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Research Article

Design and Implementation of Curriculum Knowledge Ontology-Driven SPOC Flipped Classroom Teaching Model*

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Abstract

The promotion of new teaching models like MOOC and SPOC has spurred an exponential growth in the amount of teaching resources. However, the current university education system fails to respond to the changing scenario. The curriculum teaching is in lack of penitence, timeliness, advanced methods and diverse evaluation means. Against this backdrop, this paper draws the merits of big data and ontology theory, and creates an automatic curriculum ontology construction technology. Coupled with new teaching models like SPOC and flipped classroom, the author developed a new SPOC-based flipped classroom teaching model driven by curriculum ontology. Then, the new teaching model was applied in the design of a teaching plan, and verified in the course of Electronic Commerce. After a semester of teaching practice, the results show that the proposed method is more efficient and universal than the traditional ontology construction method; more importantly, our method promotes the teaching effect and enhances the students' overall abilities like autonomous learning, collaborative research. The research findings provide reference for hybrid teaching in the future, and shed new light on the reform for individualized and diversified university curriculum teaching.

Keywords

Flipped Classroom Teaching Model • Curriculum Knowledge Ontology • Small Private Online Course (SPOC)

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The implementation of the Internet Plus strategy in education has given birth to a dazzling array of teaching models, ranging from massive open online course (MOOC), small private online course (SPOC), flipped classroom to micro-classroom. These novel teaching models create an open, equal and shared environment for the learning of university courses, making it easier to enhance teaching methods and learning efficiency (Alraimi *et al*., 2015). The proliferation of these models also leads to an explosion of curriculum teaching resources. Against this backdrop, it is very meaningful for university educators to make flexible and effective collection, integration, organization and management of these abundant but complicated resources (Sarmiento *et al*., 2016; Bremgartner *et al*., 2017).

Over the years, the theoretical system and the knowledge framework of university curriculums have undergone rapid changes. To keep abreast with the time, teachers have to devote much time and energy to browse, collect, sort out and maintain various materials related to their courses. Only in this way, can they acquire the latest information, and make timely updates to their teaching materials. Nevertheless, this approach is too labor-intensive and time-consuming to achieve efficient collection of curriculum teaching resources or effectively preparation of teaching plans. To make matters worse, most university teachers have seldom engaged in enterprise operations or field investigations. Hence, the curriculum information collected by them tends to be outdated and irrelevant. Due to the low efficiency and timeliness, the teaching theories are increasingly isolated from the reality. The gloomy situation dampens the practical effect of teaching and restricts the practical ability of students (Zeng, 2016).

Since the advent of the MOOC, much research has been done on the reform of teaching model. This gives rise to multiple new teaching models, such as SPOC, flipped classroom and micro-classroom. The previous research mainly verifies whether these new models can enhance students' cognition learning attitude, performance and capability in a feasible and timely manner. However, there is no in-depth exploration into the collection, organization, classification and update of the curriculum teaching resources in the context of these new models.

One of the most important organization techniques of curriculum knowledge is curriculum ontology, a buzz phrase in intelligent learning systems (Sarmiento *et al*., 2016; Chi, 2009). Currently, most of curriculum ontologies are constructed in manually. There are many defects with this manual method: the ontology quality hinges on the experience of experts, and the manual method is too inefficient to realize rapid update of knowledge (Zeng, 2009). What is more, the compatibility of existing construction methods for curriculum ontology with the new teaching modes is yet to be verified (Qiang & Wei, 2015).

Inspired by the big data theory, this paper integrates multi-source resources into a curriculum resource database. Based on the ontology theory in knowledge engineering, the concept abstraction and relation extraction methods were proposed for curriculum ontology, and the semantic block-based similarity algorithm was presented, seeking to create the curriculum knowledge ontology. Then, the curriculum knowledge ontology was combined with the traditional SPOC flipped classroom teaching model into a new model driven by curriculum ontology. Finally, the proposed curriculum ontology construction method was verified by a case study on the Electronic Commerce, and the proposed model was applied to the Blackboard online teaching platform.

Literature Review

SPOC-Flipped teaching mode

The shortcomings of MOOC became apparent following its recent popularity in universities around the world, including low completion rate, high input cost, poor attendance and serious waste of resources (Burge *et al*., 2015; Zhang, 2017). To make up for the defects, a new flipped classroom teaching model has been developed based on SPOC. Featuring small scale, limited access and strong interaction, the SPOC-based model has significantly enhanced the learning effect of MOOC, and become a hotspot in the online curriculum research among top universities at home and abroad (Guo, 2017).

The SPOC-based flipped classroom teaching model aims to optimize the teaching effect through the integration of face-to-face classroom teaching and online learning. Thanks to the “small-scale” and “private nature” of SPOC, the open-source SPOC platform provides tremendous support to the teaching of flipped classroom (Fox, 2013; Chen and Yang, 2015).

At present, the SPOC-based flipped classroom mainly targets students from universities or university alliances (Wang *et al*., 2015). Relevant SPOCs include Software Engineering in UC Berkeley (Fox *et al*., 2014), Copyright, Architectural Imagination and Central Challenges of American National Security, Strategy, and the Press: An Introduction in Harvard, as well as Principles of Electric Circuits and C++ Programming in Tsinghua and Beijing Normal University (Kang, 2014).

