in place of the previously defined Minpts. Compared to the inner class region samples, the samples in the boundary region have a greater contribution to the classification. Therefore, for selected Hpts, Htps ≥ Minpts > 0.

If C>Hpts, one sample is reserved for each class (C1, C2, Ci).

If C<Hpts, the number of samples retained by each class in the ε neighborhood is determined, and the calculation method is as follows:

The number of texts Tn for each sample class in the ε neighborhood is sorted in descending order;

The parameter RA=Hpts/Ciε (surplus) is set;

The text class of Tn ranked in the top RA is determined, and the sample number REci=(Hpts/C)+1 is reserved;

The number of reserved samples for the remaining text classes is: REci=Hpts/C.

Whether the other arbitrary text is in the high-density region is determined sequentially in the ε neighborhood of the sample X. If it is in a high-density region, the sample is cropped until the number of samples Tn is the same as the number of samples required to be retained in the previous step, and N = Htps.

The main process of the density cutting scheme is shown in Figure 2.

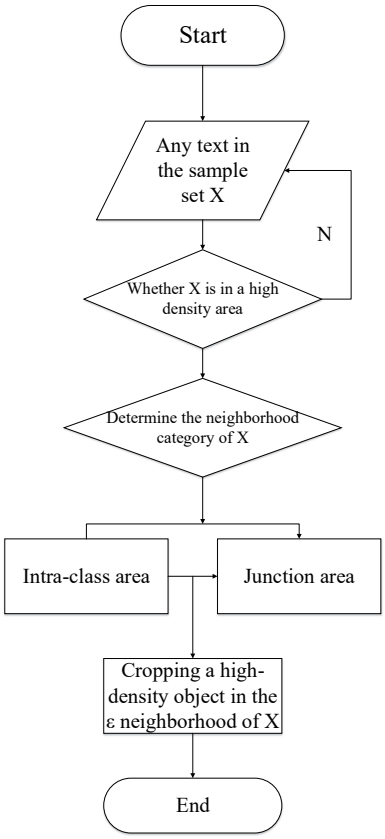

Fig. 2. Flow chart of density cutting

Input: training sample set S, neighborhood radius ε, integers greater than 0 MinPts and HPts.

Output: Cropped training sample set P.

Steps:

P={};

FOR EACH X∈S DO

BEGIN

IF X is in the inner region THEN

IF Nεx≤Minpts THEN

P=P+{X};

ELSE

IF Nεx≤Hpts THEN

P=P+{X};

END;// Keep training samples in low density areas

FOR EACH(X∈S&X∈P)DO

BEGIN

R(X)={Y|Y∈Nεx, Y∈P};// Sample within the ε neighborhood of X
H(X)={Y|Y∈R(X), Y is a high density area text};
IF X is in the inner region THEN
WHILE Nεx>Minpts DO
BEGIN
L=arg max Nεti, ti∈H(X);
Y∈TL, TL∈H(X);
IF NεY>Minpts THEN
S=S-{Y};
ELSE
Break;
END;// High density cutting in the inner region
ELSE IF X is in the boundary area
IF Cεi>Hpts// The total number of categories in the ε neighborhood of X is Cεi
WHILE Keep at least one text DO per class
BEGIN
L=arg max Nεti, ti∈H(X);
Y∈TL, TL∈H(X);
S=S-{Y};// Keep at least one sample END per class;
ELSE IF Cεi <Hpts
RA=Hpts% Cεi;
WHILE Nεx>Hpts DO
BEGIN
IF T, Ranked in the top RA
THEN
REεi=Hpts/ Cεi +1;
ELSE
RE εi =Hpts/ Cεi;
L=arg max N, ti∈H(X);
Y∈TL, TL∈H(X);
IF N CεY>REεiTHEN
S=S-{Y};
END;// High density cutting in the boundary area
P=P+N;
END;

As can be seen from the above description, the time complexity of the sample cutting process is O (2n). The time complexity of the traditional KNN algorithm is O (n2), and the time complexity of sample clipping is non-exponential. The time complexity of the KNN classification algorithm is negligible, and the time complexity of the whole algorithm is still O (n2). At the same time, n becomes smaller as the cutting process of the training sample set becomes smaller. Therefore, the time complexity of the improved algorithm becomes smaller.

In addition, the three main parameters in the density cropping scheme need to be determined, namely Hpts, Minpts and ε. According to the experimental results, it can

be seen that when the value of Hpts is taken as 5% to 8% of the average number of samples in the category, a relatively good effect can be obtained. The range of values of Minpts is an integer greater than 0 and less than or equal to Hpts. The best Minpts value is obtained through experimental debugging. The value of ε is calculated according to formula (6).

$$\varepsilon = Density_{Hpts}(S) = \frac{1}{D}\sum_{i}^{|D|} Dist_{Hpts}(X_i) \tag{6}$$

Among them, DensityHpts(S) is the average neighborhood radius of the training set S with a minimum number of samples of Hpts. Distk(X) represents the distance from the kth nearest neighbor to X of the sample X in the sample set S.

4 Results Analysis and Discussion

Weka is an open source project under the Java platform at the University of Waikato, New Zealand. It has the characteristics of cross-platform, support structure text, and database interface. In addition, many of today's most advanced machine learning and data mining algorithms are combined. It can effectively complete tasks such as preprocessing, classification, clustering, correlation, and visualization. Since Weka is an open source project, it is very convenient to perform secondary development of user algorithm embedding and parameter modification on the basis of classical algorithms. According to the previous research results, using the open source provided by Weka, the TF-IDF weight calculation method and KNN algorithm are rewritten to implement the improved algorithm.

4.1 Construction of the experimental environment

- Hardware environment: Windows10 64-bit + Intel Core i7 4720HQ+8GB
- Software environment: Weka3.8.2+Eclipse+sqlserver2010.

When downloading the Weka installer from the official website, there are two versions of weka-3-8-2-x64.exe and weka-3-8-2jre-x64.exe. Weka-3-8-2-x64.exe only installs Weka, and weka-3-8-2jre-x64.exe installs java virtual machine in addition to Weka.

Environment variables need to be configured after the installation is complete. In the system environment variable, the CLASSPATH is found to add the path to weka. For example, if Weka is installed on the D drive, D:\weka-3-8\weka.jar is added. Users need to download Eclipse and sqlserver2010 themselves. The main interface of Weka is shown in Figure 3.

Fig. 3. The main interface of Weka

The steps to import Weka source code in Eclipse are as follows:

- **First,** Weka was downloaded. The file weka-src.jar is decompressed, including three folders lib, src and META-INF and two other files;
- **Second**, under Eclipse, the java project is created, which is named weka, and a new package named weka is created under src;
- **Third,** in this project, import-->File System-->select.../weka/src/main/java/weka, and import all;
- **Fourth,** project import library file, biuldpath-->addexternaljar-->select lib java-cup.jarJFlex.nit.jar;
- **Fifth,** weka.gui.main was successfully run.
- In addition, since Weka does not support Chinese by default, the configuration file RunWeka.ini needs to be changed. This configuration file is in the directory after Weka is installed. This file is opened to find the fileEncoding=Cp1252 line to change to fileEncoding=utf-8, as shown in Figure 4.

```
1 # The file encoding; use "utf-8" instead of "Cp1252" to display UTF-8 characters in the
2 # GUI, e.g., the Explorer
3 fileEncoding=utf-8
```

Fig. 4. Modification of configuration file RunWeka.ini

Since Weka itself comes with English word segmentation and no Chinese word segmentation function, Chinese word segmentation operations need to be performed. In Eclipse, the mature word breaker tool is called. After getting the result of the word segmentation, it is called directly by Weka.

The Chinese Academy of Sciences' NLPIR system (formerly ICTCLAS) was selected. It is very simple and convenient.

First, a JAVA project was created. The jna jar package (which can be copied from the sample\JnaTest NLPIR\lib folder in the download package) is imported. The Data

folder in the download package is copied to the project root directory. Then, the NLPIR.dll and NLPIR.lib files in the folder corresponding to the operating system in the lib folder are copied to the newly created source folder in the system root directory, as shown in Figure 5.

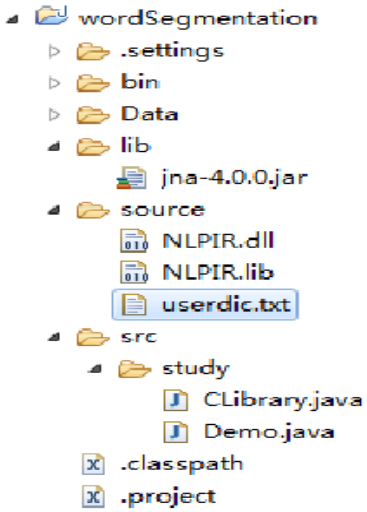

Fig. 5. Diagram of JAVA project for NLPIR system

An interface is created to inherit jna's Library interface. In the interface, an implementation of a series of NLPIR functions is defined. Finally, after the interface is instantiated in the class, the function can be called.

The result of the word segmentation obtained through the NLPIR system is stored in a .txt file format. However, since Weka can only accept .arff format files, the file type needs to be converted. This is achieved by learning from mature code already on the network.

4.2 Experimental data set

The experimental data set is a self-built corpus. The corpus contains 3,000 texts of various types and is unevenly distributed. There are 10 categories in total: mathematics, Chinese, English, physics, chemistry, biology, politics, geography, history, and others. Among them, the training set has a total of 2,100 texts and 900 test sets.

4.3 Testing and analyses of the algorithm

Based on the open source code provided by the Weka platform, the second development is carried out, the improved algorithm is implemented. Its performance is tested, and the classification effect before the algorithm improvement is compared and analyzed.

The purpose of the experiment was to find the optimal K value.

The corresponding class name of the KNN algorithm in Weka is IBk. Through the GUI, the Classify is selected and click the choose button to find IBk under weka/classifiers/lazy. Then, the red box is clicked to set the K value.

Experiment 1: The selected feature dimension was 500, and K = {5, 10, 15, 20, 25, 30, 35} were respectively tested. The experimental results are shown in Table 2.

Table 2. The effect of the K value on the macro F1 value

K	5	10	15	20	25	30	35
Macro F1 value	75.83	77.14	78.89	77.62	77.11	76.64	76.57

Analysis of results: It can be seen from the experimental data that when K takes 5~15, the macro F1 value shows an upward trend. When K=15, the macro F1 gets the maximum value. When K>15, the K value gradually decreased. Therefore, based on the experimental data set of this paper, when K=15, the classification effect is the best. At present, there is no particularly good way to determine the value of K. The main reason is to determine the K value that is most suitable for the selected data set based on experience and continuous experimentation.

Analysis of TF-IDF and improved algorithm TF-IDF_ATC results

The purpose of the experiment is to compare the classification effects before and after the improvement of TF-IDF.

Experimental environment: 2100 training texts, 900 test texts, feature dimensions of 500, and K values of 15.

Experiment 2: The TF-IDF method is defined in Weka's StringToWorldVector class, which is located in weka->filters->unsupervised->attribute->StringToWordVector.

The comparison of the experimental results before and after the improvement is shown in Table 3.

Table 3. Comparison of single class classification results

Category	TF-IDF			TF-IDF_ATC		
	Recall rate	***Accuracy***	***F1 value***	***Recall rate***	***Accuracy***	***F1 value***
Mathematics	78	83.71	80.75	80	85.26	82.55
Language and literature	82	79.16	80.55	89	84.35	86.61
English	78	96.50	86.27	78	97.65	86.73
Physical	74	87.14	80.03	76	88.34	81.71
Chemistry	75	85.67	78.83	78	86.98	82.25
Biological	72	82.55	76.91	74	85.32	79.26
Political	76	80.34	78.11	74	83.42	78.43
Geography	70	84.52	76.58	72	84.78	77.87
History	82	78.69	80.31	80	82.67	81.31
Others	68	73.28	70.54	72	74.15	73.06

In theory, English subjects and other subject texts are easy to distinguish, and the classification accuracy rate can reach 100%. However, in the experiment, the accuracy rate is low. This is because some English subjects contain only a small amount of

English, and most of them are Chinese content. For example, in a lesson plan that explains words, an English word needs to have a paragraph of Chinese to explain its meaning. The overall experimental results are shown in Table 4.

Table 4. Comparison of macro F1 values

Weight calculation method	Macro F1 value
TF-IDF	78.89
TF-IDF_ATC	80.98

From the experimental data, it can be clearly seen that the TF-IDF_ATC algorithm has a slight decrease in the recall rate in politics and history. In addition to the English recall rate, the accuracy and recall rate of other categories have increased to some extent. Moreover, the F1 value as a comprehensive evaluation indicator has also been significantly improved in each category. On the whole, the macro F1 value is also increased by about 2 percentage points compared with the TF-IDF algorithm before the improvement. It shows that the improved weight calculation method TF-IDF_ATC has better weight distribution ability than traditional TF-IDF, and has better classification effect.

Analysis of experimental results before and after KNN algorithm improvement

The purpose of the experiment is to compare the classification effect and time before and after the sample space is cropped, and determine the parameters Minpts.

Experimental environment: 2100 pieces of training text in the corpus are used as training set S, 900 pieces are used as test text, feature dimension is 500, and K value is 15. Hpts takes 5% to 8% of the average of the category samples, and Hpts=11. For the training set S, ε=DensityHpts(S) is taken, and the Minpts take values from 1 to 11. The training sample set is cropped using a sample cropping algorithm. The results of the cropping are shown in Table 5. Among them, the crop ratio = the number of cropped samples / the total number of training set samples.

Table 5. Cropping of training set S

Minpts	Number of crops	Crop ratio (%)
1	1037	49.4
2	874	41.6
3	743	35.4
4	664	31.6
5	611	29.1
6	562	26.8
7	518	24.7
8	481	22.9
9	449	21.4
10	423	20.1
11	405	19.2
Total number of samples: 2100		

As can be seen from Table 5, the proportion of cropping decreases as the Minpts increases. Even when Minpts=Hpts, the sample space crop ratio can still reach about 20%. The amount of calculation of the KNN classification is effectively reduced, and the classification time is shortened. This is not a sacrifice of the classification effect.

The classification macro F1 value comparison is performed using the training set before and after the cropping, respectively. When Minpts takes 8~11, the KNN improved algorithm of density cropping scheme can be used to obtain better macro F1 value. A better classification effect is obtained than before the improvement. Analysis of experimental results: Considering the two factors of classification time and classification effect, it is found that when the value of Mintps is in the range of 8 to 11, the performance of the improved algorithm is the best. At this time, the improved KNN algorithm applying the density cropping scheme not only reduces the classification time, but also improves the classification effect to some extent, which proves the effectiveness of the improved algorithm.

5 Conclusion

The key theories and techniques involved in the text categorization process were studied. At the same time, the steps and basic flow of text categorization are introduced, including text preprocessing, feature extraction, weight calculation and so on. This laid a solid foundation for the follow-up work. The text preprocessing process is improved by combining the characteristics of text-based primary and secondary school teaching resources. Resource characteristics were analyzed. The corpus is built through category partitioning, resource filtering, and uniform text formatting. The text preprocessing process was improved. An improved strategy is proposed for the KNN algorithm. Aiming at the problems of traditional KNN algorithm in the classification of teaching resources in primary and middle schools, an improved KNN algorithm based on density tailoring scheme is proposed. Samples of high-density regions in the sample space are cropped before the KNN algorithm is executed. The problem of misclassification caused by uneven distribution of sample spatial density is solved. At the same time, the time complexity of the KNN classification is reduced. The appropriate parameters K and Minpts were determined by comparison experiments, and the effectiveness of the improved algorithm was verified. The results show that the classification method of primary and secondary school teaching resources based on KNN algorithm is feasible and effective.

6 Acknowledgement

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Ecological Learning Space Teaching Mode based on Investigative Study – Case Study of Computer Image Processing

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Abstract—Computer Image Processing is a foundation course of computer specialty. Due to the problem of teaching method and students' ability problem, the teaching process is boring and students are absent-minded in class, thus leading to low teaching efficiency of Computer Image Processing and low teaching quality. As well, the learning effect and level cannot meet the requirement of market and society. On this basis, Computer Image Processing was chosen as the teaching case to construct ecological learning space mode meeting the course requirements on the basis of investigative study and under the guidance of interactive theory. Besides, the students of computer major were chosen as the objects of study for one-semester teaching practice. Questionnaire survey and interview were combined for empirical research in order to innovate for teaching mode of Computer Image Processing and provide higher-quality computer talents for the society. The investigation found that the teaching mode is well welcomed by students and greatly improves their learning initiative and learning effect.

Keywords—Ecological learning space; Computer Image Processing; investigative study

1 Introduction

With the popularization of internet, all walks of life have larger and larger demand for high-quality computer talents. Meanwhile, the requirements for computer accomplishments, computer knowledge and skills, and practical operation ability also become higher and higher. Computer Image Processing as a required course of computer major is also one of main functions of computer in the internet age. Besides, it is also the important knowledge and skill that each student of computer major must master. However, the teaching method of Computer Image Processing is single. Students' classroom enthusiasm is not high and their autonomous learning ability is poor. Thus, classroom teaching efficiency is not high. Seeing from practical classroom learning and social employment direction of students of computer major, if we still adopt traditional teaching mode, the learning situation of "valuing theory and neglecting practice" will form, and the job requirements of computer post for computer im-

age processing cannot be met. Besides, it goes against subject development. Ecological learning space, also called personal learning space, means students learn independently in the virtual learning space and organically combine theoretical knowledge of computer image processing and practical operation. In the ecological learning space, students can start from their own conditions, conduct self-control, choose independently, complete a series of individualized learning, enhance their theoretical knowledge, improve their operation skills and promote problem-solving ability [1].

At present, in the teaching process of Computer Image Processing, the teaching mode of ecological learning space is still a blank field, and there exist some problems. Firstly, there are many theoretical studies on ecological learning space, but the research directions are very disperse, and the cognition for the value of ecological learning space is not profound. Secondly, the research and design of ecological learning space are still in the thinking and reasoning stage, and there is almost no practical application study about mode construction. There is lack of demonstrative teaching experience for reference [2]. Thirdly, ecological learning space is rarely applied in classroom teaching. There is short of ecological learning space construction for a specific subject, and students cannot start from the course for independent study. Therefore, this study started form teaching practice and constructed the ecological learning space mode meeting the requirements of Computer Image Processing based on Computer Image Processing. This study is an innovative teaching mode study. Meanwhile, the ecological learning space was applied in the practical teaching to improve teaching quality of Computer Image Processing and students' comprehensive abilities of computer image processing, and satisfy the development requirements of market and society. It is very significant for students' learning, subject teaching and social development.

2 State of the Art

The research on personal learning space was first proposed by Sutherland. He indicated that Pebble Pad could play a role between social learning system and teaching system and could be called personal learning system or personal learning space. In the report submitted by ALT (Association for Learning Technology) in 2010, the proposal of constructing learning space with rich techniques and supporting corresponding teaching method or learning method [3]. The government of Queensland holds that learning space construction can effectively promote students' learning efficiency, so it is necessary to increase input and enhance learning space construction [4]. Ken Fisher Boogu [5] carried out the research on connective teaching approach and learning specialization and proposed the research finding that learning activity is motivated and promoted by learning space. Higgs [6] applied personal learning space in ethics course, analyzed the problems in planning and implementation process and discussed the theoretical problem of network learning teaching method. The result showed that personal learning space contributes to students' understanding and mastery of ethic knowledge. In order to comprehend how play can create a unique learning space beneficial to deep learning, Kolb et al [7] put forward an experiential learning framework.

The case study showed that the learning in the learning space could facilitate deep learning in the fields of intelligence, body, spirit and morality. The domestic research on personal learning space is still in the starting stage. Zhu [8] collated the concepts and theories of personal learning space and proposed that indicated personal learning space is the bridge between personal learning environment and virtual learning environment. Zhong [9] indicated that personal learning space is learner's individualized service on network based on individual needs and national education cloud platform.

2.1 Research on computer teaching

Foreign computer teaching develops rapidly, and foreign countries pay great attention to computer teaching. American [10] computer education level is all-round, and the educational idea is all-inclusive. The education methods are flexible and open. The popularizing rate of computers is quite high. Most students can surf the internet via computers on campus, and multiple virtual universities have been established. EU formulated various computer education development plans, drove information-based teaching development and proposed multiple measures for educational information reform. Domestic scholars also attach great importance to the research on computer teaching. In recent years, domestic scholars have paid special attention to the application of computer teaching. For example, Fan et al. [11] set forth the construction scheme of computer experiment teaching platform framework based on cloud computing, and applied it in computer experiment teaching. Song [12] proposed networked hierarchical computer teaching mode based on SPOC mode and conducted secondary development of existing network teaching platforms. There are many similar studies on computer course teaching mode, such as task-driven method, project teaching method, "smart class" construction, classification, stratification and modular teaching. However, at present, although Chinese universities have many studies on the application of computer teaching, most of them focus on computer basic courses, such as Introduction to Computers and Fundamentals of Computer Culture. There are just a few studies on the application of Computer Image Processing. For the students of computer major, computer image processing is a very important skill. So, it is very necessary to study the teaching mode. Secondly, there is almost no study on the combination of ecological learning space with computer courses and especially Computer Image Processing in teaching practice. Therefore, this study innovatively starts from the perspective of ecological learning space, takes Computer Image Processing for example and provides the reference for teaching Computer Image Processing.

3 Ecological Learning Space Teaching Mode based on Investigative Study

Theoretical basis of this study is interactive theory [13]. People generate connections and collide ideologically, called interaction. In teaching, interaction refers to an interactive behavior. People generate connections and exchange. Through interactions, learners can gain the feedback of learning results and enhance cultural and so-

cial belief. Moore put forward learning interaction distance theory and indicated three interaction forms in the learning process: student-teaching content, student-teacher, and student-student. Wherein, student-teaching content is essential and the foundation of education. The interaction between students and contents will reconstruct students' cognitive schema. Sabagh indicated that the interaction between students and contents has the greatest influence on students' learning in al interaction modes. The interaction between students and teacher is the root of teaching process and also the key to making students and learning contents form effective interactions. Meanwhile, it is also an important way of improving teaching quality. The interactions between students and teacher are more and deeper, students have higher learning enthusiasm [13]. Interactive learning diagram of Computer Image Processing based on interactive learning theory and the property of Computer Image Processing is shown in Fig.1.

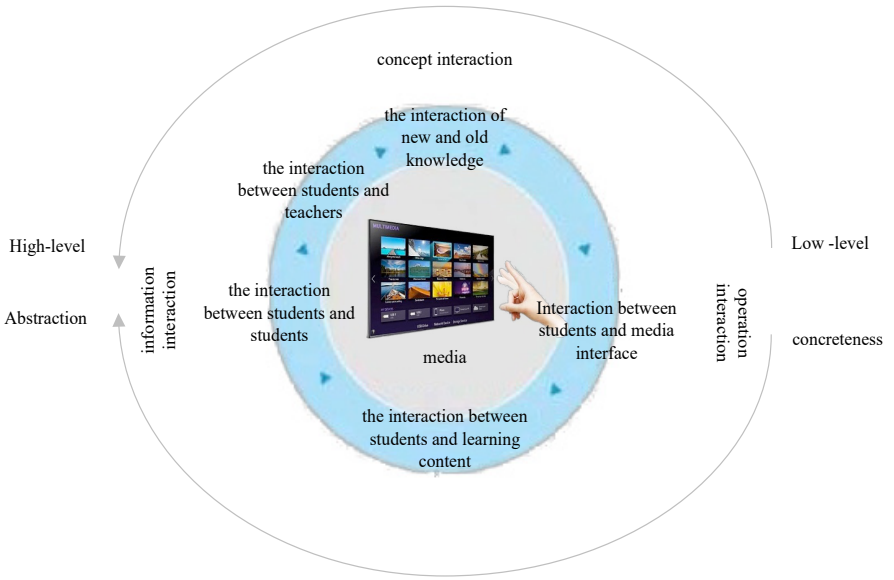

Fig. 1. Interactive learning diagram of Computer Image Processing

3.1 To specify differences between learning space and ecological learning space

Before construction of ecological learning space for Computer Image Processing, the differences between learning space and ecological learning space must be specified. Learning space contains two parts: personal network learning space with individualization which is private for every learner; public learning space which provides public service for all learners. In other words, personal learning space is ecological learning space, and also a form of learning space. The relationship between the two is shown in Fig.2.