The pre-class and in-class phases have been emphasized over the post-class phase in the existing studies on SPOC-based flipped classroom teaching at home and abroad. The neglection of the post-class phase hinders the consolidation of knowledge acquired by students during the class. In addition, more efforts are needed to rationally collect and organize the fast-updating curriculum resources, aiming to guarantee the quality of SPOC-based flipped classroom teaching (Urakawa *et al*., 2016). Against this backdrop, this paper draws the merits of the existing theories and practices on flipped classroom teaching, and attempts to create a new SPOC-based flipped classroom teaching model driven by curriculum ontology. The purpose is to improve the timeliness and long-term effectiveness of curriculum resource management.

Curriculum ontology construction

Curriculum ontology construction is a powerful tool to establish curriculum knowledge structure and sort out the key points of knowledge (Pata *et al*., 2013; Sarmiento *et al*., 2013; Shatnawi *et al*., 2014; Urakawa *et al*., 2016; Hedayati *et al*., 2017). So far, various ontology theory-inspired construction methods have been developed according to the curriculum teaching practice (Hedayati *et al*., 2017). For instance, Bai *et al*. tackled the knowledge extension issue in the teaching of interdisciplinary courses (e.g. E-Commerce), analyzed the features of these courses and the three relationships (i.e. “be related to”, “is part of” and “synonymy with”) between them, and put forward the curriculum ontology construction approach for interdisciplinary courses (Bai *et al*., 2014). In view of the course features in management information system, Zhong took Information System Analysis and Design as an example, proposed the creation method and steps of knowledge point ontology for the course, and gave formalized definitions of the concepts around the ontology; the knowledge structure was parsed and the ontology model was created following the traditional hierarchical structure: course, chapter, section and knowledge point (Zhong, 2013).

To improve the flexibility of the contents of a curriculum, Sarmiento *et al*. (2016) presented the design of a semi-automated Academic Tutor to support students and designed the Academic Tutor considering the case of an Electrical Engineering Curriculum, which was represented through ontologies, a Semantic Web technology. The Preliminary findings implied a broad and formal representation of the curriculum's knowledge could be shared and reused in the field of education and engineering.

In order to expound the ontology of public health from a perspective of university curriculum, Islam (2017) concerned, first, conceptualization of ontology of public health, secondly, nature of public health, and thirdly, curriculum development. Finally, he pointed out few issues for developing curriculum for universities.

On the upside, the above studies managed to extract the ontology elements of curriculum resources and their relations, and put forward the corresponding ontology construction methods. On the downside, the universality of the proposed methods is yet to be confirmed, due to the limited number of object (usually one discipline or course) and the high manual involvement (Tong *et al*., 2016). In addition, the scholars may have demonstrated the feasibility of the construction methods, but failed to empirically verify the support of curriculum ontology to the teaching activities (Tikhonov *et al*., 2016).

Based on the big data theory, the web mining technology was employed to achieve automatic update of curriculum resource database, and combined with curriculum ontology construction to overcome the low automation and poor universality of the existing methods. Then, this approach was verified through a case study on SPOC-based flipped classroom teaching.

Curriculum Ontopology-Driven Spoc-Flipped Classroom Teaching Model

Relying on the educational reform project of the university, and targeting at the problems of massive narration content, lagging textbooks and teaching modes and monotonous evaluation method, this paper proposes the detailed implementation plan shown in Figure 1.

Through combining the content of E-commerce course and the features of SPOC on the basis of the connotation of the flipped classroom and the systematic instructional design theories to promote the joint development of both students and teachers. This model classifies the whole teaching process into three stages, namely, knowledge transmission pre-class, knowledge internalization in- class and knowledge improvement post-class.

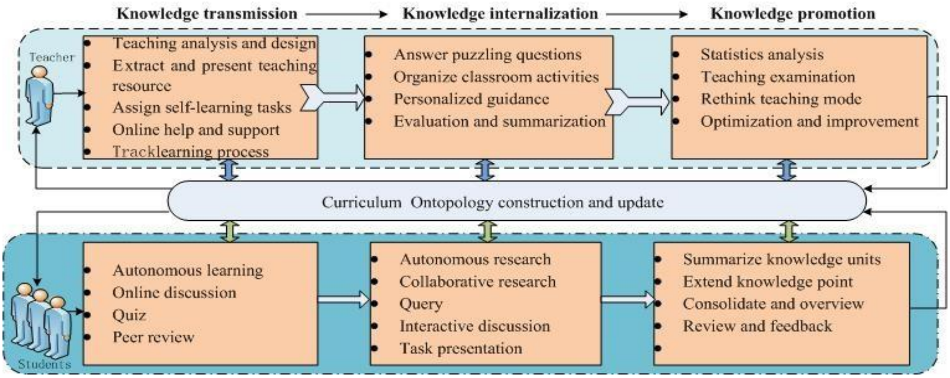

Figure 1. Schematic diagram of curriculum ontopology-driven SPOC-flipped teaching model.

Stage of Knowledge Transmission (pre-class)

This research was mainly implemented in the following steps: First, make the ontology description of curriculum knowledge according to the teaching syllabuses, and perform the overall planning of the teaching scope, key points and difficulties, considering the teaching goal and the knowledge structure/base of students; then, design the teaching resources using the online resource platform, that is, extract candidate teaching resources from films, videos, e-books, slides and news and the resources uploaded by the students (e.g. cases and news); next, sort out, rearrange and integrate the candidate resources, depending on the knowledge structure of the students and the desired organization of teaching contents; finally, share the integrated teaching resources on the online resource platform, laying the basis for the pre-class autonomous learning. Then, these resources shall be placed on the network teaching platform for sharing to ensure that students' complete pre-class self-learning tasks successfully. Finally, teachers shall assign tasks (including the basic knowledge unit and extended knowledge unit) to have students conduct pre-class learning purposefully. Teachers shall provide online help when students have questions. Meanwhile, teachers shall try their best to follow up students' learning process. They can learn about the problems encountered by students in their pre-class study by means of WeChat, QQ, teaching platform and other tools and learn about their learning status, and then design and modify the program of teaching activities in class based on the results of students' autonomous learning.

Before entering the flipped classroom, students shall conduct independent learning by virtue of the teaching videos or other learning materials released by teachers based on their own learning pace and way, which can avoid the waste of class time to some degree and ensure that teachers and students have enough time to make discussion and communication. In the course of watching video, students can ask teachers or classmates for help when encountering problems or solve these problems on their own with the help of the Internet. When students cannot get help in time or fail to solve the problems, they can write the problems down and discuss them with teachers face to face in class. After watching the video, students also need to complete the targeted classroom exercises assigned by the teacher and peer review. In this way, the students can summarize and share their problems in learning with their classmates and teachers, and upload the resources collected and marked by them for sharing. The uploaded resources will also be extracted as candidate teaching resources.

Stage of Knowledge Internalization (in-class)

In classroom face-to-face teaching, teachers need to make thorough preparations to answer puzzling questions encountered by students when watching videos and doing exercises, assign classroom tasks and organize students to carry out discussion activities and inquiry activities. In the design of discussion activities, teachers should first summarize the problems encountered by students in pre-class learning and make explanation or discussion on class. Students can ask questions that they haven't solved before class. If other students know the answer, let him/her explain the answer and then the teacher will make supplementation. If students are unable to answer the question, teachers will do. After solving the pre-class questions, teachers can put forward other questions based on these questions for grouped students to make discussion. After discussion, each group will arrange one representative to make concluding remarks. After each group presents their ideas, the teacher can provide his/her interpretation or supplement relevant teaching content, and then make a final summary. In the design of inquiry activities, teachers shall first know about students' mastery of motor skill knowledge according to their completion of pre-class work and provide individualized tutoring to students concerning the difficulties they met during operation. On this basis, teachers will put forward other questions for students to think about. Students are grouped and assigned tasks. Each student makes exploration independently first to improve the problem-solving ability. When encountering problems during the exploration, the student can collaborate with other members in the group and share the experience. The purpose is to cultivate students' cooperation and communication ability and innovation ability. Teacher should patrol the classroom during students' exploration process and provide personalized guidance when necessary. After all the group members basically complete the task, each team will send a representative to present the results. For the problems which have been solved during the exploration, students can share their experience with others, and for the problems that have not been solved, teachers and students can make communication to solve them together. After the teacher makes comment on each group's report, he/she will make a final summary. When a student is presenting his/her achievement, other students need to make comment on it. Students are required to complete the group performance rating scale after group collaborative exploration is completed, including self-assessment and group member evaluation.

Stage of Knowledge Improvement (Post-class)

At the end of the class, students can reflect on their whole learning process, make comments on this flipped learning, provide feedback to teachers and put forward suggestions for the next flipped classroom. For teachers, statistical analysis of students' learning outcome shall be carried out. They also need to evaluate the teaching effect. The problems found in the course of flipped classroom teaching and the feedback after teaching should be solved and adjusted in time to help students learn better and facilitate the subsequent development of the course.

Curriculum Ontopology Construction

Using the ontology matching method, ontology models have been constructed for various fields and multiple disciplines. In general, the ontology matching is grounded on element, structure, instance or multiple strategies (Hu *et al*., 2008; Pirró and Talia, 2010; Belhadef, 2011; Liu *et al*., 2012). Among them, the element-based method is poor in matching accuracy. This is because the method only considers the conceptual semantics, while ignoring the semantic description function of attributes and relations. The structural-based method merely takes account of the hierarchy between concepts. The instance-based method does not work well if there is no intersection between the instance sets of two ontologies. By the multi-strategy method, the conceptual semantics and the hierarchy between concepts are weighted and integrated. However, the weights are assigned too subjectively. Considering the ontology features of curriculum knowledge system and aiming to update the knowledge of curriculum ontology, this paper presents an ontology concept similarity matching algorithm based on semantic blocks according to the conceptual semantics of ontology and the hierarchy between concepts.

Hereinto, an automatic construction method for curriculum ontology is put forward through processing Web resources, teaching syllabuses and academic databases with such techniques as web crawler, text mining and association rule mining. Following this method, the curriculum ontology construction was divided into five phases: curriculum resource acquisition, domain concept extraction, ontology relation mining, ontology description and ontology updating (see Figure 2).

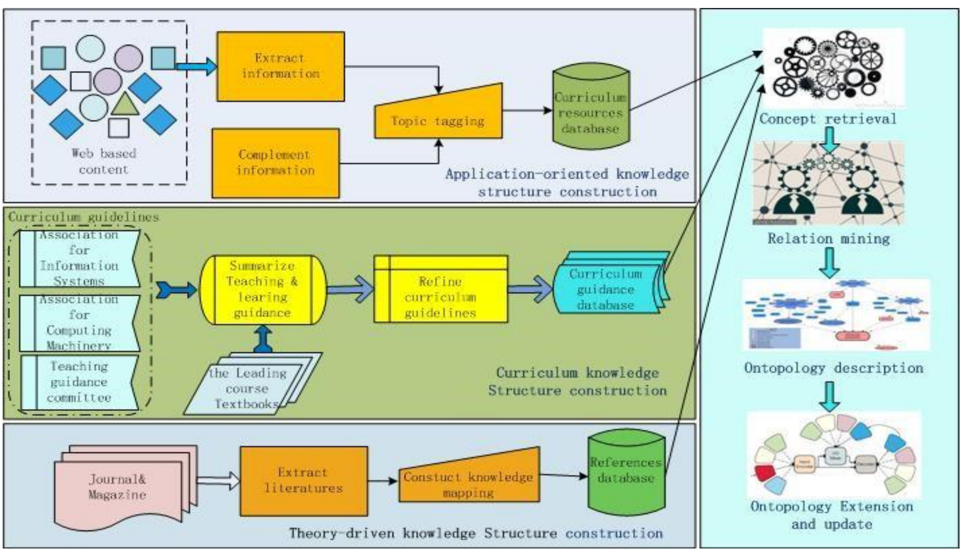

Figure 2. Flow chart of the curriculum ontology construction.