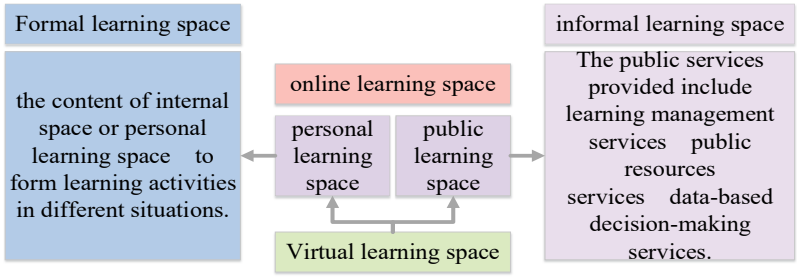

Fig. 2. Relationship between learning space and ecological learning space

3.2 To design ecological learning space

The design of ecological learning space for computer image processing mainly involves 6 steps. The design starting from the principle of ecological learning space design, combines learning activity elements of ecological learning space, specifies subjects and objects of learning activity of ecological learning space, confirms the tools used in ecological learning space, and involves labor division, cooperation and exchange to form learning community. The detailed steps are shown in Table 1.

Table 1. Design steps of ecological learning space for Computer Image Processing

Steps	Design content of ecological learning space
1. Confirm activity purpose	Set problem situation and task and understand the contradiction between subjects and the activity
2. Analyze activity objects	Confirm subjects, objects and the community as well as the relations among the three and the result
3. Analyze activity structure	Set activity content and decompose the activity into behavior and operation to make the activity proceed orderly
4. Analyze tools and rules	Confirm the supporting role of tools in the activity, specify the use roles in the activity and divide the work clearly
5. Analyze activity situation	Specify the activity situation of subjects and activity situation of the community as well as the driving function of objects
6. Analyze activity structure	Focus on interactions of each part in the activity and the interaction between the communities

3.3 System architecture of investigative study process

Investigative study means under the guidance of the teacher, students make the best of ecological learning space for resource sharing and interactive learning, and focus on learning content and theme to carry out learning activities. Teaching design and process of Computer Image Processing based on mobile technology, cloud technology, ecological learning space and interactive theory framework mainly includes 6 parts. Each part contains two aspects: explanation of key and difficult points, and practice. Course design involves three levels: before class, in class and after class. In the aspect of explanation of key and difficult points, before class, students learn the course autonomously through ecological learning space, including knowledge point

learning and video watching. The teacher tests key and difficult points, gains feedback and decides the arrangement of teaching content according to the feedback. In class, the teacher arranges the task tasks and students learn and exchange through ecological learning space. Later, the teacher answers questions. After class, students expand and extent the knowledge in ecological learning space, and the teacher discusses and summarizes the questions. In terms of work criticism and practice, before class, the teacher formulates teaching objectives according to the teaching content, and provides several works of computer image processing for students to learn and operate in ecological learning space. Students learn and practice. In class, the teacher designs teaching questions and teaching situations according to teaching objectives, organizes students to discuss and practice in ecological learning space and overall evaluates the discussion result. After class, the teacher helps students deepen and consolidate the knowledge points they cannot master in time. The framework of ecological learning space mode based on investigative study is shown in Fig.3. The application of computer image teaching software based on ecological learning space is shown in figure 4 and figure 5.

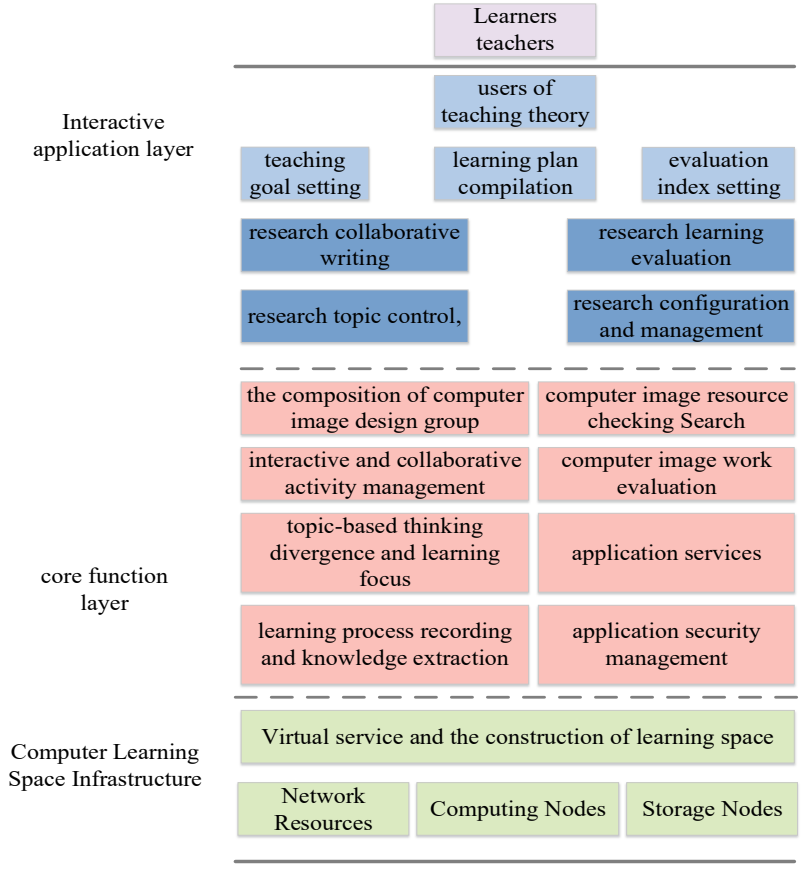

Fig. 3. Framework of ecological learning space mode based on investigative study

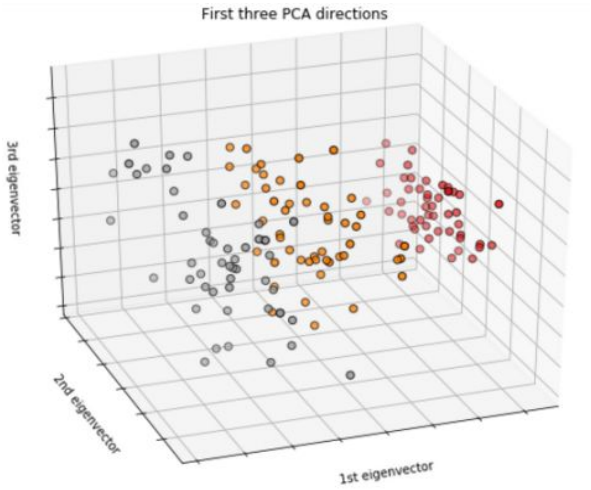

Fig. 4. Software application diagram of computer image teaching based on ecological learning space I

Fig. 5. Software application diagram of computer image teaching based on ecological learning space II

4 Teaching Example and Teaching Effect

4.1 Teaching example

The objects of this study are 40 junior students of computer major from a university, including 28 male students and 12 female students. The experimental course is Computer Image Processing. The research period is from March 2018 to July 2018. The course was taught once per week, and 2 class hours each time.

Ecological learning space design for Computer Image Processing was conducted based on investigative study and interactive learning theory. The detailed teaching process is shown in Fig.6-8.

To create the course of Computer Image Processing: The teacher needed to create the course of Computer Image Processing first in ecological learning space, select the class and students, and edit the course information such as course nature, features, objective and cultivation scheme.

To design the course content: Before each class, the teacher uploaded the learning content in the ecological learning space, such as relevant learning materials, PPT, outline and exercise, marked the key and difficult points, provided quizzes for students and received feedback.

To design course teaching process: Course teaching process includes course introduction design, course content explanation and independent study process. Course introduction should pay attention to practice to train students' operation skills and ability, combine theoretical knowledge with specific cases and apply cases to explain knowledge points. Course content explanation should mobilize students' enthusiasm, apply multimedia teaching and operate while teaching. In independent study process, the teaching content should be uploaded to the ecological learning space so that students can operate personally so as to consolidate the knowledge. Meanwhile, other similar cases should be provided so that students could draw inferences about other cases from one instance and practically improve operating skills.

To test and feedback the course: Except pre-judgment and test of students before class, the teacher should assign homework after class, specify the completion time, correct and evaluate the works of students as well as provide feedback and advice for students through ecological learning space.

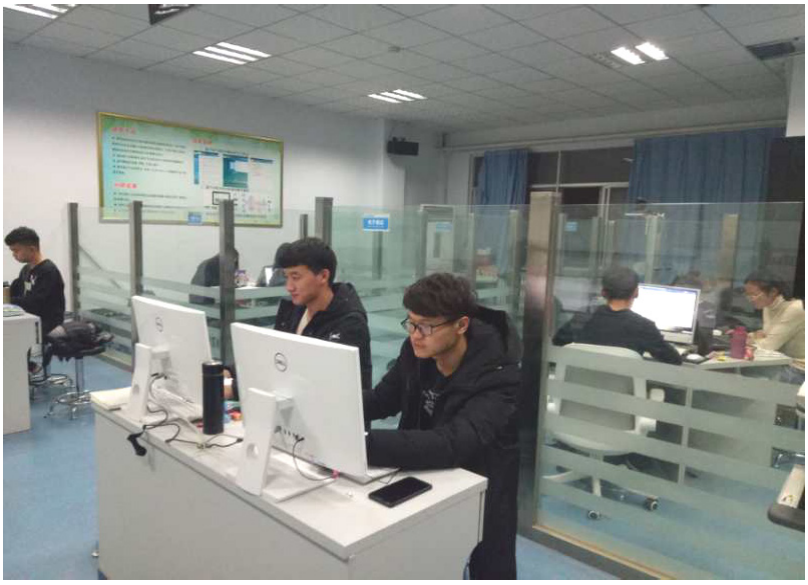

Fig. 6. Teaching process of Computer Image Processing based on ecological learning space I

Fig. 7. Teaching process of Computer Image Processing based on ecological learning space II

Fig. 8. Teaching process of Computer Image Processing based on ecological learning space III

Questionnaire survey and interview were combined to survey practical feelings of 40 students for which ecological learning space teaching mode based on investigative study was applied. The questionnaire included 10 questions and scored with 5-point scoring method of Likert scale. The students' attitudes to the teaching mode were investigated. The interview contained 3 questions to survey students' overall feelings for the course, classroom exchange feeling and the reason why they chose ecological learning space.

4.2 Teaching effect

It was found through statistical analysis of questionnaire survey results that, students accept the ecological learning space teaching mode based on investigative study, and the average score of each question is above 4.01. The average score of most questions is between 4.2 and 4.6. Students' satisfaction for "the mode can enhance class communication and cooperation" is the highest, with the average score of 4.7. The degree of recognition for "the mode can help me manage learning independently" is the lowest, with the average score of 4.01, as shown in Table 2.

Table 2. Students' attitudes to ecological learning space teaching mode based on investigative study

Question	Average sore
1.The mode is a useful tool for my study	4.41
2.The mode can enhance class communication and cooperation	4.7
3.The mode can help me seek out relevant learning resources	4.55
4.The mode can bring more learning opportunities	4.37
5.The mode can make me access course resources anytime and anywhere	4.32
6.The mode can make me receive teacher's feedback easily	4.53
7.The mode can help me exchange learning materials with classmates	4.22
8.The mode can help me manage learning independently	4.01
9.The mode can help me complete course assignments	4.44
10.The mode can help me develop learning skills	4.40

According to the interview results, when students answered the question "describe your overall feeling about Computer Image Processing under the ecological learning space teaching mode based on investigative study", it was found that students considered the mode is great, which could not just provide more before-class and after-class learning opportunities, but also help them exchange with classmates and teachers and expand their thoughts. When answering the question "whether does the ecological learning space teaching mode based on investigative study promote exchange between you and the teacher and between you and classmates?", students gave the affirmative answer and considered this mode is better than face-to-face and oral communication and discussion, because it could save opinions, provide the time for thinking, promote exchange depth and enhance exchange chance. When answering the question "what's the reason for choosing the ecological learning space teaching mode based on investigative study?" some students indicated that teacher's uploading of before-class learning materials and after-class assignment feedback could clearly provide them with the learning objectives and solve learning problems. Some indicated that the supply of exchange platform made them have more opportunities to exchange with teachers and classmates. Besides, they could learn independently and avoid awkwardness during face-to-face exchange. They are more willing to express their views and can learn the knowledge again they could not digest in time.

5 Conclusion

In this study, Computer Image Processing was chosen as the teaching case. The junior students of computer major in a university were selected as the objects of study to construct one-semester teaching practice with ecological learning space teaching mode on the basis of investigative study and under the guidance of interactive theory. Questionnaire survey and interview were combined for empirical research. The following conclusions were drawn:

- The teaching mode of ecological learning space based on investigative study should specify the differences between learning space and ecological learning space and pay attention to the design of ecological learning space and system architecture of investigative study process. On this basis, the specific course should be combined for teaching design to ensure promotion of teaching effect.
- Under the teaching mode of ecological learning space based on investigative study, Computer Image Processing teaching should focus on the interactions between students and contents, between students and teachers and between students, and pay more attention to promoting interaction effect. Interaction effectiveness is the key to improving teaching effect of Computer Image Processing.
- The teaching mode of ecological learning space based on investigative study should stress teacher's guiding role. Students' independent learning ability is still poor. In particular, the mode entirely depends on students' consciousness in before-class and after-class learning. Thus, teachers should not let them go completely, but should organize, manage and supervise them properly to maximize the role of this mode.

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Psychological Health Course Teaching Mode Based on Students' High-order Thinking Ability Development

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Abstract—Traditional teaching method cannot really promote students' psychological quality in Psychological Health course teaching. With the purpose of promoting students' high-order thinking ability development, some teaching links (theme importing, question formation, learning participation and evaluation feedback) were adopted to carry out the design and applied research of Psychological Health course teaching mode based on BOPPPS model. The results show that the mode can help students deeply understand and master psychological health knowledge, and mobilize their learning enthusiasm, participation, innovation and subjective initiative. Thus, this mode contributes to promoting students' high-order thinking abilities such as analysis ability, evaluation ability and innovation ability.

Keywords—High-order thinking; BOPPPS model; Psychological Health

1 Introduction

Under the background of quality-oriented education, the teaching objective of Psychological Health course is to promote undergraduates' psychological health handling capacity, help them establish correct psychological development direction in their future life, gain positive and healthy development after entering the society and form lifelong learning ability [1]. Thus, the public course of Psychological Health is set to impart knowledge for students, and conduct psychological experience and behavior training for students to enhance their psychological health care consciousness and prevention awareness for psychological crisis, make them master psychological health knowledge and gradually establish self-cognition framework, strengthen their interpersonal communication ability and self-regulation ability, and facilitate their all-round development [2]. Various universities attach importance to teaching research of Psychological Health education. Different from teaching design of general teaching courses, the teaching design of this course pays more attention to students gaining the experience process of self-cognition and self-development as the subjects, and students' subject participation and creativity. At present, in practical teaching process, large-scale class teaching and low examination threshold are adopted for Psychological Health. The teaching mode is "explanation-mastery-examination". The teaching is centered by the teacher and dominated by expiation. Students' participation degree is

low, and students' psychological experience process cannot be effectively implemented [3]. They cannot further apply psychological health knowledge, let alone cultivate their innovation ability. Thus, it is extremely urgent to reform the teaching mode and study the teaching design which can really improve students' psychological quality.

2 State of the Art

High-order thinking [4] refers to analysis, valuation and creation abilities, and embodies human quality cultivation by education. Thus, it is accepted and praised by numerous education experts, and many research brands derive from it. Richland et al. [5] applied high-order thinking teaching method in mathematical education. They concentrated on mathematics teaching and stressed alignments between the definition of higher order thinking based on psychology and educational objectives as described in U.S. mathematical practice standards. The results show that high-order thinking teaching contributes to enhancing students' learning interest. Moore et al. [6] proposed Malaysian higher education system also needed to focus on students' high-order thinking ability and investigated the application of high-order thinking in science curriculum. Besides, they put forward the changes in the methods to evaluate students mean teachers must teach differently. The focus has changed to development of students' analytical abilities rather than mere recall and understanding. The experiment proved that the reformed teaching is more beneficial to knowledge understanding. Fu [7] carefully analyzed current situation of the deficiency of high-order thinking ability for contemporary college students and indicated that current college students lack thinking knowledge and have severe mindset and poor thinking transfer ability, and that it is urgent to improve their high-order thinking ability. Except students' internal knowledge composition, the influence of talent training mode cannot be ignored. Liu [8] indicated that, teachers need to innovate for teaching mode and enhance design of teaching oriented to high-order thinking ability development. In recent years, BOPPPS teaching model is characterized by clear goal, fine design and strong participation. In combination of timely evaluation, it can be promoted vigorously in design research. Zhang [9] integrated high-order thinking ability training in teaching, expounded teaching mode construction framework and provided reference practice for applying the classroom training mode of high-order thinking.

Through analysis of relevant literatures, we found that the cultivation of students' high-order thinking mainly focuses on science [10], physics, chemistry and other courses, and there is no systematic teaching design scheme which conforms to development of students' psychological health study under network environment. So, high-order thinking and students' psychological health education were innovatively integrated in this study to provide the reference for relevant course reform based on BOPPPS model.

3 Psychological Health Teaching Mode with the purpose of promoting students' High-order Thinking Ability Development

Reflective thinking: high-order thinking is based on "reflective thinking" in this study. The researcher considered reflective thinking [11] is "active, persistent and careful consideration of any belief or assumed knowledge form according to the foundation supporting it and the further conclusion it tends to reach". Typical reflective thinking contains 5 stages or forms with unfixed sequence: question, observation, hypothesis, reasoning and examination. Only the "serious and coherent" thinking can lead to real knowledge. Thus, this study holds that reflective thinking activity "must become an education purpose" and proposes to organize teaching in the form of "learning by doing" through some typical questions. Students explore, do experiments, integrate and accumulate specialized knowledge in the process of solving these questions, and become proficient in the methods of experiment exploration and demonstration so as to cultivate their reflective thinking. The relationship framework between reflective thinking and high-order thinking is shown in Fig.1.

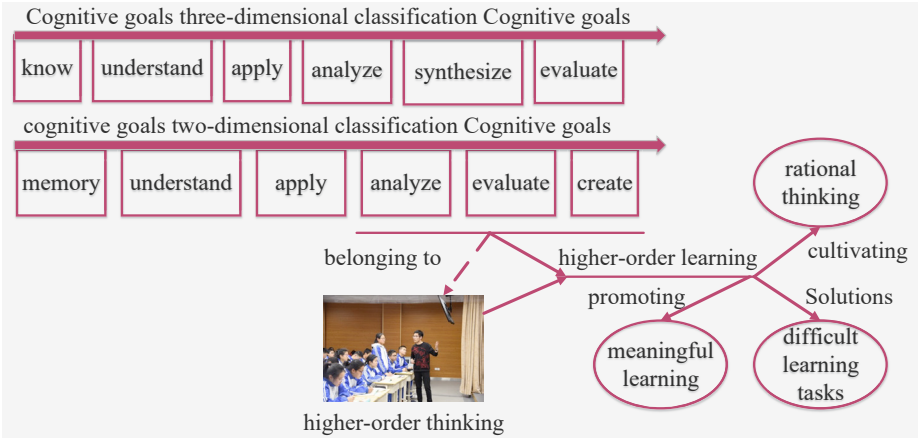

Fig. 1. Relationship framework between reflective thinking and high-order thinking

To achieve the teaching objective, teaching design should be based on course content and relevant teaching theme and combine students' individual features and environmental conditions. Teachers should make full use of principles of teaching and learning, design and plan relevant learning resources for learners and organize a series of learning activities. People are continuously exploring teaching design reform and have developed many teaching design concepts and cases.

In accordance with the theory of Anderson and other experts, schoolwork behavior expressions which should be mastered in human cognitive learning process include memory, understanding, application, analysis, evaluation and creation. Memory, understanding and application are called low-order thinking abilities, while analysis,

evaluation and creation are called high-order thinking abilities. For Psychological Health course, its teaching objective is to cultivate students' high-order thinking abilities and enhance students' interpersonal communication ability and self-regulation ability. Thus, teaching course reform also should take into account of the objective of high-order thinking ability training to establish course design mode. BOPPPS model [12] takes constructivism and communicative approach as research basis, and emphasizes students' participation in closed-loop teaching process in teaching design. It is an effective teaching design model. According to BOPPPS model, teaching process follows six stages: introduction, objective, pretest, learning participation, posttest, and summarization. The general thought is "introduction – question formation – discussion participation – examination and evaluation". In the implementation process, the whole education mode is student-centered, and fully focuses on learning objective quantification, student participation, learning test and feedback.

Guided by BOPPPS model, the teaching design model of Psychological Health was established in this study, as shown in the following figure, the teaching process is divided into the following stages.

3.1 Preparatory stage before teaching (introduction stage)

Teachers select research content according to course arrangement. The events and cases with typical significance in relevant networks and books can be fully used as topics to introduce the theme and choose research topics. Meanwhile, the correlation between topics and selection materials is analyzed to ensure high fit degree. Finally, the teaching objectives which conform to current situation of college students, contribute to college students' life and psychological health development and comply with teaching programme can be gained. Fig.2 shows teaching design flow chart based on BOPPPS model.

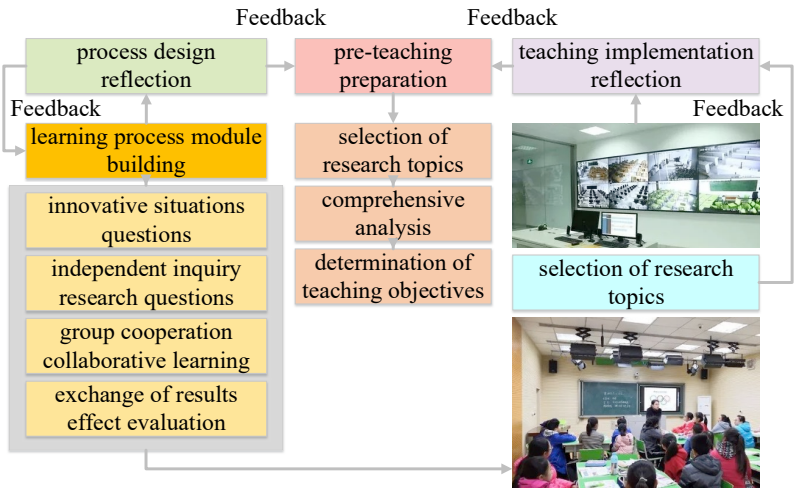

Fig. 2. Teaching design on BOPPPS model

3.2 Teaching process module design (question formation – learning participation stage)

Based on the above teaching mode design thought, teaching mode is planned into four parts, as shown in Fig.3.

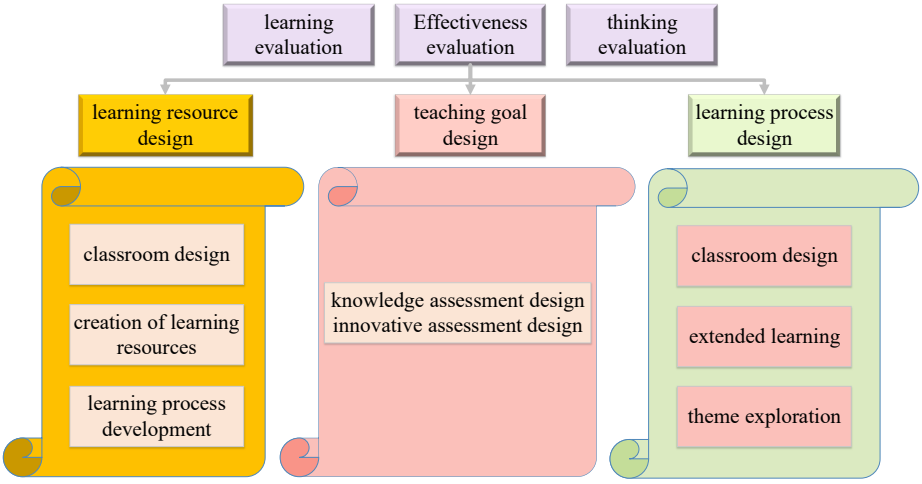

Fig. 3. Teaching process module design diagram based on BOPPPS model

Learning resource design module: This module mainly designs relevant problems of course introduction, integrates relevant learning resources from networks, books and social phenomena, and inputs relevant teaching resources for teaching design program development.

Teaching objective design module: During designing teaching objectives, the contents of examination should be combined for subdivision. According to specific course contents, the contents of examination are divided into knowledge examination content design and innovation examination content design.