Firstly, the resource screening strategy and crawling rules of web crawler were laid down, such that the employed techniques automatically acquired the relevant curriculum information. The knowledge maps of the teaching syllabuses, applications and theories were constructed based on the acquired information, forming a database. Secondly, the Word2vec software was employed to extract curriculum vocabularies, establish keyword index, calculate the frequency of keywords, and abstract the concepts of curriculum ontology. Thirdly, the association strength between concepts was calculated through association rule mining, and the associations whose strength surpassed the threshold were taken as the relations of curriculum ontology. Finally, the attributes and instances were automatically added according to the annotations of the uploaded resources, as well as the auto-extracted concepts and relations; the curriculum ontology was created with the ontology description tool, wrapping up the entire creation procedure.

Curriculum Resource Acquisition

There are three main sources of curriculum resources: (1) Teaching syllabuses, i.e. the documents on course teaching issued by ACM ((Association for Computing Machinery), AIS (Association for Information Systems) and other teaching steering committees; (2) Web resources, i.e. the online information obtained by web crawler or uploaded by learners, including but not limited to webpage contents, WeChat information, and Weibo information; (3) Academic resources, i.e. the materials extracted from such academic databases as CNKI, Springer, ACM, IEEE and Elsevier.

First, the teaching syllabuses issued over the years were converted to plain text, forming a database of teaching syllabuses; then, the Internet information (webpage content, WeChat information, and Weibo information) was captured by web crawler; the information was combined with the cases submitted by learner to create a database of applied knowledge; Finally, the theoretical knowledge database was generated through regular collection of literature and extraction of title, abstract, introduction, keywords and conclusions.

Concept Extraction

The Word2vec was adopted to segment and tag the entries in the above three databases, calculate the frequency and class of each word, and select those words capable of binding other words and representing the domain.

Curriculum ontology is a system involving curriculum terms, definitions and the description of term relations. It is the formal expression of the concepts in the discipline of the course and the relations between different concepts. The formal 6-tuple curriculum ontology can be defined as follows (Maedche & Zacharias, 2002).

Definition 1 (Curriculum Ontology). Curriculum Ontology, Cur_O, is included by Gd_Onto, Ak_O, Tk_O, guidance documents ontopology, application knowledge ontopology and theory knowledge ontopology, respectively.

Definition 2 (Ontology Structure). An ontology structure is a 6-tuple $\mathrm{Cur\_O} =< \mathrm{C}, \mathrm{R}, \mathrm{A}, \mathrm{H_C}, \mathrm{p}, \mathrm{att} >$, consisting of two disjoint sets *C* and *R*, whose elements are called concepts and relations, respectively, a concept hierarchy H_C is a directed, transitive relation $\mathrm{H}_C \subseteq C \times C$, which is also called concept taxonomy. A function *p: p→C×C*, that relates concepts non-taxonomically. A specific kind of relations are attributes *A*. The function *att: A→C* relates concepts with literal values.

Definition 3 (Ontology-Based Metadata). We consider ontology-based metadata as synonym to instances of ontologies and define a so-called metadata structure as following:

A metadata structure is a 6-tupel $\mathrm{MS} =< \mathrm{O}, \mathrm{I}, \mathrm{L}, \mathrm{inst}, \mathrm{instr}, \mathrm{instl} >$, that consists of an ontology *O*, a set *I* whose elements are called instances (correspondingly *C*, *p* and *I* are disjoint), a set of literal values *L*, a function *inst:C→2I* called concept instantiation, and a function *inst:p→2I×I.* called relation instantiation. The attribute instantiation is described via the function instl: *p→2I×L*. relates instances with literal values.

This paper uses the term frequency–inverse document frequency (TFIDF) algorithm to compute the weight (degree of importance) of candidate concepts in documents (syllabuses, webpages, etc.), and then filters out those cannot reflect the features of the domain according to the calculation results. The TFIDF is a popular numerical statistic intended to reflect how important a feature word is to a document. The TF refers to the frequency of the feature word in the document; the IDF means the probability distribution of the feature word in the collection of documents. The TFIDF formula can be expressed as (Salton and Buckley, 1998).

$$TFIDF(i) = TF(i) \times IDF(i) = \sum_{j=1}^{n} tf_{ij} \times log \frac{|D|}{df_i} \quad (1)$$

Where, tf_{ij} is the number that feature word *i* appears in document *j*; |*D*| is the total number of documents in database *C*; df_i is the total number of documents containing feature word *i*.

However, there are a few flaws that handwaved in the traditional TFIDF algorithm. Some low-frequency words contain a large amount of information is often removed due to their low weights, while some ordinary words are retained due to their high weights. The position of feature words in the document is not taken into account. Facing these defects, the TF formula of the algorithm was improved as follows. The base of the weight of the candidate feature words in the document title was set to 3. Then, these candidate feature words were classified by an interval of 200 words. For each additional class, the base of the weight was increased by 1. The base of the weight of the candidate feature words in the keywords was set to 2. Then, these candidate feature words were classified by an interval of 300 words. For each additional class, the base of the weight was increased by 1. In this way, the actual frequency of all candidate feature words in the document was obtained by the following formula:

$$TFIDF(i) = \sum_{j=1}^{n} \frac{(\beta+2)n_{C.ij} + (\mu+3)n_{T.ij}}{\sum_{k\in d_j} n_{kj}} \times log \frac{|D|}{|df_i|} \quad (2)$$

where, $\beta = n_{C.ij}/300$, $\mu = n_{T.ij}/200$ are both integers; $n_{c.ij}$ is the number that candidate concept c_i in the key concept index words appears in the body of document d_j; $n_{T.ij}$ is the number that candidate concept c_i the key concept index words appears in the tile of document d_j; $\sum_{k\in d_j} n_{ij}$ is the total number that all candidate concepts appear in document d_j.

By the above formula, the frequency of candidate concepts was effectively derived. Then, the words with a frequency greater than the threshold were taken as ontology concepts, and organized into the key concept index.

Ontology Concept Relations Mining

Relying on the key concept index, the concept relations were extracted by co-word analysis and association rules algorithm; then, the frequency of each association was computed, and taken as the association's intensity of occurrence. The associations with an intensity greater than threshold β were regarded as the relations of the curriculum ontology. The associations were calculated by the following formula:

$$R(c_i, c_j) = \frac{|(UC(c_i,H_C) \cap UC(c_j,H_C))|}{|(UC(c_i,H_C) \cap UC(c_j,H_C))|} * \delta \tag{3}$$

Where, $UC(c_i, H_c)$ and $UC(c_j, H_c)$ are the number of associations of c_i and c_j, respectively; δ is a parameter that adjusts the intensity distribution of associations.

Ontology Description

Based on the combinations of the extracted associations, the concepts and relations of curriculum ontology were corrected and modified by the association intensity. The concepts and relations were categorized as "concepts", "attributes", "functions" and "instances" ("instances" refer to the curriculum teaching resources like web documents, WeChat cases, Weibo cases, etc.). Although experts were still needed for this process, the subjectivity of the categorization was avoided effectively through in-depth statistical analysis of database and the adjustment of the ontology structure based on the association intensity. The new categorization process also unearthed potential associations, and transcended the limits of the traditional manual method based on textbook knowledge structure.

Following the above strategy, the auto-extracted concepts were adjusted manually, described in web ontology language (OWL), and used to establish the syllabus ontology, applied knowledge ontology and theoretical knowledge ontology.

Ontology Extension and Update

The concept similarity in the above three ontologies was calculated separately, in light of the conceptual semantics of ontology and the hierarchy between concepts. Then, the three ontologies were merged into the final curriculum ontology.

Let word sequences $k(c_i, H_C)$ and $k(c_j, H_C)$ be the keyword sequences in the conceptual semantic blocks of concepts c_i and c_j, respectively. The number of words in each word sequence is denoted as n and m, respectively, and expressed separately as $k(c_i, H_C)=(k_{ci.1}, k_{ci.2}, \ldots, k_{ci.n})$ and $k(c_j, H_C)=(k_{c.1}, k_{cj.2}, \ldots, k_{cj.m})$.

The similarity so between the corresponding words in the conceptual semantic blocks was calculated by the edit distance algorithm:

$$s_o = 1 - \frac{e_d(k_{c_i.o}, k_{c_j.o})}{max(|k_{c_i.o}|,|k_{c_j.o}|)} \tag{4}$$

where, $e_d(d_{ci.o}, k_{cj.o})$ is the edit distance of two strings; $max(|k_{ci.o}|,|k_{cj.o}|)$ is the length of the longest string.

The similarity of keywords in semantic blocks can be obtained by:

$$sim[k(c_i, H_C), k(c_j, H_C)] = \sum_{o=1}^{M}(w_o * s_o) \tag{5}$$

where, $M=max(n,m)$; w_O is the weight of the semantic neighbor whose concept's semantic distance is 0. The distance between the attribute neighbor and the concept neighbor is negatively correlated with the semantic relation between the concepts and the weight.

Definition 4 (InstanceAnnoation). The instance of a new concept *Cs* in Ak_O or Tk_O should be included in the curriculum repository if the similarity between the new concept and the existing concept c_t in Gd_Onto surpasses the threshold value. The instance annotation formula is as follows:

$$Ins\_annoation(c_s) = \{\exists Cs, ins(c_s) \rightarrow RES | sim[k(c_s, H_C), k(c_t, H_C)] > \theta\} \tag{6}$$

Where, $ins(C_s)$ is the instance of the new concept C_s; *RES* is the curriculum repository; θ is the similarity threshold.

The Implementation of The Model

In this section, we implement our approach by applying it on the design and instruction of an Electronic commerce course for freshman students at school of International Trade and Economics in Central University of Finance and Economics.

E-Commerce Curriculum Ontology Construction

1.Curriculum resource acquisition--first of all, the raw materials were converted into plain text, manually proofread, and developed into a syllabus database. These materials include the Curriculum Guidelines for Undergraduate Degree Programs in Information Systems (ACM& AIS, 2010), the documents issued by the E-Commerce Discipline Teaching Steering Committee, Ministry of Education of the PRC, and the mainstream textbooks on Electronic Commerce.

Then, the author searched and downloaded related information in Wise News database by the keywords: "e-commerce", "Internet Plus", "business models", etc., and downloaded hot news from WeChat public accounts and Weibo. Based on these information and news, an application knowledge structure was created to form a curriculum resources database.