Concrete implementation design model of learning process: The course content is introduced through case study, and students are required to further expand learning, summarize and explore the theme in various cases. In this process, students' participation and innovation can be fully mobilized.

Teaching content evaluation design module: This stage corresponds to posttest and summarization steps of BOPPPS model, and also the foundation of process feedback of teaching design. Through examination and evaluation of learning content and in combination of observation and analysis of students' thinking change and development, the results are fed back to other three modules for further modification and improvement so as to gain the optimal teaching design.

3.3 Teaching process monitoring stage design (examination and evaluation stage)

The design embodies teaching implementation is dominated by students and monitored by the teacher. In other words, the teacher should grasp the topic selection and focus on the course outline in students' learning process. At the same time, the teacher should manage students and let them group for cooperative learning. The teacher should be responsible for relevant organization and management work and make the learning groups can learn actively and efficiently. In particular, in the link of exploring learning themes, the teacher should strictly control to prevent the deviation between course content and the outline. For the teaching schedule and direction grasp in theme exploration, this study further analyzed how the teacher and students carried out teaching design for relevant content teaching and learning, as shown in Fig.4. The teacher should grasp group building, guidance and evaluation to make sure students can rationally form groups and carry out relevant learning. Students should make the best of intra-group learning activity for autonomous exploration, discussion and cooperation and gain the optimal learning effect in each group. Meanwhile, students should fully utilize teaching and education platforms and resources to expand learning content, record learning process and achievements in the group activity. Fig.4 shows course theme exploration teaching design based on BOPPPS model.

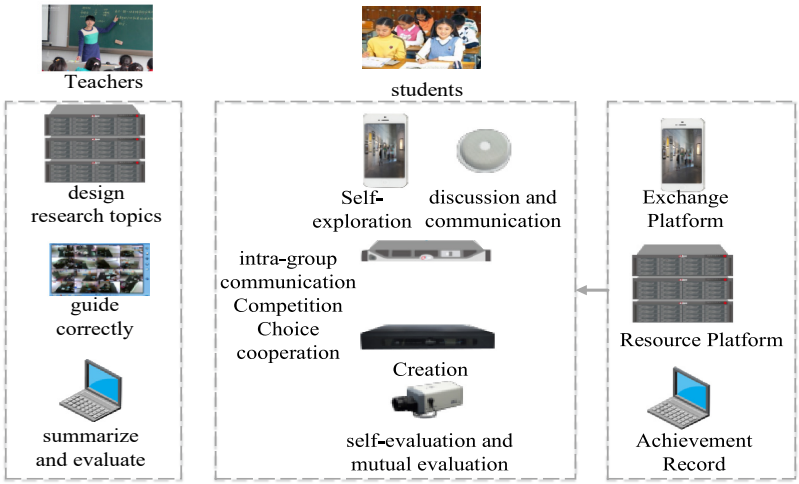

Fig. 4. Course theme exploration teaching design based on BOPPPS model

4 Teaching Example and Teaching Effect

4.1 Teaching example

Emotional Intelligence of College Students as a special content of college psychological health course has important significance for promoting college students' psy-

chological quality and learning how to correctly handle emptions and the impacts. According to the focus of low-order thinking knowledge transference and high-order thinking ability training, Psychological Health teaching design was established and the content teaching was conducted by combining the teaching mode in Fig.1 and taking Emotional Intelligence of College Students for example. The detailed process is shown in Table 1. Fig.5 shows the teaching design of Psychological Health with the purpose of developing students' high-order thinking.

Table 1. Teaching mode organization and implementation process of Emotional Intelligence of College Students

Learning stage	Learning steps	Teacher's work	Students' activity
Stage I	Topic introduction and pretest	1. Gather tragedy cases caused by the failure to effectively express emotions in recent years: personality analysis of Ma Jiajue; psychological analysis of college students from rural areas; 2.Guide students to think how to handle unhealthy emotions and ideas; 3. Test students' sensory awareness for emotions.	1. Students understand Ma Jiajue's personality analysis material; 2. Students rethink counter-measures to unhealthy emotions in life. 3. Do pretest exercises.
Stage II	Question formation, and students' participation in learning	1. Give the question for discussion: how to treat human emotions? How to correctly master one's own emotion? 2. Propose the knowledge points about "emotional intelligence"; 3. Guide students to build learning groups; 4. Guide each group to utilize network and other resources and combine campus platform to carry out group learning, exchange and evaluation;	1. Students design the research design for the question and discuss the research theme; 2. Students form groups to integrate, sum up and explore relevant resources; 3. Carry out group exchange, competition, discussion, feedback and form the theme of each group; 4. Each group conducts theme evaluation and proposes improvement suggestions.
Stage III	Achievement display and evaluation feedback	1. Check the discussion theme of emotional intelligence of each group, and carry out discussion and evaluation; 2. Rethink the teaching process; 3. Evaluate students' learning process;	1. Display group discussion results and confirm the discussion conclusions; 2. Modify and improve research theme and conclusion; 3. Rethink how to control persona emotions in the future.

For the teaching of concept of emotional intelligence, the teaching content involved is shown in Table 2. Question introduction in the theme and students' participation in theme exploration are fully considered in the table. The questions and guidance closely focus on the course outline, which makes sure the concept of emotional intelligence derives in students' real life, closely follows actual situations of college students, and mobilizes their interest in psychological health and active participation in the activity of psychological health. This can really help students fully utilize what they have learned to regulate their motions and improve their emotion control ability.

Table 2. Teaching design for the concept of emotional intelligence

Course title: "concept of emotional intelligence" (knowledge)			
Introduction: emotion analysis in the event of Ma Jiajue; mood swing in daily life; Pretest: (true or false questions) 1. Emotions cannot be controlled fundamentally. 2. Emotion control does not belong to intelligence problem, and it entirely depends on personality. 3. When one is down in spirits, playing games is a good way to control the emotion.			
Theme confirmation process and learning participation:			
Content	***Teacher's work***	***Students' activity***	***Resource***
1. Which aspects are included in the concept of emotional intelligence?	Ask questions	Think and answer	PPT
2. How to cultivate intelligence?	Inquire, group, and stress the key points of discussion	Group discussion, exchange and share	PPT, A4, pen
3. The relationship between emotional intelligence and communication ability	Inquire	Group discussion, exchange and share	PPT, A4, pen
Summarization, feedback and evaluation: 1. Cultivate emotional intelligence, and attach importance to family emotional education and emotion management in social interaction. 2. Cultivate emotional intelligence and promote communication ability. 3. Ask students to talk about their feelings about learning of emotional intelligence with one sentence.			

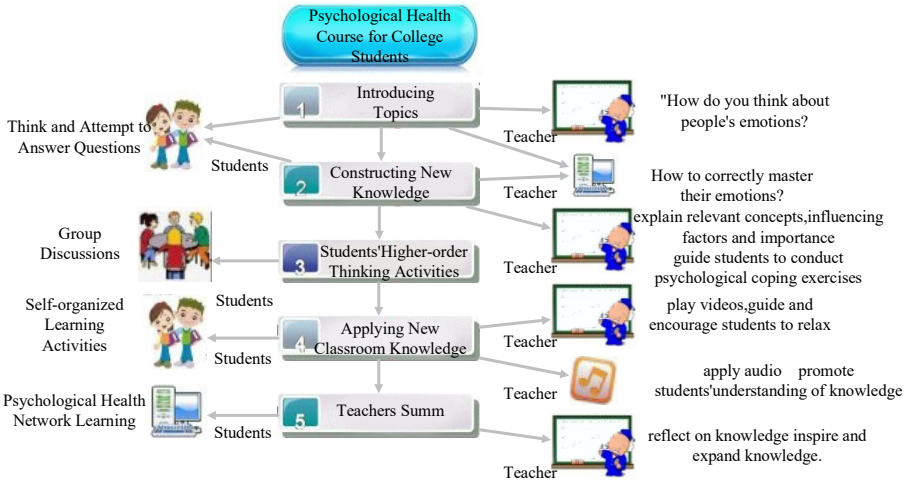

Fig. 5. Teaching design of Psychological Health with the purpose of developing students' high-order thinking I

4.2 Teaching effect

Based on the teaching mode of Psychological Health of college students, 98 sophomores from * University were chosen as the objects of study for one-semester Psychological Health teaching. To evaluate the teaching effect of psychological health course - Emotional Intelligence, students' learning process and learning results were recorded according to electronic learning files. The students were classified into 15 groups for research overview of 10 psychological health research themes. Each group was required to form research reports which were input in the electronic learning files.

After the course ended, final examination was conducted for students, and the test scores were also input in the electronic learning files. Besides, the scores were compared with previous test scores. After the semester ended, interview method was used to know students' experience and evaluation for the actual teaching process.

Records of electronic learning files: Under the similar test difficulty, the scores of final examinations in the past three years and in the research period were compared. It was found that, the score of Psychological Health course with the purpose of promoting students' high-order thinking ability development is higher than that of average score of students for whom traditional teaching method was applied. The average scores were 81.9, 82.3 and 81.6 in 2-15-2017 respectively when traditional teaching mode was used. The average score in 2018 when the teaching mode established in this study was used was 88.4, obviously higher than that of traditional teaching method. This indicates that the course design of Psychological Health with the purpose of promoting students' high-order thinking ability development obviously facilitates students' learning effect.

Psychological Health records of electronic learning files were collated, including 150 papers about the over view of psychological health research theme. This indicates students' in-depth thinking of psychological health research theme. Such innovation achievement cannot be generated by traditional teaching method. This fully embodies the advantage of such teaching mode in improving students' innovative study.

Evaluation of teaching mode implementation effect with interview method: 40 students were chosen at random for the interview about the experience of psychological health course. The interview content included: Have you ever been interested in psychological health knowledge? After finishing the course, are you interested in psychological health knowledge? Please describe the reason why your interest changes before and after learning the course. Do you like such course teaching mode? Compared with the teaching method in the freshmen year, please evaluate the teaching mode of this semester. What's your attitude to the change of teaching mode? What difficulty did you encounter in group discussion? How did you solve it? Which link do you like best in the learning process? Which link do you think should be improved?

After 40 interview records were summarized, it was found that the interviewees' interest in psychological health knowledge (course) improves greatly. The proportion of students with interest in psychological health knowledge (course) is shown in Fig.4. It can be seen that, about 65% of students were interested in it. After the new teaching mode was applied, the proportion rises to 90%.

The statistics of students' attitude to teaching mode change is shown in Fig.5. It can be seem that, 90% of students support the new teaching mode.

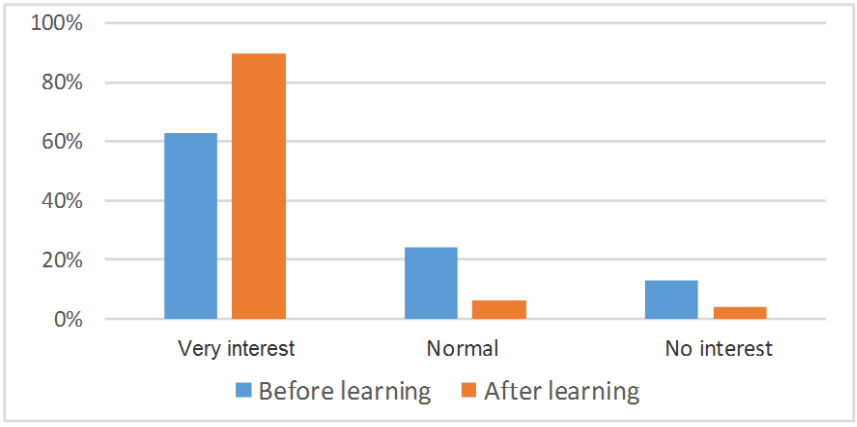

Fig. 6. Proportions of students with interest in psychological health knowledge (course) before and after the implementation of new teaching mode

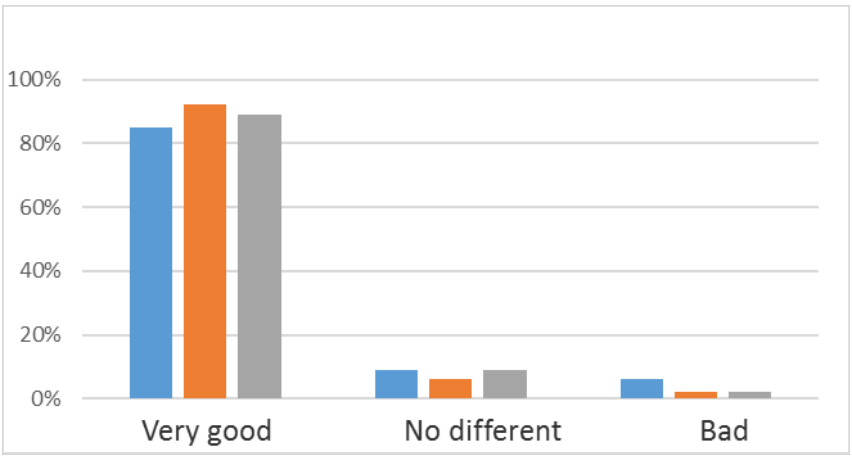

Fig. 7. Students' attitude to teaching mode reform

Seeing from the records of electronic learning files, students' scores of final examination increase, indicating that students' mastery of psychological health knowledge in the new teaching mode is more comprehensive and accurate than that in traditional teaching method. This also reflects the good learning effect. Psychological Health course design teaching mode with the purpose of promoting students' high-order thinking ability development is more beneficial for most students to grasp the knowledge points so that students fully understand psychological health knowledge in practical cases. Question introduction in the teaching mode can arouse students' interest, and the selected cases have certain representativeness and reflect psychological development history of contemporary college students to certain degree. The cases are

close to students' life. Thus, students can fully and deeply comprehend connotation and denotation of psychological health knowledge.

Psychological Health course design teaching mode with the purpose of promoting students' high-order thinking ability development adds student participation in the four teaching modules. It fully mobilizes students' learning enthusiasm, participation, innovation and subjective initiative through group discussion, expansion, extension, exchange and feedback. In the process of brainstorming, cooperation and sharing, psychological health knowledge has been absorbed and digested by students in the form of explaining profound theories in simple language. In the meantime, participants' thinking perspectives are expanded in the process of solving research overview, and their creation ability also improves in analysis and evaluation process. Campus interactive multimedia teaching platform and education resources are combined to achieve integration and sharing of relevant resources, mobilize learners' original knowledge hierarchy participation and feedback so that they can conform to learning habits in the system of learning new knowledge. Students can fully understand practical application situation of classroom knowledge points and improve their high-order thinking abilities: analysis, evaluation and innovation. Group learning mode improves their teamwork ability, innovation ability and lifelong learning ability. These are the goals of high-order thinking ability development.

5 Conclusion

With the guiding principle of promoting students' high-order thinking ability, the teaching mode of Psychological Health for college students was established based on the design thought of BOPPPS, and it was applied in teaching practice. The results show that, the teaching design with the purpose of prompting students' high-order thinking ability greatly optimizes teaching effect, which is mainly reflected in the following aspects:

- The teaching design with the purpose of prompting students' high-order thinking ability depends on case introduction, greatly promotes students' interest in psychological health knowledge and helps them more deeply grasp the connotation of knowledge learned.
- The teaching design with the purpose of prompting students' high-order thinking ability introduces questions by cases, helps students further improve knowledge application in the analysis and evaluation process and contributes to boosting learners' learning ability, innovation ability and other high-order thinking abilities.
- The teaching design adopts group learning mode, mobilizes students' learning enthusiasm, participation, innovation and subjective initiative, enhances their teamwork ability, innovation ability and lifelong learning ability and achieves the objective of high-order thinking ability cultivation.

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Innovative Applications Mode of Network Learning Space in Exercise Physiology based on Ubiquitous Learning

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Abstract—With continuous development of internet technology, the concept of ubiquitous learning and network learning space have received more and more attention from scholars, and gradually become the research focuses. College classroom has turned to network teaching from traditional teaching. In this study, literature review and case study were combined with ubiquitous learning and network learning space construction to systematically discuss classification and concept models of network learning space under the perspective of ubiquitous learning. Meanwhile, four models based on network learning space were proposed, and flipped classroom network teaching model was applied in the course of Exercise Physiology. The study showed that, the model has the good teaching effect in course teaching. It not just improves students' interest, but also lays a foundation for popularizing the teaching mode.

Keywords—Ubiquitous learning; network learning space; flipped classroom; exercise physiology

1 Introduction

Ubiquitous learning usually refers to the learning activity that anyone can carry out with any equipment anytime and anywhere. Learners are required to acquire learning resources and services with nay equipment. It is considered as a new learning method which contains rich learning theories and education significance, and makes learning any knowledge anytime and anywhere become possible [1].

With rapid development of internet technology, "Internet +" with prominent technical features and unique intelligent learning theory not merely drives economic development and generates revolutionary influence on teaching and learning mode, but also invisibly provides infinite possibilities for ubiquitous learning [2]. With continuous update and development of big data, cloud computing and "Internet +", they have become an irresistible force in current society. Hence, network learning space emerges, and becomes a new force to drive education development [3]. The in-depth development and application of network learning space teaching mode become the new requirements of education industry under internet background. Features of ubiquitous

learning organically tally with functions of network learning space to support and enhance deep application and integrated innovation of space, which provides the favorable perspective and opportunity for innovative application of network learning space.

2 State of the Art

Network learning space is conceptually classified into generalized network learning space and narrow network learning space. In a broad sense, network learning space refers to the learning activities under network support environment, such as virtual learning community, MOOC, and online course. In a narrow sense, network learning space refers to network learning environment which integrates learning resources, tools, services, communities and management under the background of "Internet +" [4]. The development of college network learning space in foreign countries is earlier than that in China. So far, network learning space has been promoted and applied widely in foreign countries, and successful application cases have emerged in colleges. For example, some private universities in US utilized network platform to provide online services. Students can achieve online tuition fee payment, course study, assignment exchange and examination assessment through this platform [5]. British open universities have gained the significant effect in the aspect of network learning space application [6]. The teaching effect from design and promotion of network learning space can be compared with face-to-face teaching. The biggest advantage of network learning platform is that it owns independent learning tools and supporting units. Students can freely plan their learning paths through the platform, and customize their learning schedule. Besides, the problems of students in the learning process can be properly adjusted on the network learning platform. Walkington et al. [7] investigated the learning space by combining research journals of two geography undergraduates. Wikis provides postgraduate reviewers with the special space to jointly develop constructive feedbacks to authors creating a supportive network learning environment. The results verified that, students could greatly improve writing enthusiasm through learning in network learning space. Hong et al. [8] proposed to utilize neural network algorithm to construct network learning space. In addition, they proposed to develop an online real-time warning system with MLP-EKFQ to foresee river temperatures influenced by the discharge of cooling water 1km downstream of a thermal power station, from real time to 2h ahead. The experiment proved the network learning space has great development potential, and is suitable for teaching. In addition, Jones Online University [9], Europe progress school [10], comprehensive media laboratory of American Denison University and University of Venice [11] have gained great achievements in terms of college network learning space construction.

Domestic research on network learning space is later than overseas research. With internet development, the development of network learning space has gradually become the research focus. Relevant researches indicate that, as many as 401 papers can be found by searching the key word "network learning space" in 2010-2016. It thus can be seen that, there are more and more researches on network learning space.

Meanwhile, the researches on network learning space mainly focus on the concept, function, construction, design and application of network learning space. With regard to network learning space construction, Zhu [12] divided network learning space into space structure, support service, access environment and user ability, and emphasized the important role of big data analysis. He proposed personal learning space information model and established it from student, resource, situation, activity and relation to better guide teachers to apply network space for teaching effect improvement. Learners improved learning efficiency with the designed application mode. About the construction and application of college network learning space, various colleges have gradually started construction of network learning space, promoted and applied it in recent years. For example, Anyang Normal University promoted network learning space construction, planning, implementation, application and promotion step by step, in the hope of reaching the better effect and providing reference for other colleges. Construction, promotion and application of network learning space play an important role in high-level talent education.

Network learning space has become a research field that researchers extensively pay attention to and study, and certain achievements have been gained in many aspects. Such learning platform not just makes students gain learning resources and changes students' learning mode, but also enhances students' learning interest and provides favorable conditions for their ubiquitous learning. Although the study on network learning space is developing at a rapid speed, certain problems exist in the development process. For instance, the development quality of network learning space needs to further improve, and its application is still in the primary stage. There are few innovations of its application modes. All these need improvement to better guide students' learning.

3 Construction of Network Learning Space based on Ubiquitous Learning

3.1 Overview of ubiquitous learning

Ubiquitous learning is a pervasive learning mode. Students can learn and acquire any information anytime and anywhere in the virtual space and under the support of computer. Based on the understanding of ubiquitous learning, the researcher considers that it mainly has four features: applicability, integrity, interactivity and situation. Ubiquitous learning process achieves organic integration of tools, modes and achievements. Besides, learners can acquire required information fast by the diversified network platforms, and achieve multiple kinds of online exchanges. The environment and modes are flexible. Thus, ubiquitous learning plays a great role in improving learning quality and quality.

3.2 Construction of network learning space based on ubiquitous learning

Classification frame of network learning space: Network learning space contains three dimensions: learning culture, resource form and application occasion [15], as shown in Fig.1. Learning culture dimension includes society and individual. Autonomy and heteronomy are the cultural dimensions of governance right allocation of network learning space. Autonomy is self-centered and means to acquire information according to individual needs and own the absolute control right for content organization, process implementation and effect evaluation. Heteronomy means to others control numerous aspects of information acquisition, and it belongs to two poles in the learning space, but the two are balanced. In the design of learning culture dimension, several factors should be taken into account, such as learning activity content, goal, students' demand and relevant background. Based on these factors, accurate orientation shall be conducted in the space dimension of individual and society. Measurement should be based on the control right of autonomy and heteronomy. In accordance with resource form, learning resources are classified into static and dynamic learning resources according to the variability. One type is the preset resource before learning, and the other type is dynamically generated resource in the learning process. The two depend on each other and transform mutually. According to the application occasions, learning resources are classified into regular and irregular resources. Regular resources usually own the set goals, and are learned in a well-organized way. Irregular resource is a kind of non-organized and course-free learning mode. The two have respective features and application occasions. They are not opposite but encompassing.

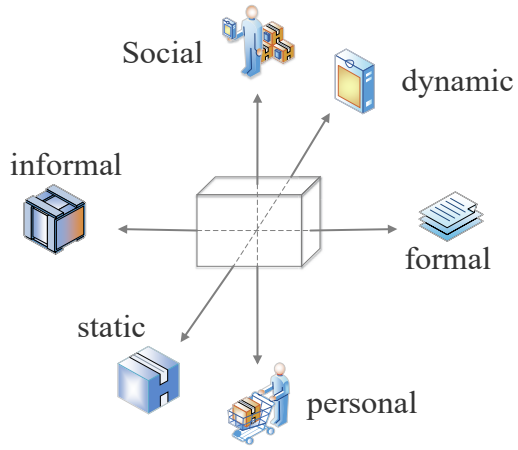

Fig. 1. Classification frame of network learning space

Conceptual model: Under the support of relevant theories and internet technology, the conceptual model of network learning space forms under the perspective of ubiquitous learning, as shown in Fig.2. The model is based on the ideas of ubiquitous

learning, teaching design, inclusive education and wisdom education. The formation of these ideas has strong guiding significance for construction of network learning space, which can prevent the defect of only paying attention to technology. Meanwhile, technical support plays a great role for construction of network learning space. Cloud computing, big data and analysis technology provide strong support for ubiquitous learning and effectively improve learning efficiency. Network learning space is not constructed by single element, but integrates some formal, informal, individualized and socialized learning modes. Organic integration and application of these modes achieve seamless fusion of learning.