Finally, the author extracted materials from such academic databases as CNKI, Springer, ACM, IEEE and Elsevier. The references database was developed from the theoretical knowledge structure and literature data embodied in the extracted materials.

2. Curriculum concept extraction--as mentioned before, the Word2vec was adopted to segment and tag the entries in the above three databases, calculate the frequency and class of each word, and calculate the important concepts capable of representing the domain by formula (2), forming the key concept index (Table 1).

Table 1
Key Concept Index of the Applied Knowledge Database (Part)

No	Rank	Field	keywords
1	743	content	e-commerce
2	23	title	Business model
3	510	content	Internet+
4	672	content	Mechanism
5	34	content	Online auction
6	347	content	Reverse auction
7	335	content	Crowd funding
8	25	content	e-retailing
9	360	content	Trust
10	298	content	Online fraud
11	303	content	Name your own price
12	102	content	Transaction fee
13	67	content	Affiliate marketing
14	245	content	Group purchasing

The crawler browsed 946 webpages, 89 messages on WeChat for Web and 234 Weibo Information. There was a total of 45,264 candidate phrases, of which 93.01% (42,101) were in the body part. Hence, the body part was selected as the focal point in the subsequent concept extraction and relation establishment.

3.Relations mining--relying on the key concept index, the concept relations were extracted by co-word analysis and association rules algorithm; then, the frequency of each association was computed by formula (3). 153 pairs of association combinations were obtained at δ=10 and β=6.5. Among them, 132 (86.27%) were effective pairs. Based on these pairs, the concept relations were extracted under the applied knowledge structure (Table 2).

4. Curriculum ontology description--the concepts and relations of the curriculum ontology were corrected and adjusted based on the 204 domain concepts and 132 pairs of concept relations. First, the domain-unrelated or meaningless concepts were removed, such as “market”, “login”, “registration” and “price”. These high-frequency words have no real meaningful for ontology construction. Second, the existing relations were analyzed by the association intensity, and categorized as “concepts”, “attributes”, “functions” and “instances”. Figure 3 shows the construction of applied knowledge ontology Ak_O.

Table 2
Extracted Concept Relations Under the Application Knowledge Structure (Part)

Keywords1	Keywords2	Relation degree
content: e-commerce	content:E-MARKETS	8.659
titile:e-commerce	content:online fraud	6.75
content: e-commerce	content: Click-and-brick organizations	8.045
content: e-markets	content: information brokers	6.532
content: e-markets	content: B2B	7.132
content: e-markets	content: revenue model	9.666
content: revenue model	content: Transaction fees	6.984
content: revenue model	content: Subscription fees	7.053
content: revenue model	content: Advertisement fees	8.968
content: revenue model	content: Affiliate fees	6.578
content: collabrative commerce	content: Supply chain improvers	7.874
content: revenue model	content: revenue stream management	9.25
content: revenue stream management	content: portfolio analysis	6.666
content: revenue stream management	content: Business Assessment	8.619
content: pricing	content: Name your price	8.15
content: pricing	content: online auction	9.242
content: pricing	content: Find the best price	6.538
content: online fraud	content: fake transaction	8.912
content: online transaction	content: value proposition	8.152

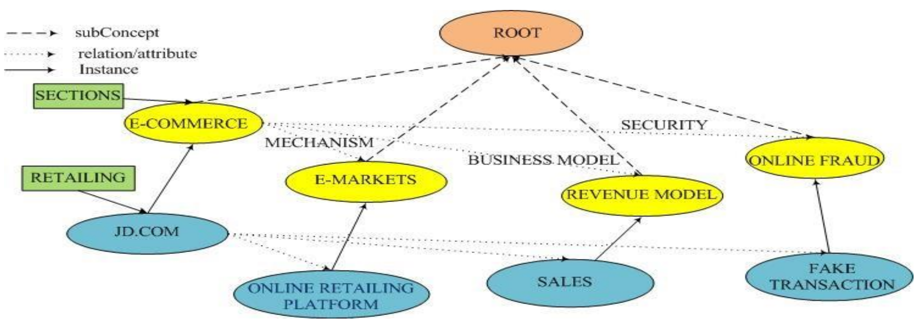

Figure 3. Description of the applied knowledge ontology Ak_O (part).

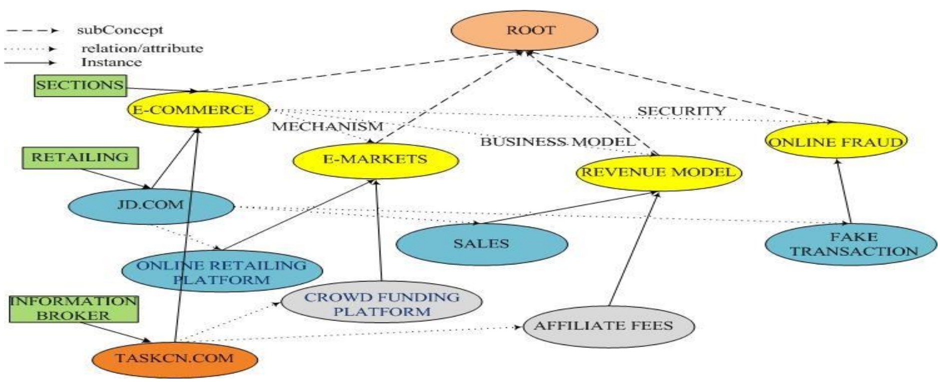

Figure 4. curriculum ontopology extension and update (Taskcn.com).