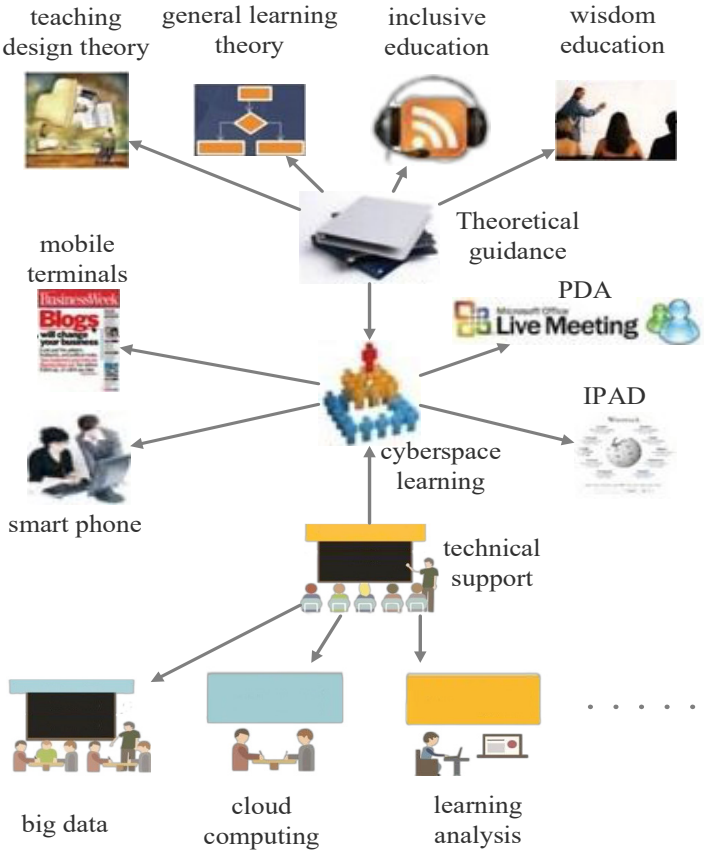

Fig. 2. Conceptual model of network learning space based on ubiquitous learning

Composition and structure: With the help of learning support service platform, network learning space provides suitable learning space for every learner. Through four elements role, content, toll and process information space, it exerts the functions of four platforms (network, management, social contact and service support) and reaches the objective with the help of cloud computing, big data and learning analysis. Four elements, four platforms and advanced technologies of network learning space

allow learners to acquire knowledge and information they want through network learning space, to form social network in the learning space, and establish net-type relations with classmates or teachers. These further promote knowledge construction, cultivate and improve problem solving and analyzing ability. Lastly, individuals develop and form collective wisdom. The composition and structure are shown in Fig.3.

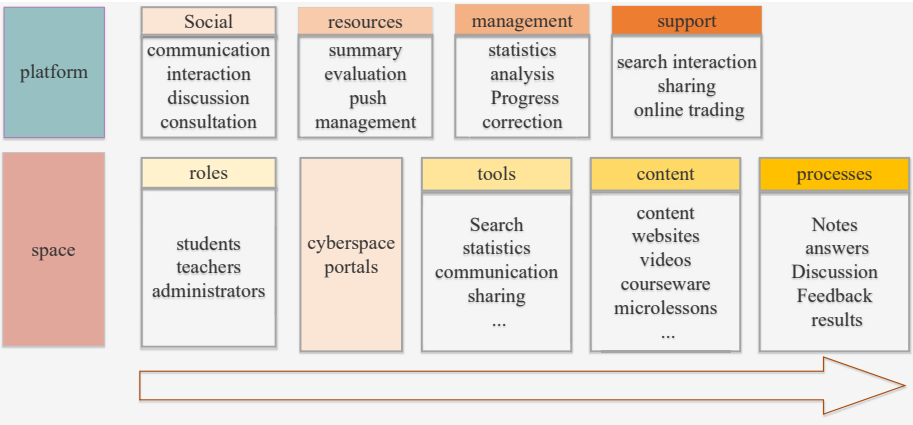

Fig. 3. Composition and structure of network learning space based on ubiquitous learning

4 Innovative Teaching Mode

4.1 Flipped classroom mode based on network learning space

Flipped classroom mainly embodies "flipped". Compared with traditional classroom, flipped classroom means the teacher-centered teaching mode is flipped to student-centered learning mode, as shown in Fig.4. Classroom center flipping is just a superficial phenomenon. The deeper-level flipped classroom refers to the change of learning mode with multiple teaching methods such as multimedia video and PPT and with the help of network learning space. The original explanation by the teacher and homework after class are changed to pre-class micro-video study and difficulty solving under the guidance of the teacher. In this way, students really become the subject of the classroom and change to active learning from passive reception. This is the change brought by flipped classroom mode based network learning space. Compared with traditional classroom, flipped classroom puts forward higher requirements for teachers, and the role of teachers also change. Teachers need to answer students' questions more professionally and deeply.

The application of flipped classroom mainly includes three aspects. Firstly, micro-course teaching video is produced. PPT is used to produce the video. Students preview the course content through the micro-course video, and mark the doubts for the targeted learning. Secondly, after the micro-course video is prepared well, it is necessary to organize and plan the classroom activity. For learning content push and class-

room content arrangement, some social platforms can be used to push videos, establish learning group and let students exchange before the class. In one word, multiple channels are applied for classroom teaching. After pre-class learning is completed through the established mode, the major task in classroom is to answer questions by the teacher and students deeply learn relevant knowledge. Finally, teaching effect of flipped classroom is evaluated from multiple aspects, such as pre-class independent study, classroom discussion participation and after-class assignment completion. The evaluation mechanism is established and corresponding improvement measures are taken for the results to achieve continuous improvement of academic performance.

The application of flipped classroom in Exercise Physiology teaching contributes to more three-dimensional and visual body science and enhancing students' hobbies and interests. Besides, it also meets students' demand for professional knowledge. The flipped classroom can enhance students' interest, cultivate students' exchange ability and learning initiative and improve teachers' professional ability so as to enhance students' problem solving ability.

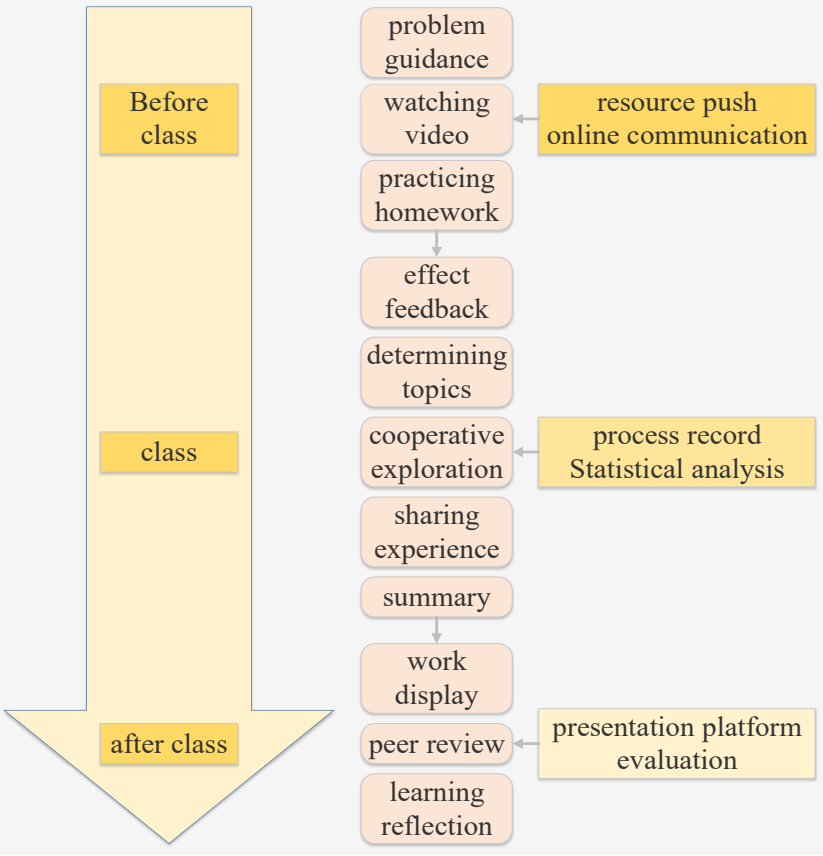

Fig. 4. Flipped classroom teaching mode based on network learning space

4.2 Affective and cognitive factor integration mode based on network learning space

Based on network learning space, scholars organically integrate affective factors and cognitive factors, mine the action rules of cognitive interaction and affective interaction and give full play to synergistic effect of mutual promotion of emotion and cognition in network learning space. Based on this theory, the model of "affective and cognitive interaction level tower" forms, as shown in Fig.5. The model includes four levels and corresponding four elements which interact complexly, but have certain rules.

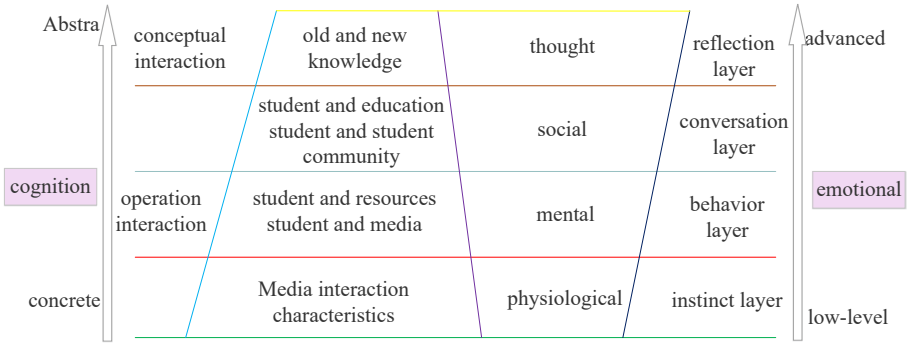

Fig. 5. Model of "affective and cognitive interaction level tower"

Based on the learning view and significance construction generated on the basis of double-subject teaching thought and knowledge, "affective and cognitive integration" network teaching mode is constructed by refereeing to relevant research results, as shown in Fig.6. "Affective and cognitive integration" network teaching mode is mainly composed of cognitive elements and affective elements. With the help of network teaching platform, students and teachers carry out human-computer interaction. The mode supports teachers and students to cognize information so as to form two cognitive elements. Meanwhile, two corresponding affective elements are produced on the basis of two cognitive elements. Thus, four core elements form. They intersect and form three basic relations. "Affective and cognitive integration" network teaching mode intensively embody four cores and three basic relations. At the same time, the interaction between teachers and students can adjust human-computer interaction, and thus a closed type forms.

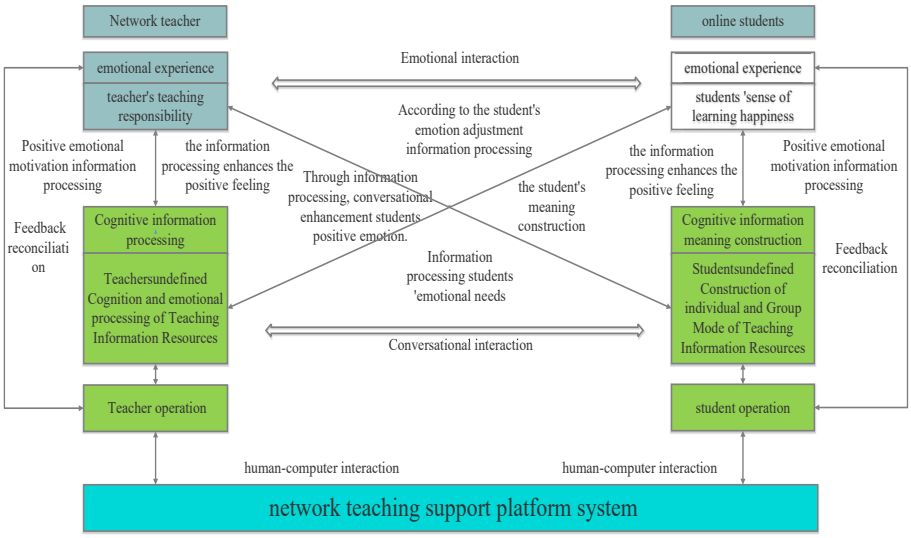

Fig. 6. "Affective and cognitive integration" network teaching mode

4.3 Virtual simulation model based on network learning space

Virtual simulation technology integrates multiple technologies and involves computer graphic, artificial intelligence, human-computer interaction and sensor technology. It applies multiple core technologies to achieve the environment we need and give people the feeling of being personally on the scene. Virtual reality technology implants real system in the virtual system through computer analog technology and imitates human-computer conversation in reality. It is a kind of advanced virtual simulation generated by simulation and virtuality. The entity may be a simulator or a set of complete virtual simulation system. These entities act in the set virtual simulation system so as to embody the true features. For the course of Exercise Physiology, the application of virtual simulation system has advantages in three aspects. Firstly, virtual simulation experiment system replaces the entity, and the experiment no longer consumes consumables or produce wastes, which not just reaches the purpose of learning but also embodies energy conservation and environmental protection awareness. Secondly, students' experiment process and times are no longer restricted. For the problematic experiments or the processes hard to understand, repeated operations can be achieved, which can help students consolidate knowledge and improve experiment skills. Thirdly, the improvement of virtual simulation technology also means students' improvement. Students can carry out expanded learning through this platform, without the limitation of materials and space. Even, students can study after class. It thus can be seen that, virtual simulation technology platform creates learning space and improves students' learning interest. The process of constructing virtual simulation technology and applying it in the experiment goes through primary stage, module establishment stage and model application stage. Students know well and cognize the system to reach the state of human-computer integration. Then, the

knowledge module is implanted in the virtual simulation system according to the demands of students and course arrangement. The final stage is module application stage. This stage aims to carry out basic experiment through the knowledge learned, apply and develop knowledge of somatology and exercise physiology. This stage is crucial. The results differ a lot according to different understanding. Virtual simulation technology as a scientific teaching mode with innovativeness can effectively improve interestingness of Exercise Physiology and learning visibility so that students well promote their specialty, enhance their understanding of experimental curriculum and boost learning effect of Exercise Physiology.

4.4 Specialty development mode based on network learning space

Specialty development refers to the process where one gradually becomes the expert from a green hand in terms of specialized knowledge, skills and values of an industry. Network learning space can easily gather the persons of the same occupation together for exchange and learning and form a team invisibly. Specialty development mode based on network learning space under the perspective of ubiquitous learning is shown in Fig.7.

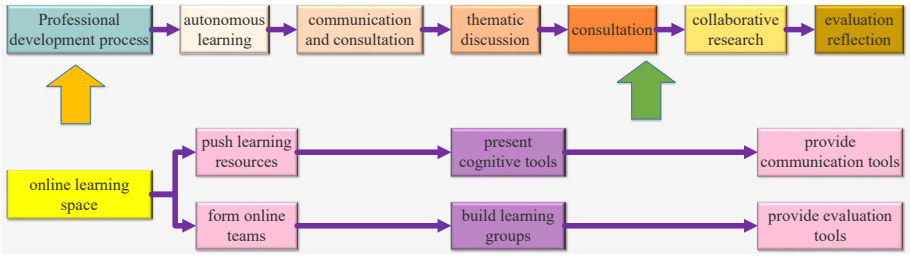

Fig. 7. Specialty development mode based on network learning space

The mode can be divided into six processes: independent study, exchange and consultation, special discussion, consultation and exchange, collaborative research, and evaluation and introspection. Firstly, with strong autonomous learning ability, professionals can utilize relevant resources and the platform for learning and study. Secondly, when professionals are confronted with the problems which cannot be solved, they can exchange, consult and discuss to solve problems, gain different understanding and view knowledge and specialty from multiple levels and perspectives. Thirdly, special discussion. When the similar problems are met in the platform, special topic can form spontaneously for discussion and exchange so as to reach full understanding of knowledge. Fourthly, professionals can consult and exchange with the experts in the field to gain more professional guidance. Fifthly, for the complex and comprehensive theme, the collaborative team can be built to solve problems by dividing the work. Sixthly, evaluation and introspection stage. The knowledge acquired needs to be repeatedly examined, corrected and adjusted. Specialty development mode based on network learning space is of great guiding significance for professionals with occupational qualification.

5 Teaching Effect

Exercise Physiology as a branch of human physiology aims to study development and change laws of functions in one exercise training or repeated exercise. It is one of important basic theoretical courses of PE major in sports colleges. The course involves theory and basic application. The course has important teaching significance and social significance in the aspects of developing sports science theory, strengthening PE teaching theory and method and improving athletic ability. However, this course with rich contents and strong theory is closely related to many other courses of PE major, and involves multiple disciplines such as physics, chemistry, biology, human anatomy and human physiology. In addition, it has certain requirements for logical thinking and abstract thinking, thus leading to unsatisfactory teaching effect and difficulty in grasping the knowledge. This brings certain challenges for teaching and learning. In the face of this situation, it is necessary to explore the teaching mode which adapts to current situation and reaches the ideal teaching effect. The establishment of network learning space application mode under the perspective of ubiquitous learning opens up a new way for Exercise Physiology teaching. Rapid development of internet era and organic integration provide favorable conditions for implementation and promotion of network learning space application mode. Meanwhile, teaching and network complement each other. The mode simplifies course difficulty, enhances students' learning interest and promotes teaching development of Exercise Physiology.

5.1 Flipped classroom teaching mode

Compared with traditional classroom, flipped classroom means the teacher-centered teaching mode is flipped to student-centered learning mode. Flipped classroom refers to the change of learning mode with multiple teaching methods and with the help of network learning space. The original explanation by the teacher and homework after class are changed to pre-class micro-video study and difficulty solving under the guidance of the teacher. In this way, students really become the subject of the classroom and change to active learning from passive reception.

5.2 Object of study

80 students participating in flipped classroom teaching mode were chosen as the object of study. 80 questionnaires were distributed, and all questionnaires were recovered, with the recovery rate of 100%.

5.3 Research method

Pre-class micro-video production: The teacher produced PPT and micro-vide in accordance with teaching content and course arrangement of Exercise Physiology as well as students' learning conditions to form classroom teaching video. In the aspect

of students, the teacher sent the teaching video in advance, and required students to carefully view the video, look up materials, propose problems, formulate the solutions, exchange and discuss.

Classroom organization and planning: According to network teaching mode of flipped classroom, the teacher answered students' questions deeply from multiple perspectives, diverged students' thinking and explored students' potential based on interactions between students and the teacher. At the same time, the teacher dominated the course schedule, organized case discussion, project cooperation, consultation and exchange, and continuously enlightened students. Moreover, the teacher participated actively and formed the harmonious classroom interaction with students.

Establishment of experimental scheme: In the experiment teaching of Exercise Physiology, flipped classroom network teaching mode was applied. The teacher guided students to view the experiment video, and asked students to autonomously design experimental scheme based on the experimental project and to learn through the open exchange form, assisted students in solving the problems in the experiment and cultivated their autonomous learning habit.

5.4 Results

The effect of flipped classroom network application in Exercise Physiology was recorded. The investigation results are shown in Table 1.

Table 1. Investigation results of flipped classroom network application mode

Items	Course design is rational and significant	Provide students with independent learning and problem solving ability	Classroom atmosphere, improve learning efficiency	Enlighten thinking, deepen understanding, arouse learning interest	Enhance teamwork awareness and ability	Teaching method is appropriate and deserves to be promoted
Satisfied	98.0%	91.9%	93.2%	91.5%	96.0%	85.2%
Dissatisfied	2.0%	8.1%	6.8%	8.5%	4.0%	14.8%

The findings show that, flipped classroom teaching mode applied in Exercise Physiology teaching is highly satisfied from course design, independent study, classroom atmosphere, thinking enlightenment, team awareness and teaching method, and has certain promotion value. The flipped classroom improves students' enthusiasm and knowledge mastery ability. The application feedbacks provide experimental basis for feasibility of flipped classroom and lay a foundation for improving classroom quality.

6 Conclusion

Four application modes of network learning space under the perspective of ubiquitous learning were proposed in this study, i.e. flipped classroom mode based on network learning space, "affective and cognitive integration" network learning space mode, virtual simulation network mode and specialty development mode. The flipped

classroom mode was chosen as the object of study, and applied in Exercise Physiology to study its teaching effect. The investigation indicated that flipped classroom teaching mode has good teaching effect in the course, enhances students' interest and improves learning efficiency and teaching quality. Therefore, it deserves to be popularized in other fields.

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Intelligent Emotion Evaluation Method of Classroom Teaching Based on Expression Recognition

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Abstract—To solve the problem of emotional loss in teaching and improve the teaching effect, an intelligent teaching method based on facial expression recognition was studied. The traditional active shape model (ASM) was improved to extract facial feature points. Facial expression was identified by using the geometric features of facial features and support vector machine (SVM). In the expression recognition process, facial geometry and SVM methods were used to generate expression classifiers. Results showed that the SVM method based on the geometric characteristics of facial feature points effectively realized the automatic recognition of facial expressions. Therefore, the automatic classification of facial expressions is realized, and the problem of emotional deficiency in intelligent teaching is effectively solved.

Keywords—Intelligent teaching, emotion recognition, support vector machine (SVM)

1 Introduction

With the development of information intelligence technology, artificial intelligence education faces challenges and opportunities. Multimedia computers are widely used in the field of education, which has a great impact on the traditional teaching process. A variety of emerging advanced teaching equipment have entered the classroom. The teaching form is developing in a diversified direction. The intelligent computer-aided teaching system is integrated with network, artificial intelligence and multimedia technology. It differs from traditional computer-aided teaching systems. The distinguishing feature is its intelligent and personalized teaching function, which has the advantages of interactivity, sharing, autonomy and efficiency. In the process of learning, human-computer interaction is realized. Teachers and students can realize the interaction between teaching and learning through the network. Based on the geometric features of the image, commonly used linear kernel functions, polynomial kernel functions, and radial kernel functions are applied. The issue of kernel function selection and parameter optimization in SVM (support vector machine) is further explored. Combined with the geometric features based on facial features, the SVM method is used to identify facial expressions. Finally, automatic classification of facial expressions is achieved. The experimental results were analyzed and compared.

2 State of the Art

With the continuous deepening of education informatization, the demand for intelligent teaching products in the education industry has grown rapidly. Intelligent computer-aided instruction was used in the field of medical education. As a new type of teaching media, virtual classrooms were the product of computer, multimedia, and network communication and other information technology, multi-disciplinary and multi-field integration. Through computer networks, multimedia communication technology was used to construct the learning environment, which can realize virtual classroom teaching monitoring, multimedia individualized interactive network learning and other functions. Teachers and students in different locations can carry out most teaching activities. Neoh et al. [1] studied the intelligent recognition of facial expressions based on hierarchical coding cascade optimization model. Liu et al. [2] discussed several designs for face-to-face digital classroom environments. Elżbieta et al. [3] studied the interaction between teachers and students in the digital interactive classroom to expand the teaching space of teachers. Its research and development were also combined with the publication of digital books, and teaching books were digitized. The system was being promoted on campus across the country. Lee and Shin [4] studied the virtual teacher software system. It creates a more user-friendly, flexible and smarter online learning system for users. In the Global Chinese Computer Education Application Conference, Wei and Zhao [5] proposed to introduce the role of virtual teacher or virtual instructor in the learning system. Based on the concept of mobile learning and hybrid learning, Ko [6] used a personal digital assistant (PDA) for teaching. Test and note functions were added when the student's handheld device was connected to the teacher's PC. At the same time, the application supports a single user to use the PDA as an external input and output device. PAD was used as a front-end device for personalization and intelligence. Other applications or device interfaces were the future development direction, which was also a research hotspot of intelligent teaching. Shah et al. [7] established the candle project. Based on the digital community of the network learning integrated environment, mobile technology was used to provide content and communication. This brings hope to information education in remote areas. Shojaeilangari et al. [8] studied dynamic facial expression analysis based on gradient direction extended space-time histogram. Based on the Japan Female Facial Expression (JAFFE) Database and grayscale features, the relationship between kernel function and feature quantity and expression recognition accuracy and time consumption was discussed. Combined with the experimental results, the relevant guiding principles were proposed for the selection of the kernel function and the selection of the number of features.

In summary, traditional teaching methods cannot meet current needs. Information technology such as computers, multimedia, and network communications were introduced into classroom teaching activities. However, previous studies have not applied expression recognition technology to the classroom. The student's emotions were ignored. Therefore, to solve the problem of emotional loss in teaching and improve the teaching effect, an intelligent teaching method based on facial expression recognition was studied. First, the research background and meaning were introduced. Sec-

ond, previous research findings and theories in this field were reviewed. Third, the facial expression data set was introduced. The issue of kernel function selection and parameter optimization in SVM was discussed. Finally, the proposed method was verified. Results showed that the SVM method based on the geometric characteristics of facial feature points effectively realized the automatic recognition of facial expressions.

3 Methodology

3.1 Emotional calculation

In 1997, Professor R. Picard of the Massachusetts Institute of Technology Media Lab defined the concept of emotional computing in her monograph "Affective Computing." Emotional computing is a calculation that derives from emotions. The purpose of emotional computing is to establish a harmonious human-machine environment. By giving computers the ability to recognize, understand, express, and adapt to human emotions, computers have higher and more comprehensive intelligence. Emotional computing theory and technology have been widely concerned by academic circles at home and abroad. It is one of the most challenging scientific issues in the field of harmonious human-computer interaction research. The emotion calculation includes several parts as shown in Figure 1.

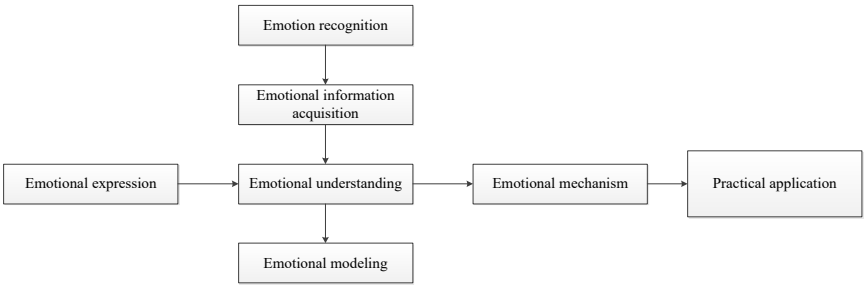

Fig. 1. Research content of emotional computing

3.2 Key technology of emotional computing

In the field of emotional computing, there are several key technologies, including the study of emotional signal sensors, biometrics, analysis of human emotion states based on expression features and physiological signals, emotional modeling and recognition, the effective expression of identified emotional outcomes, the fusion, integration, and knowledge reasoning systems of various perceptual data.

Psychology theory believes that emotion as a psychological process has a unique external manifestation. Expressions include facial expressions, gesture expressions, and tone expressions. In the process of emotional expression, psychologists have shown that facial expressions can best express one's emotions, which accounts for

55% of emotional expression. Sound accounts for 38% of emotional expression, while language accounts for only 7% of emotional expression. Figure 2 shows the specific distribution. It can be seen that in these three expressions, facial expressions best reflect one's emotions, followed by sound, and finally language.

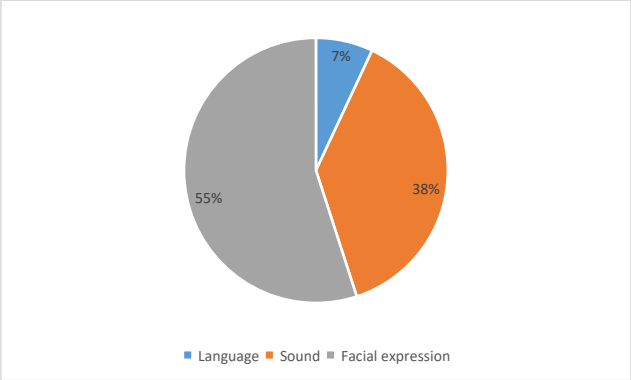

Fig. 2. Proportion of expression

In the process of using emotional computing and computer technology to evaluate the quality of classroom teaching, the facial and posture expression images of students are first obtained. Emotional calculations are then used to analyze the characteristics of the learner's facial and gesture expressions to identify student emotions. Finally, through the obtained student's emotional results, according to the learner's emotional model, the students' learning state and effect are analyzed, and the teacher's classroom teaching quality is judged.

Facial expression recognition technology covers three aspects: detection and recognition of facial expressions, feature extraction and classification. Figure 3 shows the flow of facial expression recognition.

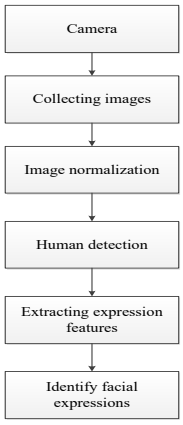

Fig. 3. Facial expression recognition process

In facial expression recognition, feature face is a common method, but this method is also insufficient. First, the amount of calculation is relatively large, and second, the requirements for pictures are relatively strict. The information for extracting facial expression images is based on the feature extraction points of the still images. The advantage of this method is that it is simple and fast. However, the disadvantage of this method is that the requirements for the extracted face image are relatively high. The expression of the face in the extracted facial expression picture must be particularly exaggerated. Therefore, the robustness of the method is bad and the recognition rate is low. Active shape model (ASM) is a popular face feature point localization algorithm. The global shape model is also known as the point distribution model (PDM). It is a shape model based on the statistical properties of training samples. The purpose of establishing a local texture model is to determine the best selected position for each feature point. By collecting the brightness of the face image, the local texture is normalized to obtain a specific vector. The facial motion coding system analyzes the characteristics and related expressions of such motion units. It consists of approximately 46 separate and connected motion units (AUs). This method is relatively straightforward and easy to understand. However, in terms of applications, the accuracy, speed and efficiency of the system need to be improved.

There are many characteristic parameters in a person's spoken voice that can explain a person's emotional state. People's emotions are different, and the corresponding emotional characteristics are also changed differently. Therefore, it is very important to study the characteristic parameters of speech that can express emotions such as speech rate, intonation, time structure, amplitude structure, fundamental frequency structure, and formant. If a person is excited now, the speed of speech will be faster than usual. Therefore, the speech rate characteristic parameter in the speech signal can be used to judge the degree of excitement of a person. If a person is in a sad state, the amplitude parameter in the speech parameter feature will be lower. If a person is in an emotional state of joy, anger, and surprise, the amplitude parameter in the speech parameter feature will be higher, the span of the amplitude parameter value will be larger, and the magnitude of the emotional change will be greater.

3.3 Facial expression data set

Facial expression recognition is affected by many factors such as illumination, background, ornaments, time, etc. These factors directly affect the robustness of facial expression recognition algorithms, which greatly hinders the application of facial expression recognition. Therefore, the current research on facial expression recognition still has great challenges, such as face recognition and expression recognition. The research, development and testing of algorithms require a lot of relevant facial expression images. Moreover, the relevant facial expression images are rich, and the negative influence of the above factors on the robustness of the facial expression recognition algorithm is easily overcome. This helps to further improve the recognition rate of the expression. At present, most algorithms are suitable for situations where the background is simple and the face pose is fixed, and the effect is good. However, for complex backgrounds and unknown face gestures, facial expression

recognition is still a difficult problem at this stage. Moreover, the detection speed and accuracy are difficult to achieve good results at the same time. Therefore, in addition to considering the situation of the positive face, the face expression with an unfixed posture should also be considered so that it can be better applied to intelligent teaching.

To increase the diversity of the data set, frontal and many facial expression images with deflection angles are included for expression recognition at different angles. To detect the recognition rate of the classifier, the plurality of expression databases is used as the test basis for the research method. In the experiment, a common facial expression database was used, such as JAFFE, Bio ID-Face Database and Yale Face of Kyushu University in Japan. The expression data set consists of 1603 384*286 images. Four expressions were shown, including happy, interest, confused, and tired. The data set contains the frontal face image and the picture with a deflected angle. The picture with the angle of deflection selects the frontal face with a tilt angle between (-30, +30). Images with different angles and different lighting conditions are included. The number of pictures for each expression is as follows: happy-442, interest-934, confused-459, and tired-145. Due to the limited number of facial expression images with the deflection angle, the number of various types of expression images in the expression database is not balanced.

Due to experimental conditions and personnel limitations, the emoticons in this experiment come from multiple libraries. Most of them come from the currently popular expression library. Since these expression libraries are created by professional departments, they are ideal for image viewing angles and facial expressions, and are suitable for related research. The images in the expression database are mainly derived from the following expression libraries.

Among them, the Japan Female Facial Expression Database (JAFFE) includes 213 gray-scale expression images of ten Japanese women, and each person displays a total of seven expressions including neutral expressions. Since the image is captured without limiting the illumination and head pose, some faces have a small angle of deflection to some extent. In the JAFFE library, each expression image has been semantically described, and the library can be used as a reference for other library expression classification. This experiment refers to the expression classification in the library when classifying facial expressions.

Bio ID Face Database, which includes 1521 face images in 384*286 grayscale natural scenes, provided by 23 testers. At the same time, it also includes the position of the eyes of each face. This database is also commonly used for face recognition and human eye positioning. Since the commonly used facial expression database is a face image collected under constraints, these databases ignore the influence of time and age information on facial expressions. The expression data set includes facial expression images of various ages, such as adding a plurality of child pictures, which makes the image samples more diverse. The recognition rate of expressions is further improved. Figure 4 shows a partial emoticon image in the dataset.

Fig. 4. Facial expression image

After the expression library is created, the library is divided into two parts: one part is used to train the face feature shape model, which is called training expression library. The library manually extracts features from the image and provides training data sets for subsequent experiments. The other part is used for testing, which is called the test expression library. This part of the data is mainly used for the test of the face feature shape model and the test of the expression classifier. The number of pictures in the training expression library is 1538. The four emoticons of happy, interest, confused, and tired are 423, 934, 133, and 448, respectively. The number of images in the test emoticon is 113. The four types of emoticons are 33, 25, 25, and 30, respectively.

3.4 Data preprocessing

Data preparation needs to be done before creating a facial expression classifier. Data preprocessing is performed on feature point information. Most importantly, the correctness and validity of the data in the test sample and the training sample data set are guaranteed. By checking the completed feature extraction image, the mark of the feature point is checked to determine the vacancy value. The location of the mark should be specified to ensure the validity of the data. For the problems that occur in the above data processing, the image needs to be remarked.

The data is processed into the following svm specified format:

[label][index1];[value1] [index2]; [value2]

Label is the kind of classification, which is usually some integer. Four types of emotions are included, and the values of the labels are defined as 1, 2, 3, and 4, respectively. Index is an ordered index, which usually takes a real number. With 68 feature points, the number of eigenvalues is 136, and the index value is [1, 136]. Value is the data value to be trained, that is, the coordinate value corresponding to each feature point. Each data should be separated by a space. Finally, the classifier is used to classify the test samples and the results are generated as labels.

Before training the expression classifier, to avoid an imbalance in the training due to a feature being too large or too small, all data is normalized. The original sample is scaled. The normalization of feature points not only facilitates data processing, but also speeds up the convergence of the training network. Normally, the zoom range is between [0,1] or [-1,1]. It should be noted that the original training set and the original test set are treated as the same data set during the normalization process.

The coordinate values of the feature points are normalized as input data to obtain normalized data. The data range is distributed between [-1, 1]. In this way, all the data

points are in a high-dimensional space with the origin as the center and the radius of 1 in the sphere. The entire data set contains m images, so it has m rows. Each image has n feature points, and a matrix of m*n is constructed. Each column constitutes a feature column. For a certain feature column, the maximum value G_{max} and the minimum value G_{min} are obtained. The normalized data range will be distributed between [R_{min}, R_{max}]. All feature values X on this column use the following normalization formula:

$$X_i = R_{\max} + \frac{X - G_{\min}}{G_{\max} - G_{\min}} \times (R_{\max} - R_{\min}) \tag{1}$$

Feature points are normalized to the original training set and the original test set using SVM. After normalization, a normalized file is generated in the directory. The data in the file is the normalized data. This file can be used to create a face classifier, which is called the training set.

3.5 Optimal kernel function selection and parameter optimization

Kernel functions are widely used in the field of pattern recognition. The theory about kernel functions appeared earlier. In 1964, in the study of the potential function method, the kernel function was introduced into the field of machine learning. However, until 1992, linear SVMS research was extended to nonlinear SVMS research. Through experimental methods, the kernel function is discussed and the kernel function suitable for this study is selected. The kernel function method was introduced into the support vector machine, which is inseparable from its characteristics. First, the dimension of the input space does not affect the kernel function matrix. The kernel function method can use high-dimensional input, which effectively avoids "dimensionality disaster" and reduces the amount of calculation. Second, the function does not have to care about the form and parameters of the nonlinear transformation function. Third, when the input data is mapped to the high-dimensional feature space through the nonlinear function, the selected kernel function type and parameters will affect the properties of the feature space, which will affect the performance of various kernel function methods. The kernel function method is flexible in its specific use. It can form various kernel function methods with other algorithms. In the process of use, appropriate algorithms and kernel functions are selected according to actual needs.

Commonly used kernel functions include radial basis functions, perceptron kernel functions, Gaussian kernel functions and polynomial kernel functions. Based on the geometric characteristics of face features, the following three kernel functions are discussed, namely linear kernel function, radial basis function (RBF) and polynomial kernel function. Through the relevant experiments, the relationship between the kernel function and the recognition accuracy is further explored. Through comparative analysis, suitable kernel functions were selected for emotion recognition in this study, which prepares for the next step of recognition. At the same time, relevant conclusions can be extended to other data sets and features.

First, the kernel function selected in the experiment is introduced:

Radial basis function: The radial basis function is widely used in SVM, which is radial symmetry scalar function. For any point x in space, the monotonic function of Euclidean distance between it and a certain center xc can be represented by k(||x-xc||). When the distance between x and xc is far, the value of the function is small. In practical applications, the commonly used radial basis function is a Gaussian kernel function. The definition is:

$$k(\| x - xc \|) = \exp\{- \| x - xc \|^{\wedge} 2/(2 * \sigma)^{\wedge} 2\} \tag{2}$$

In the formula, xc is the center of the kernel function. σ is the width parameter of the function, which controls the radial extent of the function. The nature of the Gaussian function determines that it can filter the image well in both the spatial and frequency domains, so it is widely used in image processing.

Linear kernel function: $k(x_i, x_j)=x_i, x_j$, the linear kernel function actually performs a dot product operation on two vectors, which realizes the nonlinear transformation of the kernel mapping.

Polynomial kernel function: k(x, y) = (1 + x. y) d. The polynomial kernel d is the order of the polynomial. The larger the order, the larger the nonlinearity. The core is prone to infinity when the sample size is large.

Cross-validation is mainly used in modeling, such as regression modeling of PCR (Principal Component Regression) and PLS (Partial Least Squares Method). The sample to be modeled is divided into two parts: one part is used to build the model, and the other part is used to test the built model. The number of samples used for testing is relatively small. The prediction errors of the test samples are calculated and their squared sums are recorded. This process is repeated. When all samples are predicted one time later, the prediction error of each sample is squared and summed. This process is called PRESS. Cross-validation is also known as cross-matching, which is mainly to avoid over-fitting phenomena to obtain a reliable and stable model. It is a commonly used accuracy test method and is usually an important indicator to measure the quality of a trainer. For example, a 5-fold cross validation divides the data set into five parts. One of the four training sessions was used for each test. The accuracy of the algorithm is estimated using the mean of the five results. Usually, multiple times of cross-validation is used to find the average.

In the process of creating a facial expression classifier, when using the kernel function, two parameters c and γ are considered, where c is the penalty coefficient, and γ is different for different kernel functions. Since there is no prior knowledge of the choice of parameters, a parametric search is done to get the best (c, γ). c and γ suitable for creating this classifier are used. In this way, the classifier can better predict the test set data and improve the recognition rate of the expression. The expression data sets were respectively subjected to 3, 5, and 10 times cross-comparison, and the corresponding parameters c and γ were recorded.

The algorithm is as follows:

First, the training set is disrupted;

Second, if the cross-validation coefficient is selected as n, the training set is divided into n parts;

Third, if i=O, when i≤n-1, the following loop is performed;

Fourth, when each training is carried out, the ith share is reserved for testing;

Fifth, according to the set parameters, the remaining training sets are trained to obtain the model;

Sixth, for all vectors in the ith, the model in the fifth step is used for prediction. The classification result of the test is saved. This process is complete.

For the normalized training set, the training set is first loaded and then trained. Tests were performed using three kernel functions, including test set data and data in the training set. v is the number of cross-comparisons. Table 1 shows the experimental results.

Table 1. Kernel function test

Kernel function	Vvalue	Cvalue	γvalue	Total recognition rate of training data (%)	Total recognition rate of test set data (%)
Radial basis function	3	127.0	0.124	88.2	66
	5	127.0	0.124	88.2	73
	10	127.0	0.124	88.2	71
	3	127.0	0.124	78.6	60
Linear kernel function	5	127.0	0.124	88.2	72.6
	10	127.0	0.124	88.2	73.1
	3	127.0	0.124	84.1	63
Polynomial kernel function	5	127.0	0.124	88.2	70.4
	10	127.0	0.124	88.2	70.5

As can be seen from Table 1, not the larger the v value, the higher the total recognition rate of the data in the training set and the total recognition rate of the test set data. Here, the recognition rate refers to the average recognition rate of the four expressions in the test set. The 5-fold cross-validation effect is the best, followed by a 10-fold cross-validation. Based overall experimental situation, the creation of the expression classifier will use the radial basis function. Among them, the values of v, c, and γ are 5, 127.0, and 0.124, respectively.

3.6 Automatic recognition of facial expressions

The recognition of facial expressions involves two processes. The first process is to create an expression classifier using the training data set. The support vector machine constructs an expression classifier by analyzing the attributes in the data set. The support vector machine (SVM) was introduced for training to generate an automatic facial expression classifier. The second process is to use the built-in classifier for classification, and automatic classification of facial expressions is implemented.

Different parts of the face contribute differently to the recognition. For example, the eyes and mouth are more important than the nose. Facial expression recognition has different degrees of information on different parts of the face, and the eye information plays a greater role. In the process of expression recognition, the information of the face part has a great influence on the recognition.

Facial expressions accurately reflect people's emotions. Therefore, different facial muscles play a leading role in facial expressions that express different emotions. For example, when people show surprises, the eyes and mouth are opened a lot. When people are sad, their eyebrows and mouth are drooping. When people feel happy, there will be changes in eyebrows, small eyes, upturned corners, etc. Among them, the shape of the mouth changes most obviously. In addition, the shape of the eyebrows, the spacing of the upper and lower eyelids of the eyes, the position of the pupil in the eye, the position and shape of the lips, etc., can all be used to reflect facial expressions. Through the observation and analysis of various expression features, facial expressions are complex and rich. However, because each facial expression is caused by a series of muscle activities, different muscle activities will show different characteristics. Therefore, various facial expressions have a certain distinction between certain parts. To better distinguish each expression, the geometric relationship between the feature points is used to generate corresponding feature points. Then, it is used together with 68 feature points as training set data. The geometric feature points are the features that best represent and distinguish the expressions, which can effectively improve the recognition accuracy.Figure 5 shows the calibration of feature points.

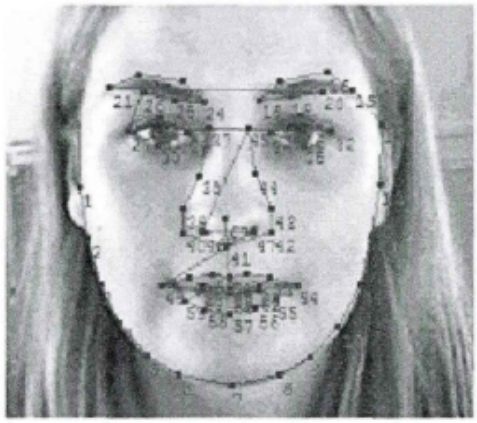

Fig. 5. Calibration of feature points

Table 2 shows the geometric feature selection in the experiment. When each expression changes, the facial organs will be distorted accordingly. Based on this expression, for example, when people are happy, the mouth is enlarged and the distance between the upper and lower lips is increased. However, for neutral expressions and angry expressions, the upper and lower lips are spaced less because the mouth is usually closed. The ratio of the width to the height of the mouth is calculated to distinguish between happy and neutral expressions. Therefore, the new eigenvalue D1 is added. It is the ratio of the distance between the upper and lower lips and the Euclidean distance between the left and right corners. In addition, when people are confused, the eyebrows will wrinkle together and the distance between the two brows will become smaller. However, for the happy expression, the eyebrows will bend down and

the brows will be relaxed, but the inner corners of the eyes will not change. Based on this feature, the Euclidean distance between the left and right brows and the two inner corners of the eye is calculated to better distinguish the confused and happy expressions, such as D9.

Table 2. Geometric feature selection

Dm	Euclidean distance ratio	Dm	Euclidean distance ratio
D1	d52,53/d49,55	D6	D24,25/d25,26
D2	D25,30/d28,49	D7	D29,31/d34,36
D3	D19,35/d33,55	D8	D34,36/d33,35
D4	D19,25/d25,55	D9	D19,25/d30,35
D5	D18,19/d19,20	D10	d52,55/d49,55

4 Result Analysis and Discussion

The expression data set used in the experiment consisted of 1603 384*286 images, which displayed four expressions, including four emotions: happy, interesting, confused and tired. The picture is selected as a frontal face with a tilt angle between (-45, +45), including pictures with different angles and different lighting conditions. Figure 6 shows the frontal face.

Fig. 6. Frontal face

Table 3 shows the classification results for each expression.

Table 3. Classification of facial expression recognition

Expression	Number of test pictures	Number of interests	Number of happy	Number of confused	Number of tired
Interest	33	30	2	1	0
Happy	25	3	21	1	0
Confused	25	4	2	19	0
Tired	30	3	3	4	20

As can be seen from Table 3, the classification effect of "interest" is good, which can reach 70%. For the case of misclassification, "interest" may be judged as "happy" or "confused". Through the observation of the wrong picture, it is found that the "interest" expression is similar to the "happy" or "confused" expression. The corner of the mouth rises slightly, but the lips and teeth are not separated. In the process of identification, it may be greatly affected by the pre-classification features D1 and D9. The reason why the “interest” expression is not regarded as “tired” expression is that from the spatial analysis based on the basic emotion, the two types of expressions are in the opposite angles of the cone model, and they are opposite each other. From the point of view of the expression picture, the two types of expressions are clearly different. For the "tired" expression, the eyebrows are depressed, causing the upper eyelid to be depressed and the upper and lower lips to be closed. In the process of identification, it may be greatly affected by geometric feature points D3, D4, D5 and D9.

For the classification of "happy" expressions, most of them are classified into "interest" expressions. The expressions in this type of wrong picture are more relaxed and the shape of the mouth changes less. The two expressions belong to the neighboring emotions, the nature is similar, and the difference is not significant. In the process of identification, it may be greatly affected by geometric feature points D2, D3, D9. "happy" is rarely judged as "confused". The main reason is that the brows in both types of expressions have the characteristics of being lifted, which may be affected by the geometric feature point D5. However, there are many differences between the two and other expressions, such as the shape of the eye, the position of the corner of the mouth, and the shape of the mouth. It may be affected by the classification features D1, D2, D3. The main reason why the "happy" expression is not considered as the "tired" expression is that it is similar to "interest". In addition, the "happy" expression is similar to the "interest" expression. They are opposite to the "tired" expression and are also antagonistic in nature.

Part of the "confused" expression was judged as "interest". These expressions have the characteristics of large eyes and a slight opening of the mouth. This may be affected by the classification features D1, D7 and D8. The "confused" expression is treated as a "happy" expression. These expressions have the characteristics of a large mouth and a downward bend of the eyebrows. This may be affected by geometric feature points D1, D5, D6. There is a significant difference between "confused" and "tired" expressions. For example, for the "tired" expression, the corner of the mouth is squatting and closed, the brow is depressed, and the upper eyelid is lowered. The shape of the eye changes more obviously. In comparison, the "confused" expression is opened and the brow is raised. The difference between the two can be distinguished by the D1, D5 and D6 geometric feature points.

The "tired" expression was judged as a "confused" expression. The reason is that it is affected by the D2 and D5 geometric feature points. Although the eyebrows of the two are reversed, the values of D2 and D3 are very close due to the pull-down of the mouth of the "tired" expression. Through the analysis of the influence of features on various expressions, this method can be used as a reference for the selection of classification features in expression recognition. In future experiments, the suitable combination of geometric feature classification features can be selected based on the recog-

nition of the expression. This provides ideas for future related research. For different expressions, the combination of the two methods is adopted for identification. Its characteristics and laws were found, and the ideal recognition of expressions was realized.

5 Conclusion

First, based on the geometric features of the image, the commonly used linear kernel functions, polynomial kernel functions and radial kernel functions are discussed. Through the experimental method, the problems of kernel function selection and parameter optimization in SVM are further discussed. Then, the proposed geometric characteristics and SVM classification methods are introduced in detail. The results of the identification were analyzed, which provided ideas for future related research. Finally, the SVM is used to construct the expression recognition classifier, and the face expression automatic recognition model is used. The automatic classification of facial expressions was realized, and the experimental results were analyzed and compared. The proposed emotion recognition method can be applied to intelligent teaching, and a good recognition rate is obtained for some facial expressions in the four expression data sets. The validity of the method was verified. The method of facial expression recognition in intelligent teaching is studied. Facial expression recognition is applied to intelligent teaching. Emotional problems in traditional intelligent teaching are studied. At present, emotional teaching is applied in situations where the background is not too complicated and the face posture is fixed (i.e., frontal face). In view of this, an improved active shape model method is proposed to extract facial feature points. The expression classifier is built using a support vector machine. In this process, the SVM method is used to effectively realize the automatic recognition of facial expressions based on the geometric characteristics of facial feature points.