For Ak_O, $\mathrm{AK\_O} =< \mathrm{C, R, A, H_C, p, att} >$, here on the basis of *C*:={E-COMMERCE, E-MARKETS, REVENUE MODEL, ONLINE FRAUD}, *p*:={MECHANISM, BUSINESS MODEL, SECURITY}, *A*:={SECTIONS} the relations MECHANISM(E-COMMERCE, E-MARKETS), BUSINESS MODEL(E-COMMERCE, REVENUE MODEL), SECURITY(E-COMMERCE, ONLINE FRAUD) with its domain/range restrictions and the attribute SECTIONS(E-COMMERCE) are defined.

Let *I*:={JD.COM, ONLINE RETAILING PLATFORM, AFFILIATE FEES, FAKE TRANSACTION}, *inst* is applied as follows: *inst*(JD.COM)=E-COMMERCE, *inst*(ONLINE RETAILING PLATFORM)= E-MARKETS, *inst*(FAKE TRANSACTION)= ONLINE FRAUD, *inst*(REVENUE MODEL)= SALES. Furthermore, we define relations between the instances and an attribute for the E-COMMERCE instance. This is done as follows: We define MECHANISM(JD.COM, ONLINE RETAILING PLATFORM), BUSINESS MODEL(JD.COM, ONLINE RETAILING PLATFORM) , SECURITY(JD.COM, FAKE TRANSACTION) with its domain/range restrictions and the attribute SECTIONS(JD.COM, RETAILING).

5.Curriculum ontology extension and update--the three ontologies structures Gd_Onto, Ak_O and Tk_O (i.e. syllabus ontology, applied knowledge ontology and theoretical knowledge ontology) were integrated into the curriculum ontology of the Electronic Commercecourse Cur_Onto.

Citing taskcn.com as an example (Figure 4), the *inst*(taskcn.com)=E-COMMERCE was extracted from the case database; the new concept was CROWD FUNDING PLATFORM, and the corresponding instance was *inst*(CROWD FUNDING PLATFORM)= E-MARKETS; *inst*(REVENUE MODEL)= AFFILIATE FEES.

According to formula (5), the similarity between CROWD FUNDING PLATFORM and ONLINE RETAILING PLATFORM was 0.92 in the semantic block keyword sequence in the parent concept “E-MARKETS”. Since the similarity was greater than θ=0.86, the CROWD FUNDING PLATFORM was treated as a subclass of E-MARKETS, and added to the curriculum ontology. Similarly, the similarity between AFFILIATE FEES and SALES (0.89) was also greater than θ, and the AFFILIATE FEES was thus taken as a subclass of REVENUE MODEL. In this way, the curriculum ontology was extended and updated.

Then, the instance taskcn.com was used as an instance tag to mark the applied knowledge database, for the purpose of quick reference in lectures on business models.

Similarly, the concepts of virtual reality (secondlife.com), custom services (bluenile.com), time-limited sales (zulily.com) and crowd creation (quirky.com) were included in the curriculum ontology.

Implementation of Curriculum Ontology-Driven SPOC Flipped Teaching Model

Based on the Blackboard platform with such technical advantages as simple operation, strong openness, controllable backstage, and authentication security, SPOC flipped classroom teaching practice was carried out for the Electronic commerce course according to the program shown in Figure 1. The undergraduates of 2016 majored in international economics and trade in the School of Economics of Central University of Finance and Economics are selected as the research object (Class 16-1 is taken as the Curriculum Knowledge Ontology-Driven SPOC flipped class (CKO-SPOC), with 42 students and Class 16-2 is taken as the traditional SPOC flipped class (traditional SPOC), with 40 students) The teaching content is “Business model and electronic market mechanism”. The purpose of learning is to master the electronic market and its main operational tools and mechanisms, understand the business modes and analysis method.

1. Pre-class activities--after communication with the educational administration teachers of the School of Economics and the commissary in charge of studies, it is learned that the students in class 16-1 and class 16-2 have learned such courses as Advanced Mathematics, Introduction to Management, and Introduction of Computer Technology, so that they are equipped with the basic knowledge required to take the Introduction of E-commerce as an elective course. Then, in order to help student make a more comprehensive analysis of the business model, understand the e-market tools and mechanism, using the set of instances in the curriculum ontology of the Electronic Commerce, the unit teaching objectives shown in Table 3 are formulated based on the target taxonomy theory (Bloom, 1994), combining students' existing knowledge reserve and online experience.

Table 3
Teaching Objectives of the Unit of "Business Mode and E-market Mechanism"

Knowledge point	Target level	Specific behavior description
Profit model	know about	able to state the concept, classification, features and application fields of the profit mode
Business model	understand	able toexplain the business model composition and basic operation thought
Income flux analysis	application	compare and analyze the combination optimization of business model combining the case data
Platformization and desertification	application	able to analyze the competition environment and situation of Chinese Internet platform from the perspective of business model evolution
e-market	know about	able to state the concept, classification and components of the electronic market
e-market intermediary	understand	Explain the role of credit intermediation and envisage regulatory strategy combining the consultation on artificially boosting their sales and reputation
Auction mechanism	know about	Able to state the classification, features and specific application scenario of e-auction
Social business	know about	able to state the core idea of social business
Crowd fundingand crowdsourcing	understand	able to explain the operation mechanism and features of crowd funding and crowdsourcing and existing problems
VR	know about	Able to tell the difference of VR and AR and know about the application fields of VR e-commerce

According to the above teaching objectives, and utilizing the e-commerce course network resource platform developed independently by the teaching team, the teacher extracts flash from the website of Second life, the introduction video of Future Ops Online and the auction video of Dounan flowers and plants and collects and sorts out such cases as bluenile.com, ZBJ.Com, dfmeibao.com, quirky.com as the candidate teaching resources, news information and the annual reports data of listed companies. The candidate resources are designed and integrated according to the teaching requirement and placed on the Blackboard teaching platform one week in advance.