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The Use of Tangible User Interface in Interactive System to Learn about Countries

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Abstract—Tangible User Interface (TUI) is an interface that allows user to interact with digital information through physical environment. We have developed an interactive system serves the educational field within the geographical domain. The system allows children to discover and learn about countries from different continents using tangible objects. In our project we selected so far six countries that represent six continents in the world. The selected countries are: Saudi Arabia, Egypt, United States of America, France, Brazil, and Australia. With the system, children are required to manipulate tangible objects. Their task is to select a landmark from a country and placing it on the table top. The system will recognize the object and provides users with feedback. The system involves the recognition of six elements for each country: (capital, flag, climate, currency, population and industries). This application has been evaluated in a field study with children 9–11 years of age. The initial results are promising and show that such an interactive system can support interaction and collaboration among young children, as well as enriches the learning process and makes it more enjoyable.

Keywords—Tangible User Interface (TUI), Learning, Education, Geographic, Countries, edutainment, collaboration, Fun.

1 Introduction

New interactive systems such as mobile device, tablet, games and simulations, Tangible User Interface (TUI) have spread dramatically in the educational field. These systems allow interaction between user and digital information through physical objects. Using these systems for learning purpose can create an interactive environment that support edutainment for both students and teachers. Specifically, TUI support collaborative activities and promoted social learning process [4]. We propose in this paper to increase another technology to this range of products: Discover Countries interactive system (Figure 1).

We decided to use TUI concept that that allows users to interact with digital information through physical environment [8]. The proposed system are mainly based on reacTIVision platform which is a computer vision framework for the fast tracking of fiducial markers attached onto physical objects [9]. The system detects objects

equipped with fiducial markers when they are placed on the table. Each object has a unique fiducial marker that allows the system to retrieve and display the data for each object. The system has six different objects represents the land mark for each country. Kaaba for Kingdom of Saudi Arabia, Amazon Theater for Brazil, Pyramid for Egypt, Opera house for Australia, Eiffel tower for France, and Statue of Liberty for United State for America (Figure 2). By placing an object on the table, basic information of the country will display on the computer screen with oral and visual feedback. Basic information include: climate, industries, population, flag, capital and currency).

Fig. 1. Discover Countries interactive system. Using Statue of Liberty object to display information about USA

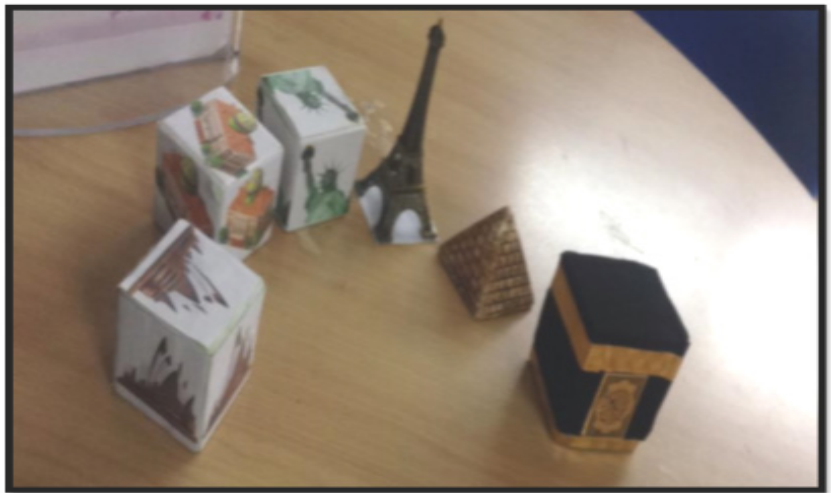


Fig. 2. The six objects (land marks) of the system

In recent years there has been an increasing development of interactive technology that promotes learning and play [13,14,7,6,18,1,10,2,11]. Discover Countries interactive system used in a school class with children to learn and recognize different countries and landmark from different continents. An empirical experiment was performed with 50 children to evaluate the affect of TUIs in children's learning environment. In this paper, we plan to propose design and architecture for the interactive table, as w. In addition, we will share the results of the experiment.

1.1 Learning with tangible technology

TUI attempt to take everyday objects and invest them with computation instead of sitting in front of a screen using a keyboard and a mouse to point and click on digital data.[5] shows that children are more productive when they cooperate with peers in a group of children and more able to do tasks in efficiently way. [12] Illustrates that learning with TUI supports conceptual metaphors and enhance learning for mathematics in young children. Scientists [3] suggest that TUI is a good solution for providing innovative ways for children to play and learn, through novel forms of interacting and discovering. Antle, propose a Tangible Learning Design Framework [15] argues that TUIs present unique opportunities to support learning interactions by reducing cognitive load and mappings between physical and digital objects.

Many studies [15,20,17,16] provides evidence of TUI benefits in learning with children in different domains, such as color, mathematics, chemistry, numbers, shapes, programming language and much more. However, little empirical work exists that provides evidence for enhanced learning geographic domain, especially in learning about countries, continents, and their famous landmark. Discover Counties interactive system develop to enrich the learning process and makes it more enjoyable within the geographical domain. It design by providing the users an over control of the system in a digital space, while matching between the real world and the digital one.

2 The Tabletop as Learning Interface

Discover Countries interactive system is a table-top, tangible user interface with which to interact with physical objects and present information. We are developing a system that includes software that enables users to transform tabletop physical objects into interactive tokens. Our setup is adopted from [2] which consist of a transparent box that has useful tabletop surface, webcam, and everyday objects that are tagged with fiducial markers. The fiducial markers attached at the bottom of the objects can be recognize by a webcam, and manipulating the objects creates and alters information and feedback that are displayed on screen.

2.1 How does it work?

The bottom of each landmark is attached with a fiducial marker specially designed to be identified by the reacTIVision platform [9]. The web camera placed below the table captures the image of the fiducial markers in real time. The reacTIVision recognizes the ID of each identified marker while this information is interpreted by the TUIO protocol. TUIO protocol is adopted for encoding the state of tangible objects from our interactive tabletop, and then transfer it into our system's software. The system software developed by Processing 1programming sketchbook (Figure 3).

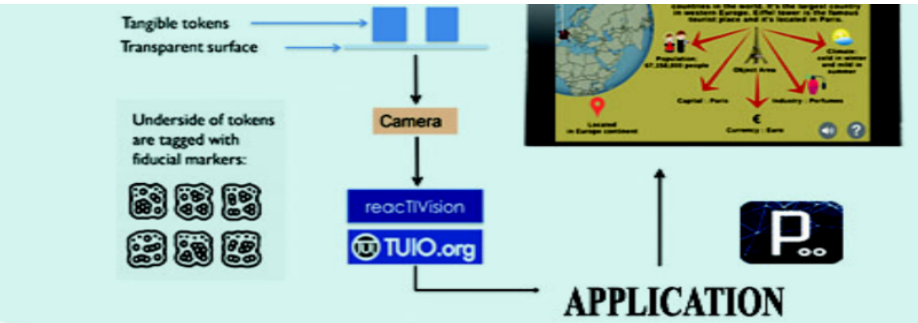


Fig. 3. A schema clarify how does the system work

3 Experimental Design and Evaluation

We conducted a user study in a private school located at Jeddah, Saudi Arabia. 50 students participated in the testing process. The students are in the age group of 9-11 (all are girls). The students are vary between third, fourth and fifth grades.

The prime goal of this study is to comprehend that using TUI improve children learning. In particular we are interested in:

- Does Discover Countries interactive system enhance children collaboration?
- Does Discover Countries interactive system support playfulness while learning?
- Students achievements "grades" after using the system
- The time taken to answer the questions?

3.1 Experiment procedure

Sessions took place in children classroom, while noise levels and distraction were on control. There were five children per each session. Sessions lasted between twelve and twenty minutes. It was then explained in general terms that the goal of the study was to find out what help children learn about countries. At first, all groups asked to answer questions about some countries information such as: capital, flag, currency,

[1] Processing (2014) Processing Software and Language. Available at: https://processing.org/

weather, and landmark. We called this session DegreePre. Students answer the questions using paper and pencils. After that, each group asked to play with the system.

The researchers sit the landmark objects on a table and asked the students to place the landmark on the interactive system table. While the land mark on top of our system's table, the information of the country is displayed on the laptop's screen, see Figure 4 . Each group should try all the six land marks.

Fig. 4. On the right placing pyramid object on the table. On the left information about Egypt is displayed on the screen.

Later than, all groups were asked to answer questions about some countries information such as: capital, flag, currency, weather, and landmark. It was different questions than the one in the Degree Pre-session. We called this session Degree Post.

3.2 Test hypotheses

The 'null hypothesis' might be:

- **H0**: There is no difference in mean pre- and post-grades

An alternative hypothesis' might be:

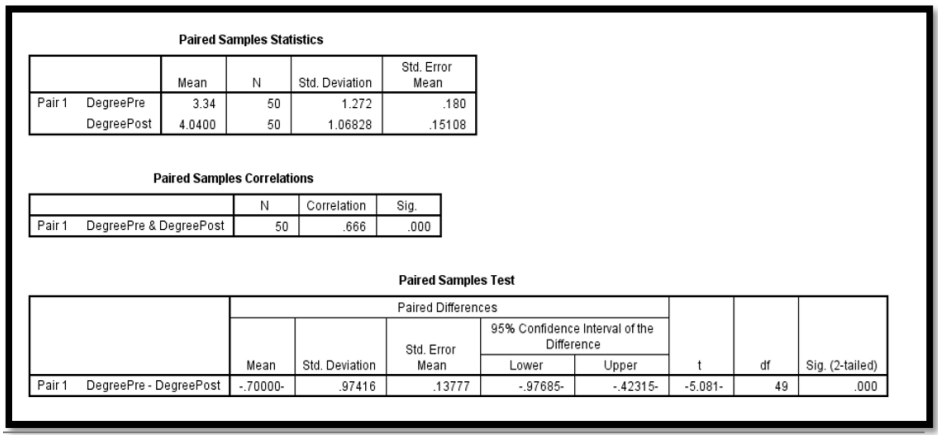
- **H1**: There is a difference in mean pre- and post-marks. See Figure 5

The relevant results for the paired t-test:
We observe the t statistic, t = -5.081, and p = 0.00.
The null hypothesis is rejected, since p < 0.05 (in fact p = 0.00).

Linear Regression Analysis The regression analyses for the post degree as independent factor, with time, collaboration and age as dependent factors. See Figure 6

There are two dependent factors that affect the degree "grade", which are collaboration and age. The collaboration t = 2.134, and p = 0.038, and age t = 6.288, and p = 0.000. The null hypothesis is rejected, since p < 0.05 (in fact collaboration p = 0.038 and age p=.000).

In addition, after the students finished using our TUI system we asked them to fill the evaluation form. The purpose of the evaluation form is to test the usability factors of the interactive system as well as to ensure that the system is error free. See Table 1.



Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	DegreePre	3.34	50	1.272	.180
	DegreePost	4.0400	50	1.06828	.15108

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	DegreePre & DegreePost	50	.666	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	DegreePre - DegreePost	-.70000-	.97416	.13777	-.97685-	-.42315-	-5.081-	49	.000

Fig. 5. Paired T-Test

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-7.055	1.895		-3.722	.001
	TimePost	.210	.211	.125	.997	.324
	CollaborationPost	.492	.231	.213	2.134	.038
	Age	.927	.147	.784	6.288	.000

a. Dependent Variable: DegreePost

Fig. 6. Linear regression

Table 1. The evaluation and assessment form of Discover Countries Interactive System

Question	Answer	Total	Average
Does the overall system is attractive?	Yes	50	100%
	No	0	0%
	Somehow	0	0%
Does the system have a good balance of text?	Yes	45	90%
	No	0	0%
	Somehow	5	10%
The information is easy to read?	Yes	43	86%
	No	2	4%
	Somehow	5	10%
Do you like to use again?	Yes	42	84%
	No	2	4%
	Somehow	6	12%
Do you like the system?	Yes	47	94%
	No	0	0%
	Somehow	3	6%
Does the colors used in the system are attractive?	Yes	47	94%
	No	0	0%
	Somehow	3	6%

The results show high acceptance of the system from the students with good percentage of usability factors.

4 Conclusion

Many researchers have suggested that tangible user interface (TUI) have significant impacts on learning. It promotes collaboration, exploratory and expressive activities, offer learning of abstract concepts through concrete representations and allow embodied interaction. However, little empirical work exists that provides evidence for enhanced learning in geographic domain, specifically for learning about countries and its basic information by young children (9-11 years). Our study has shown that children can identify more county using landmark objects. At the same time, children were able to clarify country's flag, capital, and currency more easily using Discover Country interactive system than using a book. We can say that using TUI with children improve their learning about different countries. As well as, it improves their collaboration and raises their motivation to learn more about countries.

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Facebook as a Platform of Social Interactions for Meaningful Learning

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Abstract—Undeniably, Facebook has become a significant part of students' life in the 21st century. Therefore, interactions between instructors and students play a major role in learning through an online social learning environment like Facebook. Such an interaction is known as the key elements that can measure students' learning process, particularly in an online learning environment. Past researchers have agreed that a social networking site does not only promote social interaction but also have high potential to be used for teaching and learning purposes. However, interactions that occur in social networking sites are meaningless due to lack of proper guidance. Lack of proper guidance will lead to no or little intellectual growth among students because the students might be very likely to discuss unrelated topics. Therefore, the goal of this study is to discuss the social interactions that exist in Facebook and its potential as a platform to enhance meaningful learning among students.

Keywords—Facebook, social interactions, meaningful learning, online social learning environment.

1 Introduction

The social networking sites exist concurrent with the inclination of university students towards learning in an online environment. Social networking sites (SNS) such as Facebook has proven to be attractive to students in high school, college, and university because the platform brings orientation towards self-presentation, the viewing of other's personal information, and multiple means of communication [1]. Facebook is a social networking site that has grown rapidly in popularity in recent years and is often conceived as a space for exchanging thoughts and opinion among students. As one of the member-based internet communities, Facebook allows users to communicate with each other in innovative ways, such as by sending public or private online messages or by sharing photos online [2]. Recently, Facebook has been widely used for educational purpose.

Facebook is the most popular social networking tool among university students, with the users' age ranging between 17 and 61 years [3]. In one study conducted among students [4], it was found that all of them have a Facebook account thus

indicating that Facebook is the students' most preferred account. The services offered by Facebook are free of charge and the users can connect with each other within their network at no cost. Also, most social networking sites including Facebook provide multiple services, such as instant messaging, blogging, photo-sharing, emailing, and chatting services. All of these services allow students to interact easily with each other. Using Facebook for educational purpose has also brought a number of benefits. As indicated by Selwyn [1], peer interactions can enhance the experience of informal learning. Students can also instantly obtain new information about their academic contents from other students or teachers. Furthermore, Facebook can be one of the teaching methodologies that can be used by instructors to boost the teaching and learning process [5].

According to Santos et al. [6], social networking sites have the potential to support a teaching-and-learning session because they complement the activities in traditional and online classrooms. Another study [7] has shown that students can benefit from a social network site in various ways, such as by integrating it with class activities or by sharing information about the activities they are engaged in. In one study the participants were found to be able to contribute to discussions on Facebook by using fewer clicks compared to when they were using a virtual learning environment (VLE) [8]. A social networking site such as Facebook was also found to be able to promote informal dialogues and knowledge sharing among students [6]. According to [9], social networking tools have the potential to support innovative pedagogical practices and various styles of learning. For instance, the Facebook site has become a platform for students and teachers to be connected. This connection allows them to communicate and share their thoughts, emotions, facts, and opinions without feeling hesitant and shy towards others because the communications take place virtually. This tool is an alternative to students who cannot attend their class physically and regularly due to time and space constraints. [10].

In a social learning environment like Facebook, interaction plays a key element that can measure a student's learning process. A learning process can occur interchangeably from both outside and inside of a classroom with the participation of members in a learning environment through Facebook [10]. Although Facebook allows interactions between members in a learning environment, , the conversations that take place can be ineffective because students may prone to discuss unrelated topics, particularly without the guidance from instructors or skillful peers. One study [11] found that less monitoring from mentor had garnered minimum number of replies and comments from participants. To excite further discussion, instructors need to design an interaction and understand their role in the discussion [12], An instructor acts as a cheerleader who encourages his or her students to delve into the materials given. The instructor cum administrator of a Facebook group therefore needs a post that clarifies the discussion because lack of intonation may lead to misunderstanding and arguments among students [8].

Clear and good interaction among members is vital in learning through a Facebook group. An interaction that occurs systematically may lead to meaningful learning, and meaningful learning is needed to enhance students' academic performance and

achievements. Therefore, this study intends to discuss the educational potential of Facebook as a platform of social interaction for meaningful learning.

2 Literature Review

2.1 Meaningful learning

As stated by Novak [13], useful knowledge and constructions of new knowledge are essentials in meaningful learning. He stated that meaningful learning is the basis to human constructivism. The combination of meaningful contents, course instructors, and peers are significant in fostering meaning learning experience in students' interaction [14].

The main challenge faced by instructors is how to construct an online discussion that contributes to meaningful learning. One study [15] proposed three guidelines that can enhance meaningful learning in online discussion, which are:

- Facilitator's guidelines
- Evaluation rubrics
- Posting of protocol items

Facilitator's guideline can expand a discussion thread in an online discussion. An evaluation rubric is an item that contributes to the weight of examination grade and was proven to be an effective means that can encourage students to discuss and elaborate a particular content. Posting protocols items, however, should not restrict the length of students' posts in a discussion.

2.2 Social interactions

Social interactions include all styles of social relations including

- Visiting
- Doing activities together
- Having a communications whether on phone, face to face, online, email, Short Message Service (SMS), or fax [16].

Finding from the same study [16] also revealed the evolvement of information communication technology (ICT) towards engaging social relations among people in various distances. Social networking sites (SNS) such as Facebook is one of the new forms of ICT. One study revealed that social interaction that occurs in a social networking environment might bring strong student engagement; students would give response to their friends' works, share various resources, post questions, and discuss particular topics [17]. The study also stated that a social networking environment is a place where students develop and form social connections in an online group discussion, including a forum.

In conclusion, the social networking environment including that of Facebook can be beneficial to students. Facebook is a place where interactions occur without any restrictions. Members of Facebook can interact freely. The huge number of Facebook usage among university students has prompted many researches to study the integration of Facebook for academic purposes. The following section will discuss further the use of Facebook for academic purpose.

2.3 Facebook for academic purposes

Using Facebook for academic purpose, whether formally or informally, may lead to positive affect to students. Interactions that occur among students and instructors can provide opportunities for students to increase their knowledge. An academic discussion through Facebook can prompt field instructors or lecturers to understand the interest of their students hence provide opportunity for them to demonstrate their intellect [2]. Another scholar [5] found that Facebook had brought positive effect in regard to fulfilling educational purposes. Additional interactions that occur in Facebook particularly through discussion indicates that students get better engagement and understanding about the content of their course materials compared to those who participated less in a Facebook discussion [18]. Another study revealed that most of the students used Facebook to transfer knowledge [19]. As shown in Table 1, majority of the students (60.4%) used the social media to share knowledge. Only 2% of the students were not using the social media for knowledge transfer.

Table 1. Knowledge Transfer through Facebook

Knowledge Transfer	Percentage (%)
Always	60.4
Usually	18.3
Often	17.8
Occasionally	1.5
Seldom	2

Source: Suebsom (2015).

As concluded by a previous researcher [10], this kind of technology tends to reach learners extensively. Students who are not active in class due to shyness or other reasons can participate actively in this space. In another study, it was found that integrating education into Facebook might disturb a student's learning process yet they would be alert about their assignment when their friends post about the matter in a discussion space such as a Facebook group [8]. The same study found that most of the students agreed that a Facebook group is suitable for revision purposes because the discussion in the group can match all learning styles. Accordingly, the study presented the following three guidelines on using Facebook for educational purpose:

- A policy is needed to prevent misuse of a Facebook group
- Consistency in which few groups is needed or needs to be created for all courses offered by an institution
- Staffs or instructors need to be consistently involved in a Facebook group

A policy created in a Facebook group may confine students to discussing only related topics. However, the protocol created should not limit the length of students' posting because such a limitation will give a negative impact to the discussion [15]. Furthermore, institutions need to create multiple Facebook groups in order to make a Facebook group discussion as one of their learning tools. The consistent involvement of staff members such as instructors and lecturers in a Facebook group may also increase students' interactions in the learning platform.

To increase the effectiveness of using a Facebook group for educational purpose, two interactions are considered as crucial factors: student-student interaction and student-instructor interaction. Building interactions are essentials in an online learning environment [20]. There are three key of interaction in an online learning environment [20; 21]:

- Student-student interaction
- Student-instructor interaction
- Student-content interaction

Student-student interaction or peer interactions is an interaction that occurs among students. This is one of the key factors to successful online learning. As reported in one study [20], a high-level interaction among students contributed to interactive, meaningful discussion, large number of participation, and longer responses. Communication between students allowed them to share learning experiences [21]. In terms of effect to individual, such interaction can form students' perception that they are part of a community thus helping them to increase their understanding on particular topic [22]. According to [21], interactions between students can create social presences, which in turn, support and maintain their cognitive development. Another study [23] found five elements that can create interactions among students, which are

- Introductions
- Collaborative group project
- Sharing of personal experiences
- Class discussions
- Exchange of resources

In addition, one study [24] concluded that to encourage students to interact with each other requires elements such as the sharing of learning experiences, a sense of community, and teamwork building. Facebook offers some of these features that can contribute to the interaction; for example, users will receive notifications when their friends interact or post on the site [25].

Student-instructor interaction is a communication that occurs between students and instructors. Social interaction between students and instructors exist when an instructor applies strategies to build interpersonal encouragement [26]. One study reported a strong relationship between the level of student-instructor interaction and the level of student's satisfaction with their courses and level of learning [20]. This kind of interaction is crucial in an online learning because it can predict a student's

level of achievement in his or her learning [27]. Another study revealed that students used Facebook continuously because by using the site, they can discuss, communicate, and interact with peers easily [28]. The benefits of interaction on Facebook to students have been summarized as follows [10]:

- Allowing informal learning in informal communication
- Encouraging collaboration
- Encouraging response or feedback on thoughts
- Collaboration that can occur not in a specific space and time

As to the instructors, they can benefit from the following:

- Getting response or feedback from students
- Continuous communication with students
- Creating instructional strategies for their customers effectively

This interaction occurs between learners generally and the content in the learning space. According to [23], an appropriate design of content can increase a sense of community in an online learning space.

The user-friendliness of an interface can:

- Enhance the motivation for students to learn
- Assist good interaction between students and instructors

2.4 Instructors' responsibility on Facebook

Besides maintaining a fun, honest, and clear interaction, instructors need to use various learning strategies that are appropriate to their students [10]. One of the instructor's roles is to make the interactions smooth and give necessary guidance to students [28].To initiate students' interaction on Facebook, an instructor can post a topic for the students to discuss, or he or she can insert a video as in icebreaker along with study questions [30]. Sher's [24] study recommends that an instructor supports his or her students to participate actively by:

- Giving feedback to students
- Serving them as individuals

In another study, Sarapin & Morris [31] found that instructors who communicated socially on Facebook managed to increase their students' academic performance and satisfaction. Facebook promotes a two-way communication, in which an instructor can give feedback to students, and in turn, encourages students to maintain their participation in a Facebook group [28].

Instructors are responsible to make students interact with each other to yield meaningful learning experience [14]. One study revealed that an instructor can give expectations about class materials, student projects, and assignments, which enables knowledge to be shared beyond physical classroom [29]. Instructors should stress on interactions that occur in a Facebook discussion. There is a need for applications of

guidelines that can initiate and expand students' interactions towards meaningful learning. Therefore, beside applications policy and full use of Facebook, interaction plays an important role in meaningful learning.

3 Conclusion

Interactions among students and students-instructors are vital towards meaningful learning. Interaction that occurs without any guideline or purpose may lead to little intellectual growth among students. As described, many studies have designed interaction as an effort to engage students and enhance their learning through Facebook. As the main motivators in engaging students, instructors need to understand their role and design appropriate interactions in Facebook group towards meaningful learning.

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Multimedia based Teaching Platform for English Listening in Universities

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Abstract—This paper aims to optimize the application of multimedia technologies in the teaching of English listening. For this purpose, the author carried out a comprehensive analysis on the theoretical bases, principles and design of multimedia-based English teaching, and designed a multimedia-based teaching platform for English listening in universities. Specifically, a questionnaire survey was conducted to qualitatively measure the demand of listening teaching, clarify the current situation of the teaching of English listening, and improve the acceptance of multimedia-based technology. Moreover, the effect of the proposed platform was verified through a teaching experiment. The research findings shed new light on the understanding and application of multimedia-based teaching of English listening.

Keywords—Multimedia technology, English listening, Questionnaire survey, parallel classes

1 Introduction

To enhance the overall English proficiency, English learners must improve their linguistic abilities in listening, speaking, reading, writing and translation. The existing studies have shown that the five abilities are ranked as listening (45%), speaking (30%), reading (16%), writing (9%) and translation (9%) in terms of importance [1]. It is clear that listening is the most important aspect of English learning. As a result, the English teaching effect in universities depends directly on the listening ability of the students.

The rapid development of the Internet and computer software has initiated a new trend in English education: the integration of information technology. With the aid of multimedia and software, university English teachers are competing to reform their ideas, methods and contents of listening teaching.

In 2000, foreign scholars investigated the acquisition of English listening ability in a computer-based multimedia environment (CBME), revealing that the learners can make a rapid progress because the multimedia supports the fast and effective information dissemination and input, scientific guidance and timely monitoring and feedback [2].

Recent years has seen Chinese scholars making in-depth explorations into multimedia-aided teaching of English listening [3]. Some pointed out the poor effect of the traditional three-step teaching method, which involves: playing an audio clip, checking the answers and replaying the clip; some combined audio and video resources into an easy-to-recall teaching method; some also advocated the integrated audiovisual approach based on the psychological finding that students obtain 15% of knowledge from hearing and 25% from vision [4].

Overall, fruitful results have been achieved in multimedia-based technology and listening teaching in China. However, there are few reports on the application of multimedia technologies in the teaching of English listening [5].

To make up for the gap, this paper carries out a comprehensive analysis on the theoretical bases, principles and design of multimedia-based English teaching, and designs a multimedia-based teaching platform for English listening in universities. Specifically, a questionnaire survey was conducted to qualitatively measure the demand of listening teaching, clarify the current situation of the teaching of English listening, and improve the acceptance of multimedia-based technology. Moreover, the effect of the proposed platform was verified through a teaching experiment. The research findings shed new light on the understanding and application of multimedia-based teaching of English listening (MBTEL).

2 Theoretical Bases of MBTEL

2.1 Theoretical bases of MBTEL

Constructivism: The MBTEL reflects the constructivist understanding of learning environment. In constructivism, the learning process is viewed as the construction of knowledge. The new knowledge is not transferred directly from teachers to students, but acquired by the students under the assistance of teachers or computer technologies.

Constructivism puts students at the center of learning, treating them as the subject of cognition and constructor of meaning, and attributes learning to the psychological interaction between the cognitive subject and the external environment. The new knowledge is assimilated to the subject of cognition in three steps: balance, imbalance and new balance. The role of the learning environment in knowledge construction is also highlighted in constructivism [6].

Krashen's theory of second language acquisition: On second language learning, Krashen put forward the “input hypothesis”, calling teachers to provide students with enough inputs and a relaxed learning environment. Besides, Krashen regarded proper linguistic input and moderate emotional filtering as the keys to language learning.

Based on the input hypothesis, the MBTEL offers students a multimedia platform of images, audios, animations and texts, which arouses students’ interest in learning and enhances the efficiency of listening teaching [7].

2.2 Principles and design of MBTEL

Principles: The application of multimedia technology in English teaching should abide by the learner-centered principle, the optimality principle, and the interactive principle.

Learner-centered principle: The students should be placed at the center of the learning process through autonomous planning, organization and evaluation, while teachers and teaching-assisting tools should play instructive and assistive roles only [8].

Optimality principle: Multimedia-based teaching involves a wide range of teaching styles. To optimize the teaching effect, the specific means of presentation, structural arrangement, role collocation and teaching method should be selected in light of the demand of the materials.

Interactive principle: In multimedia-based teaching, teachers and students are treated as equal beings. The traditional teacher-centered mode should be replaced with the student-oriented mode, allowing students to interact with each other freely and communicate with teachers about the common problems [9].

Design: In spite of their popularity in university, most of the existing MBTEL platforms are simply a group of slides or webpages on the contents of textbooks. The teaching effect is undoubtedly poor [10]. This calls for a systematic, scientific method to analyze, organize and coordinate the various elements of the teaching system, before integrating them into an optimal teaching plan. Below are two multimedia-based teaching cases designed by the authors.

Fig. 1. Introduction to world famous universities

Figure 1 shows the design of a slide show about world famous universities. The slide show presents a number of videos made from various images and audios. The information on top universities is only a click away. The students can watch, listen and read the introduction to these universities along with the videos.

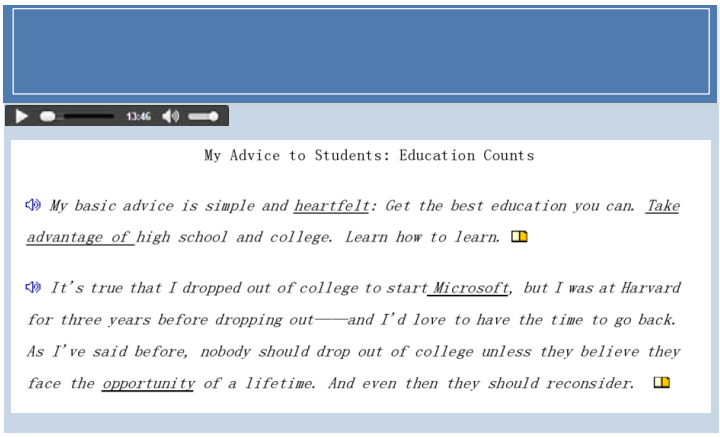

Fig. 2. Listening to Bill Gates' speech excerpt

Figure 2 presents the excerpt of a speech by Bill Gate used in listening class. Once the teacher clicks the play button, the audio of the speech excerpt will be played, while the script will be displayed with notes on the key words. In this way, the students can grasp the meaning of the speech accurately through listening practice.

The design of the MBTEL must also cater to the teaching demand and the students' individual needs.

3 Demand Analysis of MBTEL

In this information era, the MBTEL is critical to the style, quality and environment of English teaching [11].

3.1 Questionnaire design

Our questionnaire survey aims to identify the university students' attitude towards the MBTEL, the effect of multimedia application on classroom teaching, and the disadvantages of the existing MBTEL platforms [12].

A total of 320 questionnaires were issued to Grade 1 to Grade 4 students with varied English proficiency in a Chinese university and 318 valid copies were returned.

3.2 Statistics and analysis

Table 1. Students' awareness of multimedia-based teaching

Degree of awareness	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
Number of answers	0	18	94	179	27
Percentage	0%	5.7%	29.5%	56.2%	8.5%

Table 1 shows that the students had a poor awareness of multimedia-based teaching, with only 5.7% of them had heard about this teaching mode. This reflects the relatively low cognition and limited application of multimedia in university teaching across China.

Table 2. Students' recognition of multimedia-based teaching

Degree of recognition	Totally agree	Agree	Not sure	Disagree	Strongly disagree
Number of answers	79	198	32	4	5
Percentage	24.8%	62.3%	10.1%	1.3%	1.6%

As shown in Table 2, the students held different opinions on multimedia-based teaching. Of course, most of students (87.1%) agreed that this teaching mode is conducive to English listening.

Table 3. Students' attitude towards traditional listening teaching methods

Degree of dissatisfaction	Totally agree	Agree	Not sure	Disagree	strongly disagree
Number of answers	32	27	35	123	98
Percentage	10.1%	8.5%	11.0%	39.6%	30.8%

It can be seen from Table 3 that most students wanted to preserve the traditional teaching mode for English listening, for fear of reduced student-teacher communication (e.g. teachers' evaluation and students' feedbacks) in multimedia-based teaching [13].

Hence, university teachers must realize scientific design of the contents and make rational time allocation between human-computer interaction and teacher-student communication. In addition, images, videos and other multimedia resources should be utilized fully to increase the interest of students and boost teachers' participation [14].

Table 4 lists the reasons of the students said about their poor listening ability.

Table 4. Reasons for poor listening ability

	Totally agree	Agree	Not sure	Disagree	strongly disagree
Lack of training	31	85	56	79	67
Percentage	9.8%	26.7%	17.6%	24.8%	21.1%
Improper teaching methods	56	85	79	67	31
Percentage	17.6%	26.7%	24.8%	21.1%	9.8%
Backward materials	79	85	61	57	36
Percentage	24.8%	26.7%	19.2%	17.9%	11.3%
Poor linguistic environment	79	85	69	54	31
Percentage	24.8%	26.7%	21.7%	17%	9.8%

It is learned from Table 4 that most students attributed their poor listening ability to the out-of-date listening materials and the poor linguistic environment. Therefore, the teachers should, on the one hand, update and diversify the listening materials timely to arouse the students' interest, and, on the other hand, create more opportunities for the students to practice oral English in class, thus indirectly improve their listening ability.

4 Experimental Verification of the MBTEL

4.1 Experimental design

Two parallel classes in the English department of a Chinese university were selected for a semester-long teaching experiment to verify the effect of the proposed MBTEL. The two classes sit a test before the experiment and another at the end of the experiment. One class was treated as the test class and the other as the control class.

Goals: The experiment aims to quantitatively evaluate the impact of the MBTEL on English listening and determine the optimal teaching style through the analysis of the test results.

Test materials:

- **Test material 1:** Fifty English listening questions were selected randomly from the latest CET-4 test, covering such parts as statement dictation, statement comprehension, conversation comprehension, passage comprehension and spot dictation. Each part contains 10 questions. Every question is an objective multiple-choice question with 2 points, putting the full mark at 100 points. The test lasted for 30min.
- **Test material 2:** Several questions were designed by the teachers according to a video clip from Family Album, U.S.A. The full mark is 100 points.

Experimental process: The experiment lasted 16 weeks. In each week, the two classes attended listening class separately for 1h. The 35 students of the test class received multimedia-based listening practice every two weeks, while the 33 students of the control class received 2h-long listening teaching in traditional mode every two weeks.

4.2 Result analysis

Results analysis of test material 1. As shown in Tables 5 and 6, the test group and the control group had almost equal mean score before the experiment. After the experiment, the test group achieved a 6.9% increase in the mean score, greater than the 3.5% than the control group. This means the multimedia-based technology has a greater positive impact on listening ability than the traditional teaching mode.

Table 5. Test results on test material 1

Class	Pre-experiment	Post-experiment	Improvement (%)
	Mean score	*Mean score*	
Test class	62.5	66.8	6.9
Control class	62.4	64.6	3.5

Table 6. Test results on test material 1 (by part)

Class	Part	Points	Pre-experiment score	Post-experiment score
Test class	Statement dictation	20	11.4	12.0
	Statement comprehension	20	13.8	14.9
	Conversation comprehension	20	12.3	13.3
	Passage comprehension	20	11.1	12.3
	Spot dictation	20	11.1	12.3
	Total score	100	62.5	66.8
Control class	Statement dictation	20	11.5	11.7
	Statement comprehension	20	13.6	14.4
	Conversation comprehension	20	12.2	12.5
	Passage comprehension	20	11.1	11.6
	Spot dictation	20	14	14.3
	Total score	100	62.4	64.6

Results analysis of test material 2. As shown in Table 7, the two classes had only a slight difference in mean score before the experiment. The difference was amplified through the experiment. In the post-experiment test, the mean score of the test class increased by 9.2%, compared with the 5.8% of the control class. Thus, multimedia-based teaching is more beneficial to listening learning than the traditional mode.

In addition, there was no significant difference between the two classes in the score of each part in Table 6, but a major gap between them in video listening score in Table 7. These phenomena could be explained by the lack of content diversity in test material 1, which limited the effect of the multimedia teaching environment. In other words, the choice of listening material is the key to the success of the MBTEL.

Table 7. Test results on test material 2

	Number	Pre-experiment	Post-experiment	Percentage increase
Test group	35	68.8	72.8	5.8
Control group	33	70.5	77.1	9.2

5 Conclusion

The MBTEL is neither widely applied in Chinese universities nor extensively applied by education scholars. To solve the problems, this paper carries out a comprehensive analysis on the theoretical bases, principles and design of multimedia-based English teaching, and designs an MBTEL for English listening in universities. Moreover, the effect of the proposed platform was verified through a teaching experiment. The following conclusions were derived from the research:

- The pre- and post-experiment test results indicate that the proposed MBTEL outshines the traditional teaching mode of English listening.
- The choice of listening material is the key to the success of the MBTEL.

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Reading Preferences of ESL Students: Electronic Texts vs. Printed

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Abstract—The present study investigated the reading preferences of international students regarding their choices between electronic texts (e-texts) and printed texts (p-texts). The study also explored the influence of reading e-texts and p-texts on comprehending their contents, as well as the purpose of students using these electronic devices (e-devices). The data were collected using a questionnaire completed by non-native English speakers (36 males, 24 females) at a southwestern university in the United States. The findings indicated that the students preferred using p-texts over e-texts. Among these students, there was no gender difference in terms of reading preferences. Moreover, the results indicated a statistically significant difference between males and females regarding understanding the content in the printed format. The females understood the content better than the males when they read p-text. The findings also revealed that students preferred using electronic devices for personal uses rather than academic uses. Such personal uses were web browsing, listening to or watching media, and reading and writing emails. The study suggested several pedagogical implications for students and e-book developers and designers.

Keywords—Electronic text, printed text, second language reading, electronic devices

1 Introduction

Online reading has become widely used among college students. [2] define online reading as a "moment-by-moment processing of text during reading" (p. 70). New devices and integrated tools have played a significant role in improving the choices offered for reading in English. As these devices are available everywhere and can be bought from stores, the continued evolution of electronic texts is now challenging the availability of the printed ones. The differences between electronic texts (e-texts) and printed texts (p-texts) depend on their features and the people who use them. Some people prefer using p-texts for certain reasons, while others have their own opinions when it comes to reading e-texts. A p-text is an actual paper text that people borrow or purchase from traditional libraries and bookstores. On the other hand, an e-text is "an electronic version of a textbook presented in software form" [1].

E-books have progressed through several phases and formats. These phases have started by Project Gutenberg in 1971 which established the first online library initially, then moved to Portable Document Format (PDFs), and later in 2011 Google Books website, which scans the physical books to create PDF documents and uploads them to the web. In fact, many e-books are now "born digital" [3] as they are created online, accessible only via the web, and are totally separate entities from their printed counterparts. These new formats can be read by numerous popular devices and tools, such as Kindle, tablets, computers, mobile phones, and navigation devices [4].

Interestingly, students carry their electronic devices (e-devices) (i.e., laptops, tablets, and cellphones) everywhere they go, even at a university. Students perhaps use these devices when doing their assignments and reading course materials, or to increase their reading comprehension or to download all the course materials to their devices in order to use them occasionally. Therefore, the purpose of the study was to find out whether international ESL students preferred using traditional texts (t-texts) or electronic texts (e-texts) for reading their course materials. In addition, the study explored the influence of reading e-text on the students' understanding of the content. Personal and academic uses of electronic devices were also investigated. The study intended to answer the following questions:

- What type of text format (printed or electronic) do students prefer for reading course materials?
- Is there a difference between males and females in terms of reading preferences?
- Is there a difference between males and females in terms of reading comprehension with e-texts and t-texts?
- How do students use electronic devices (i.e., tablets)?

2 Literature Review

Several research studies have explored the use of electronic texts and their effects on second language reading. These studies also attempted to find out preferences regarding the use of electronic text or printed text for reading course materials and reasons behind this preference. Surprisingly, the majority of studies revealed that a large number of readers still prefer using p-texts [5], [6], [7], [8]. Other studies investigated the problems encountered by students when they read e-texts [9], [10], [11]. However, few studies have investigated ESL students from different disciplines in terms of reading preferences, gender differences, and which text type is better for comprehending the contents of the book. Therefore, the present paper explored whether international students' preferences (both males and females) have changed after the emergence of new tools and devices.

2.1 Preferences for printed text

A number of studies have reported preferring p-texts over e-texts when it comes for academic uses. [6] Conducted a study to investigate reading preferences among un-

dergraduate students using a convenient survey. The findings revealed that students preferred reading p-texts (72%) over e-texts (7%). Students also reported that they found it easier to remember information read from p-texts (60.8%) than e-texts. That is, if students were given choices regarding the type of text, they would choose paper texts (71.7%). As a result, students tended to print out and read materials rather than read them online.

[8] Carried out a practical investigation to examine the preferences of 45 graduates and 41 undergraduates about using e-books for teaching and learning. Both groups showed positive attitudes towards the use of e-book readers and their e-book reading experiences. Surprisingly, graduate and undergraduate students preferred p-books over e-books and were still willing to use e-books and e-book readers for their studies.

[5] Surveyed 223 university students in the United States about their attitudes and preferences regarding reading from four types of books: loose-leaf, hardcover, paperback, and e-books. When the students were asked to choose their most preferred book, the students chose a printed textbook (45.2%), followed by a hardback textbook (33.3%) and the e-textbook (11.9%). The students' main reasons for their preferences were ease of using printed textbooks, price, ownership, and health concerns.

Surprising results were found by [11] who surveyed 91 undergraduate students in the Department of Psychology. The study intended to determine e-book preferences and uses among students who had previous experience of using them. The results showed that even though the participants had satisfactory experiences in using e-books and computers still preferred reading printed books rather than electronic ones. Students also reported that they would not purchase e-books, even though they were cheaper than the printed ones.

In an EFL context, [12] examined 495 college students' perceptions towards using e-books and related issues. The students were studying in different disciplines at various levels ranging from diploma to doctoral level. The results reported that students preferred printed books over e-books, at 65.98% and 17.60%, respectively. In addition, the students used books for two main purposes: general information and academics.

2.2 Preferences for electronic texts

Conversely, [13] study was one of a few that supported a preference for e-texts. One of the five investigated framework points was the substituting of printed course materials with digital ones. Three ways were used to collect data: a special program software installed on an iPad, a questionnaire, and interviews with faculty and students. The study concluded that students and faculty preferred reading digital course materials. Furthermore, the faculty members recommended that students should use tablets for reading these materials. One of the reasons for this was the fact that the special software had the *iAnnotate* tool, which made reading e-books more helpful and enjoyable.

Along the same lines, [14] investigated the use of e-books, tablet computers, and reading habits among 100 undergraduate students in Turkey. The findings revealed that the majority of the students preferred using e-texts while studying with few health

concerns because e-texts can be carried and read everywhere. The students' reading habits included reading through a tablet only, reading and taking notes either on a separate sheet, the pdf file, or the tablets.

2.3 Pros and cons of both types of text

Reading e-texts either online or on a tablet seems to be problematic. [9] carried out a study involving 20 undergraduate students by implementing a thinking-aloud strategy to investigate how the students used e-books versus printed books. The study revealed unique results. Even though students were considered highly computer literate, they did not know how to navigate and use e-texts effectively. Students reported that they got confused when they read e-texts because of the presentation. [15] also claims that the font size was an issue; some letters were too small or too big, while others were too hazy or too wide because of pixel limitations. [16] found that readers sometime felt fatigued when reading on computer screen. [9] mentions that "eye strain and fatigue from reading on a computer for a prolong time is perhaps the most common usability complaint among e-book users" (p. 519).

3 Method

3.1 Participants

The participants in the study were 60 non-native-English-speaking international students. 36 students were male and 24 were female. The students were at the beginning of their second and third semester at a midwestern university in the United States, majoring in 25 different disciplines. Their native languages were varied: Chinese (51.7%), Korean (16.7%), Arabic (15%), Spanish (6%), and other languages (10%) including Indian languages, Portuguese, and African Languages. Table 1 shows the demographic characteristics of the participants.

Table 1. The demographic characteristics of the participants

Demographic Information		Frequency	%	Total Responses
Gender	Male	36	60.0	60
	Female	24	40.0	
Class	Freshman	2	3.3	60
	Sophomore	20	33.3	
	Junior	20	33.3	
	Senior	1	1.7	
	Graduate	17	28.3	
Self-reported Reading Comprehension Ability	Moderate	12	20.7	58
	Good	28	48.3	
	Very Good	16	27.6	
	Excellent	2	3.4	

3.2 Instrument

The data for this study were collected through a questionnaire designed to determine students' preferences in using e-texts compared to p-texts. The questionnaire consisted of two sections: the first section addressed reading course materials on electronic devices (i.e., tablets, laptops, cellphones) compared with p-texts. The section also included students' opinions and purposes regarding using e-devices for reading course materials as well as external materials. The second section elicited some demographic information such as gender, age, and language proficiency.

The questionnaire (see Appendix A) was partly adapted from [13] and then was developed by the author. The questionnaire was piloted with two Ph.D. TESL students to ensure there were no mistakes or ambiguities and to improve the word choices. Then the questionnaire was administered at the end of individual *composition* class periods with the help of instructors. All responses remained anonymous and confidential.

The reliability of the questionnaire was measured by Cronbach's Alpha. In this study, the Cronbach's Alpha was not available for the whole survey. Yet, question (8) about "*How often do you use tablets for the following?"* was the only measurable item**.** The main reason for this was that no other items shared a same Likert scale result. Each item had different rating scale designed to determine specific points related to the research questions. Item (8) was also important because it represented the fourth research question; *What other uses of electronic devices (i.e., tablets) are there in nonacademic settings?* Obviously, the results showed an acceptable internal consistency (reliability) for question (8) that consisted of nine subscale items (a = .734).

3.3 Data analysis

Descriptive statistical procedures were applied by using SPSS software to analyze the obtained data. The aim was to examine the reading preferences of ESL students between e-texts and p-texts. The same procedures were applied to ascertain the extent to which the reading preferences varied by gender (males vs. females). Moreover, gender differences in terms of understanding e-texts compared to p-texts were analyzed using an independent *t*-test. Finally, the data were examined to determine the purposes of using electronic devices (i.e., tablets, laptops, cellphones) in the nonacademic environment. The results are presented in the next section.

4 Results and Discussion

The results obtained from the analysis in the study are shown and discussed in the following subsections. In general, students reported that they preferred reading course materials from p-text more than e-texts. The students also revealed that they used cellphones (47%) and iPads (38%) more frequently.

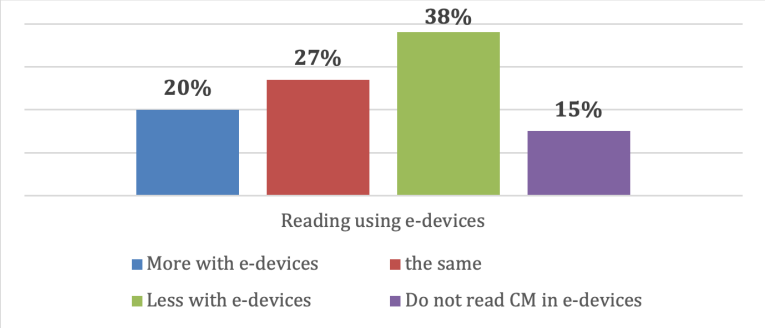

Fig. 1. Overall results of reading course materials on e-devices

4.1 Students' preferences for using e-texts over p-texts

Figure 1 shows the results of the first research question, which was designed to discover the students' preferences in using e-texts over p-texts. The results demonstrated that students who chose "more with a e-devices" most likely preferred reading their course materials through electronic devices (i.e., a tablet). In contrast, those who selected "less with e-devices" preferred using traditional books. Obviously, fewer students reported that they read course material on e-devices (i.e., e-books; 20%) compared to traditional books (38%). Other students reported that they did not read course materials on e-devices (15%). Consequently, the amount of time spent on reading electronic texts was shorter than that spent for reading traditional texts. Almost half of the students spent much more time reading traditional books (51%) than electronic books (25%). The findings revealed that students preferred reading their course materials in a p-text format instead of an e-text. These findings support the previous studies mentioned in the literature review [6], [16], [7], [17].

On the other hand, the study contradicted the work of [13]. They found that students and faculty at the Naval War College preferred reading course materials on their electronic devices (i.e., tablets, laptops, and cellphones). One possible reason for this result could be related to a special application installed on the iPad of the participants. In the study, they implemented a new application called iAnnotate, which provided different, helpful, and enjoyable features. [18], as cited in [13], stated that:

"The *iAnnotate* application on the iPad provides annotation tools not inherent on the iPad for PDF files… It allows for annotations in the form of highlighting, underlining, free-form drawing, text notes, and bookmarking. Also, file structure is added through its PDF library with folders. In addition, multiple documents can be open simultaneously utilizing tabs to switch between them. Individual documents and the full library of PDFs can be searched." (p.46)

4.2 Differences between males and females in terms of reading preferences

Tables 2 and 3 present the results of the second research question about the differences between males and females regarding reading preferences. Both male and fe-

male participants preferred reading traditional texts over the electronic ones. Statistically speaking, there was no difference between male and female participants in terms of e-text versus p-text reading preferences [$t(60) = .523$, $p<.050$] and the amount of time spent on reading on e-devices [$t(60) = .975$, $p<.050$]. The results also revealed that there was no statistical difference between male and female participants regarding reading course materials in e-texts compared to p-texts format. Even though the study agreed with a few of the previous studies, it contradicted [19] study. They discovered that female readers preferred using paper books (73.2%) more than males (51.3%). They also mentioned that females printed documents more often than males.

Table 2. Reading preferences by using e-devices based on gender

	Male	Female	Total
More with e-devices	9	3	12
The same	10	6	16
Less with e-devices	10	13	23
Do not read course materials in Tablet	7	2	9
Total	36	24	60
Mean	2.42	2.58	5

Table 3. Period of reading on e-devices based on gender

	Male	Female	Total
Longer with e-devices	8	7	15
The same	10	4	14
Shorter with e-devices	17	13	30
Total	35	24	59
Mean	2.26	2.25	4.51

4.3 Difference between males and females in terms of comprehending with e-text or t-text

Figures 2 and 3 presents the results obtained to answer the third research question about difference between males and females in terms of comprehending with e-text over t-text. The most important reasons behind preferring traditional texts over electronic texts was that students comprehended more when they read t-texts than e-texts. The results showed that 55% of students understood information read from p-text, while approximately 38% reported that they understood less when they read from t-text. On the other hand, few students (10%) reported that they understood when they read from e-text, while (52%) stated that they understood less when they read from e-text. Statistically, the t-test was applied to find out the differences between males and females. The results revealed that there was a statistical difference between male ($m=1.67$) and female ($m=1.29$) participants in terms of comprehension when reading t-text [$t(60) = .020$, $p>.050$]. In other words, females understood more than males when they read documents in a t-text format. The previous studies investigated reading comprehension in relation to reading strategies; [20] found that there was no significant difference between controlled and treatment groups in terms of reading comprehension.

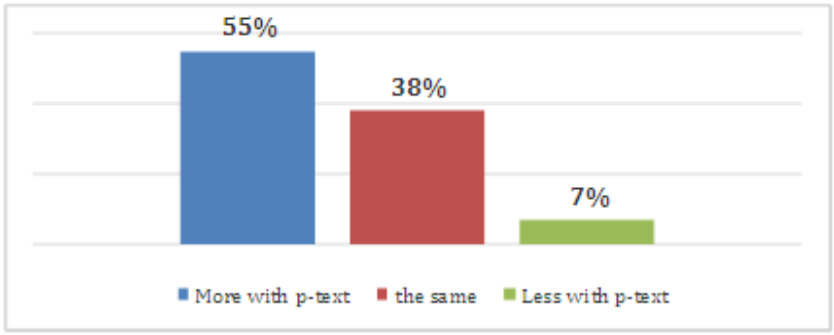

Fig. 2. Overall Results of understanding content when reading from p-text

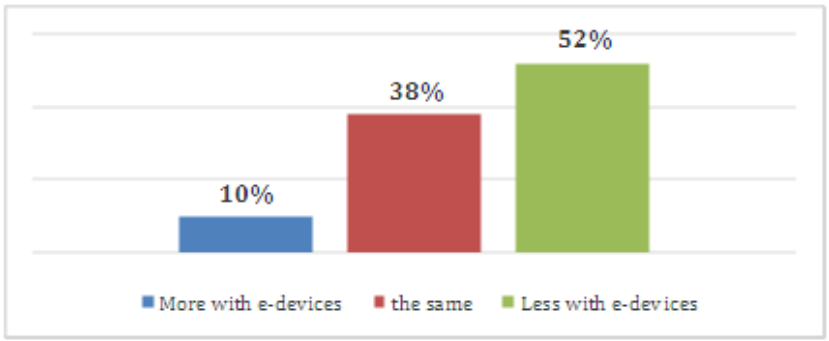

Fig. 3. Overall results of understanding content when reading on e-devices

4.4 Different uses of uses of electronic devices

Finally, Table 4 presents the answers for the last research question. Students preferred using electronic devices (i.e., tablets) to browse the Internet (m=3.43), to listen to or watch media (m=3.41), to read emails (m=3.40), and to write emails (m=3.02). As for reading course materials, the mean was 2.54 out of 4.00. With regards to personal uses of electronic devices compared to academic uses, approximately 56% of the students frequently used tablets for personal uses, compared with 13% for academic uses.

The results of the fourth research question revealed the frequent uses of electronic devices (i.e., tablets) in nonacademic settings. It was clear that students preferred using e-devices for personal reasons compared to academic ones. Such personal uses were web browsing, listening to or watching media, and reading and writing emails. These results clearly described what was mentioned earlier about reading preferences. Students preferred using p-text for reading course materials, whereas they preferred using tablets for personal reasons. Note-taking was the feature least used by students. However, [21] suggested that matrix style note-taking successfully improved college students' online learning.

Table 4. The overall results for the purposes of using e-devices

Web Browsing	Media	Reading Emails	Writing Email	News Reading	Gaming	Reading Courses Materials	Answering Assignments	Note Taking
3.43	3.41	3.40	3.02	2.90	2.67	2.54	2.37	1.93

5 Conclusion

The main purpose of the study was to investigate the reading preferences of ESL students in terms of e-text compared to p-text. In addition, the study investigated the influence of reading e-text or p-text on comprehending the contents. The purposes of using electronic devices among students were also explored. The findings indicated that students preferred using p-text over e-text. Moreover, the results indicated a significant difference between male and female participants in terms of understanding content being read in a printed format. Lastly, students preferred using electronic devices for personal uses rather than academic.

This study suggested several pedagogical implications. First, since few studies have revealed strong uses or preferences of e-text, it is likely the participants in these studies were given special tools. Therefore, application developers have to invent more helpful applications for tablets as well as computers. Second, students need to familiarize themselves with the technological revolution of electronic texts. Students also have to take advantage of the reasonable prices of e-books available in online stores. Lastly, e-book developers need to take a significant step forward in designing new e-books platforms and formats to convince readers to use e-books rather than printed books.

The present study had some limitations. It investigated the reading preferences of course materials among ESL students and the frequent uses of electronic devices in different settings. Other studies are worthwhile to investigate in details the reasons behind this preference. Since the self-reported English proficiency level was not equal between the highly proficient (16) and moderately proficient (43), it was not possible to make a comparison between both groups.

6 Acknowledgement

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Measuring Students Satisfaction in Using Learning Management System

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Abstract—The purpose of this study to determine what are the influenced factors for student satisfaction on learning management system at a private university that operates online learning system. The research was conducted to find out whether there is influence of information quality, system quality, service quality, perceived usefulness, perceived ease of use, and communication quality to student satisfaction toward learning management system. This study took a sample of 100 student respondents at the university. The used analytical method to test the effect is partial least square. The results show that information quality, service quality, and perceived ease of use have a significant effect on student satisfaction. Service quality is the most dominant factor that affects the satisfaction of students to learning management system.

Keywords—Learning management system, online learning, partial least square

1 Introduction

The growth of internet has an impact on the development of education, where education is now required to be flexible [1]. Flexible in learning methods that can be done anywhere and anytime without any geographical restrictions has becomes a highly demand to fulfill the educational needs of professionals, entrepreneurs and even housewives who want to continue their education to a higher level.

Media technology that connect the learning process of classroom e-learning is learning management system (LMS) [2]. LMS is an application that manages online learning systems, distributes learning materials, and enables interaction between lectures and students [3] LMS supports teaching and learning activities, helps to organize e-learning content on storage systems, provides unlimited access to e-learning materials so that the tracking students' progress becomes easier.

LMS is not a new thing nowadays, universities that run e-learning mostly adopt this system. There is one private university that runs e-learning in Jakarta, Indonesia. This private university is an information technology based educational institution that has experience in conducting education using Information and Communications Technology (ICT) for the students. One of ICT-based learning system is the online

learning system where teaching and learning process is done through web-based learning.

Students will be satisfied with the process of learning by using the media on the website because the interaction via website is fun, encouraging the learning process and success compared with conventional lectures [4]. Based on the prior reserachers, there are several factors that influence student's satisfaction toward LMS. According to Ramayah and Lee (2012) that the satisfaction of students toward LMS is influenced by the quality of the information, system and services provided by educational institutions. The quality of communication in the LMS needs to be concerned, as the learning process runs via online without meeting each other. The quality of good communication through media affects student satisfaction [5]. Another factor of satisfaction, according to Islam (2015) is where the LMS is easy to learn and can help the learning performance.

The purpose of this study to determine what factors that affect student satisfaction on learning management system at a private university that organizes online learning system.

2 Literature Review

2.1 Information quality

According to Miller (1996), the quality of information is an information where the users are able to use it and get helped. The quality of information can be identified by two stages which are highlighting the important attribute information and determining how that attribute affects the user. The examined attributes by Miller are relevance, accuracy, timeless, completeness, coherence, format, accessibility, compatibility, security, and validity.

DeLone and McLean (2003) examine the relationship between the quality of information and individual impacts that can be measured by accuracy, timeliness, completeness, relevancy, and consistency. According to Ramirez, Rondan, Arenas, & Alfaro (2017), the quality of information can be defined as the output characteristics offered by information systems, such as: accuracy, timeliness, and completeness of metrics. Similarly, conducted research by Alsabawy (2016), quality of information is measured by using elements of importance, availability, usability, understanbility, and conciseness.

2.2 System quality

Asda According to Almarashdeh, Sahari, Zin, & Alsmadi (2010), system quality is defined as the stability, reliability and suitability of hardware and software that provides the required information. Quality systems in LMS measures the intrinsic features of technology including system performance and user interface. The used elements to measure LMS are responsetime, usability, availability, reliability, completeness, system flexibility, and security. Meanwhile, according to Urbach, Smolnik, &

Riempp (2010), to measure the quality of employee portal system consider the characteristics of performance, functionality, and usability.

System quality is also defined as the compatibility, reliability of the system, and the stability of software and hardware where information needs to be supported [6].

2.3 Service quality

According to Almarashdeh, Sahari, Zin, & Alsmadi (2010), service quality is concerned with overall support provided by distance learning service providers or technology. Service quality can be measured through access to technical support, prompt responsiveness, assurance, empathy, and subsequent services.

In the study of Alsabawy (2016) to measure the services quality using efficiency, availability, fulfillment, privacy, responsiveness, and contact. Similarly, research conducted by Gorla, Somers, & Wong (2010) to determine the organizational influence of system quality, information quality, and service quality. Service quality is measured by responsiveness, reliability, empathy, and assurance elements

2.4 Perceived usefulness

Davis (2003) explains that perceived usefulness is the level of confidence a person to a system that can improve its performance. Alsabawy (2016) adopted the notion of Davis and measured perceived usefulness using elements of accomplish quickly, improving performance, increasing productivity, easier study, overall usefulness.

2.5 Perceived ease of use

According to Davis (2003) perceived ease of use is the level of confidence a person against a system that can free his business from the use of the system. To measure perceived ease of use, Davis uses elements such as ease of use, user expectation, user interaction, flexibility, increase performance, and easy to use.

2.6 Communication quality

Communication is an interpersonal process for sending and receiving information so that messages are well delivered. Information technology has played an important role in providing communication support for an organization. Some of the factors that determine IT technology can be used to provide communication support such as participants, resources and goals, media, place, and time [7].

In the research of Wang & Chiu (2011) which measures communication quality using elements of information quality, system quality, and service quality shows the empirical results which the quality of information and the quality of the system affect the communication quality significantly, where the quality of the system can improve the quality of communication between users in using e-learning system.

2.7 User satisfaction

User satisfaction is defined by Almarashdeh (2016) as a general evaluation of the user experience of the system and likely to influence users. Research conducted by Amin, Rezaei, & Abolghasemi (2014) shows user satisfaction with mobile websites positively influenced by trust, perceived usefulness and perceived ease of use.

Wang & Chiu (2011) explained in the results of his research that the relationship between the communication quality has a significant relationship to user satisfaction. Communication quality helps users share information, provide feedback, negotiate and integrate system users. It can also improve user satisfaction with e-learning system learning.

2.8 Research model

Information quality is information that can be felt and used by users [8]. Information quality can be identified by two stages of highlighting which information attributes are important and determining how those attributes affect the user. In this study, information quality construction refers to the theory developed by DeLone and McLean (1992) and Wang & Wang (2009) where using accuracy, relevacy, completeness, availability, usability, and understandability indicators in measuring information quality.

Almarashdeh, Sahari, Zin, & Alsmadi (2010) defines system quality as the stability, reliability, and compatibility of hardware and software that provides the required information. System quality in LMS measures intrinsic technology features including system performance and user interface. The system quality construct in this study refers to the theory developed by DeLone and McLean (1992), Alsabawy, Cater-Steel, & Soar (2016), and Urbach, Smolnik, & Riempp (2010) which use indicators of reliability, functionality, navigation, flexibility, accessibility, and facility in measuring system quality.

According to Almarashdeh, Sahari, Zin, & Alsmadi (2010), service quality is concerned with overall support provided by distance learning service providers or technology. Service quality can be measured through access to technical support, rapid responsiveness, assurance, empathy, and subsequent services. Service quality construct refers to the theory developed by DeLone McLean (2003) and Urbach, Smolnik, & Riempp (2010) where using indicators of availability, reliability, responsive, and assurance in measuring service quality.

Davis (1989) describes perceived usefulness is the level of confidence a person to a system can improve its performance. Similarly, research conducted by Arbaugh (2000a, 2000b) argues that perceived usefulness of electronic media in the delivery of learning can improve students' attitudes toward experience and in the future they will adopt learning via internet. The results support the argument and confirm that perceived usefulness positively affects student satisfaction. Perceived usefulness constructs in this study refers to the theory of Davis (1989) and Alsabaway (2016) using improving performance indicators, increasing productivity, easier study, and overall usefulness in measuring perceived usefulness.

Perceived ease of use is the level of confidence in a system that can free its business from the use of the system (Davis, 2003). The perceived ease of use construct in this study refers to Davis (1989) and Amin, Rezaei, & Abolghasemi (2014) theory using easy to use, user interaction, user expectation, and flexibility in measuring perceived ease of use.

Communication quality depends on whether both parties are motivated to continue to interact. This interaction through words and language. Through language, learners can seek information and send information about their opinions [9]. Aspects of communication quality to assess whether learners get the benefit from interactive communication, such as sharing, feedback and negotiation in discussions [5]. Construct communication quality in this research refers to the theory developed by Wang and Chiu (2011) which consists of chat forum, video conference, user's feedback, interchange opinions, review opinions, integrate opinions.

Referring to DeLone and McLean (2003), user satisfaction describes the user's response to the use of the information system. The user satisfaction construct in this study refers to the theory developed by Alsabawy (2013). User satisfaction uses experience, performance, and learning tool indicators.

Based on the explanation of the framework, it can be described the paradigm of realated research to information quality, system quality, service quality, perceived usefulness, perceived ease of use, and communication quality.

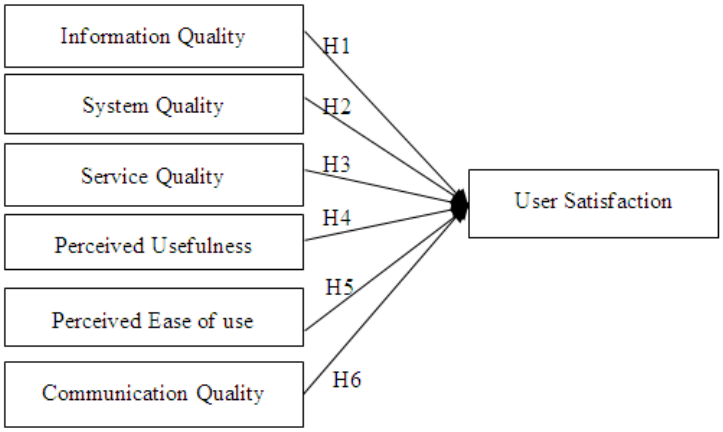

Fig. 1. Research Framework

Based on literature review and research framework, it can be formulated research hypothesis that is:

- **H1:** Information quality have a significant effect on user satisfaction.
- **H2** : System quality have a significant effect on user satisfaction
- **H3** : Service quality have a significant effect on user satisfaction
- **H4** : Perceived usefulness have a significant effect on user satisfaction
- **H5** : Perceived ease of use have a significant effect on user satisfaction

- **H6** : Communication quality have a significant effect on user satisfaction

3 Research Method

This study uses questionnaires as a means of data collection, as it is necessary to test the validity and reliability. The next stage is to analyze and interpret the obtained data in the field by using descriptive statistical analysis and inferential statistics. The number of samples taken is 100 students majoring in Master of Information Technology (MIT) and Master of Management Information Systems (MMIS). Spreading the questionnaire has been done by random sampling using google form, the samples obtained are 33 students majoring in MIT and 67 students majoring in MMIS. Measurement of questionnaires using Likert scale from 1 to 5. The duration of survey is one month (in the period of November 2017). The inferential statistics method used in data analysis is Partial Least Square (PLS). Data obtained from the samples were analyzed using PLS based on SmartPLS 3.0 software.

4 Result

4.1 Measurement model

Measurement model is done to ensure that the measurement used is feasible to be measured by testing the validity and reliability. The performed analyzes or tests on the outer model are convergent validity, discriminant validity, composite reliability (CR), and average variance extracted (AVE).

The research model was built with 36 indicator items and consisted of 7 dimensions of student satisfaction characteristics. All indicators for the dimensions in each construct resulted in a loading factor (**λ**) greater than 0.5 so no indicator was excluded from the following model:

Table 1. Result from Outer Model

Construct	Dimension	λ	CR	AVE
Information quality	Accuracy	0.800	0,918	0,652
	Relevancy	0.805		
	Completeness	0.800		
	Availability	0.790		
	Usability	0.852		
	Understandability	0.796		
System quality	Reliability	0.805	0,901	0,504
	Functionality	0.749		
	Navigation	0.650		
	Flexibility	0.715		
	Accessibility	0.743		
	Facility	0.655		
Service quality	Availability	0.942	0,958	0,853
	Reliability	0.954		
	Responsive	0.941		

Construct	Dimension	λ	CR	AVE
	Assurance	0.853		
Perceived usefulness	Improving Performance	0.933	0,966	0,877
	Increasing Productivity	0.933		
	Easier Study	0.932		
	Overall Usefulness	0.947		
Perceived ease of use	Easy to use	0.852	0,966	0,757
	User interaction	0.873		
	User expectation	0.871		
	Flexibility	0.883		
Communication quality	Forum chat	0.778	0,930	0,691
	Video conference	0.672		
	User's feedback	0.878		
	Interchange opinions	0.869		
	Review opinions	0.896		
	Integrate opinions	0.873		
User satisfaction	LMS experience	0.935	0,965	0,903
	LMS performance	0.966		
	LMS learning tools	0.950		

4.2 Structural model

The next step is the examination of the structural model which includes the ability of the independent variable to explain the dependent variable and the significance of the path relationship.

Table 2. Output R – Square

	R – Square	R – Square Adjusted
US	0.847	0.837

The result of R-Square is 0.847 means that the variability of user satisfaction can be well explained by variability of information quality (IQ), system quality (SQ), service quality (SEQ), perceived usefulness (PU), perceived ease of use (PEOU), and communication quality (CQ) of 84.7% and 15.3 % is explained by variables outside of the research.

Table 3. User satisfaction evaluation model hypothesis

No	Hypothesis	(β)	T Statistics	P Values	Result	Effect size
H1	IQ -> US	0.173	2.045	0.043	Support	Medium
H2	SQ -> US	0.146	1.501	0.136	Not Support	Medium
H3	SEQ -> US	0.218	3.690	0.000	Support	Large
H4	PU -> US	0.042	0.440	0.661	Not Support	Small
H5	PEOU -> US	0.431	4.195	0.000	Support	Large
H6	CQ -> US	0.031	0.570	0.570	Not Support	Small

From the results of the study can be seen at table 3 that information quality proved significant because the value of p-value information quality is 0.043, which is smaller than 0.05. The value of Original Sample is 0.173, meaning that if there is an increase of information quality of 1 unit will affect student's satisfaction of 0.173 units.

This research result is similar with previous research conducted by Almarashdeh (2016) which states that information quality has the least influence of the factors studied because the information quality is based on the quality of the content and the accuracy of the content provided by the instructor and the LMS service. Similarly, what happens in the information quality at these colleges, where the information quality is based on the content information in accordance with the lectures taken such as lecture information, course material information, and information services available to students.

System quality proved not significantly affect user satisfaction because the value of p-value system quality is 0.136, which is greater than 0.05. This indicates that the system quality factor does not affect student's satisfaction with learning management system (LMS). From the results of questionnaires given by the students indicate that the interaction performance between pages needs to be improved, the LMS facility to connect with the library menu in the mobile phone app needs to be improved, and needs to be upgraded LMS for mobile phone application version. This research result is not similar with previous research conducted by Almarashdeh (2016) which states that high system quality is influenced by several factors such as one of the ease of accessibility of the use of LMS.

Service quality proved significantly affect user satisfaction because the value of p-value service quality is 0.000, which is smaller than 0.05. The value of Original Sample is 0.218, meaning that if there is an increase service quality of 1 unit will affect student satisfaction of 0.218 units. This research result is similar with previous research conducted by Almarashdeh (2016) which states that if the LMS provides reliable and available 24/7 service quality, and services ready for use by the instructor, then the instructor's satisfaction will increase. Similarly, what happens to service quality in this college, where service quality focus on services performed by staff admin to students.

Perceived usefulness proved to be insignificant in affecting user satisfaction because the value of p-value perceived usefulness is 0.661, which is greater than 0.05. This indicates that perceived usefulness factor does not affect student's satisfaction with learning management system (LMS). This research result is not similar with previous research conducted by Almarashdeh (2016) which states that the use of LMS that can be felt can make the instructor reuse it because LMS is an interesting factor in interacting with distance learners. However, the significance in this study can be concluded that the LMS system is the main platform of learning for students so that teaching and learning activities are done online.

Perceived ease of use proved to significantly affect user satisfaction. The Original Sample value is 0.431, meaning that if there is a perceived increase of ease of use of 1 unit will affect student's satisfaction of 0.431 unit. This research result indicates the similar result with previous research conducted by Almarashdeh (2016) and Amin, Rezaei, & Abolghasemi (2014) which states that mobile learning should be easy to use and easy to learn, overall mobile learning should be considered easy to use. Likewise in this study, LMS can be used anywhere and anytime without any geographical restrictions. LMS is expected to be flexible for both website and mobile application.

Communication quality proved not to significantly affect user satisfaction because the value of p-value perceived usefulness is 0.570, which is greater than 0.05. This indicates that communication quality factor does not affect student's satisfaction to learning management system (LMS). This research result is not similar with previous research by Wang and Chiu (2011) which stated that communication quality is significant to user satisfaction, where the results of the research stated that sharing information, giving information feedback, and exchanging opinions among users on the disccusion board can help e-learning users interact with each other, and therefore can improve student satisfaction with e-learning system learning.

Six hypotheses have been tested, there are three variables that significantly influence the satisfaction of the students (user satisfaction) using learning management system (LMS) that is information quality, service quality, and perceived ease of use.

5 Conclusion

From the result of this research, it can be concluded that student satisfaction towards learning management system influenced by information quality which have influence to user satisfaction equal to 0,173, service quality which have influence to user satisfaction equal to 0,431, and perceived ease of use which have influence to user satisfaction equal to 0,218. Variable service quality has the highest coefficient value of other variables. This overall result shows that service quality is the most dominant factor affecting students' satisfaction on learning management system (LMS).

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