Finally, the teacher needs to assign the learning task (as shown in Table 4) and issue the group skill assessment form, mutual evaluation table, and feedback list to have students conduct pre-class learning purposely. Teachers should also answer students' questions when they are carrying out independent learning and learn about their learning situation. Students shall complete the basic learning of "business mode and e-market mechanism" through watching the teaching resources on the platform according to the list of tasks. They also need to upload the test results to the platform after completing the listed tasks. In case of any problems encountered during their learning process, students can communication and discuss with teachers or students through the platform or in the form of Webchat and QQ, and record the unapprehend content or problems that cannot be solved to feed back to teachers.

Table 4
Learning Task List of CO-SPOC Flipped Classroom (Business Mode and E-market Mechanism)

I. Study Guide
1. Knowledge Unit: *Electronic Commerce* -- Business Models and E-Market Mechanisms
2. Learning Content: ● Grasp the concept and types of the profit model; ● Understand the concept and constituents of the business model; ● Master the business model optimization methods based on revenue flow analysis; ● Understand the causes for platform and desertification of e-commerce in China; ● Grasp the concept and composition of electronic market; ● Master the main tools, mechanisms of the electronic market; ● Focus on reverse auction, web 2.0, crowdsourcing, crowdfunding and other new mechanisms.
3. Study Goals: Before class, by utilizing the teaching resources (video, reading materials and other forms) on the Blackboard, students are required to learn the knowledge points, grasp the concept and classification of business models, as well as the components and main mechanisms of electronic market. During class, students are required to analyze the causes of platform and desertification in domestic e-commerce, master the methods to analyze and evaluate the business models.
4. Learning Methods Recommendation: Online Learning, Discussion Learning, Inquiry Learning
5. Notice for Teaching Forms: ● Preview questions answered by the teacher; (5 minutes) ● discuss the reasons for the platform and desertification in domestic e-commerce in groups; (10 minutes) ● study collaboratively, complete the evaluation of business model's portfolio based on revenue stream analysis in groups; (15 minutes) ● study collaboratively, conceive regulatory strategies for e-market platforms under the circumstance of click farming (papers) in groups; (20 minutes) ● Exhibit the excellent assignments, share learning experience, at the same time peer reviews among students then the teacher's comment and feedback; (each group of 8 minutes * 5 groups) ● Teacher makes the summary. (5 minutes)
II. Study Tasks
1. Watch teaching resources and study independently, and complete the following tasks. Specific requirements: ● Know the concepts, classification and characteristics of profit model; Understand the composition and basic operation of business model; Know the concepts, classification and composition of electronic market; Know the classification, characteristics and application scenarios of electronic auction; Understand the core idea of social business; Be able to explain the operation mechanism and characteristics of crowdfunding and crowdsourcing. ● Complete and submit tests for business model and e-market; ● Complete the group assignments – develop regulatory strategies for e-market platforms based on the click farming situation. Upload packaged files to the course platform; 2. Next class task: Make a presentation about "E-commerce products and services with Chinese characteristics". 3. After next class: Modify and improve the presentation according to teacher's comments, and upload assignments to the platform name after student ID. Make self-assessment and mutual rating among the group members and fill in the feedback form about the flipped classroom.
III. Study Record
Note down the difficulties and questions, then ask the teacher questions in class or discuss with teammates.

2. In-class activities--according to the statistical analysis of the test scores of students and the feedback of students before class, teachers find that students have a better understanding of the basic concepts such as electronic market, business model and profit mode, while they are confused about the concepts of e-market transaction intermediary and information intermediary. They don't have a solid mastery of the eight elements of the business mode and their functions. To achieve the unit teaching objectives, the teacher selected the high-relevance cases from the intermediary instances in the curriculum ontology, classified these cases into different categories, and elaborated each type of intermediaries in the class. The elaboration manifested the connotations and functions of the eight elements in business models.

The discussion activities were organized based on the curriculum ontology of the Electronic Commerce. In the curriculum ontology, the monopoly information on Chinese e-commerce market was cited to guide the group discussion among the students. 1) whether there is monopoly? 2) whether monopoly will lead to platformization and desertification? 3) the formation and circumvention of the platformization and desertification from the perspective of business model evolution, and then the students are guided to carry out collaborative exploration activities. The revenue stream analysis-based business model portfolio evaluation will be made through calculating the variable coefficient according to the annual report data of the Internet listed companies. Finally, the regulatory strategy for the e-market platform under the fake transactions will be explored in groups based on the provided news about fake reviews and shilling reputation and be submitted to the platform.

Teachers should patrol the classroom during students' discussion and exploration process and help the group members solve difficult problems (calculating the cost for faking the sales data and the concept of two-sided market) and provide personalized guidance to help students complete task. After all the group members basically complete the exploration, each team will send a representative to present the results. The teachers will make comments on the results and will make summary for the course finally.

3.Post-class activity--by analyzing the self-assessment, mutual evaluation between team members, as well as the flipped classroom feedback form submitted by students, the teacher found that: 1) through collaborative inquiry activity, students had a deeper understanding of the business model and electronic market; 2) students are quite interested in discovering and analyzing the realistic problems facing current domestic e-commerce using what they have learned. However, there are two problems:1) The classroom teaching shall properly add the learning link of independent inquiry to improve students' independent learning and practical ability (only collaborative inquiry activities are designed in this unit); 2) The introduction of some new terminology is suggested to uploaded to the platform before class, such as the network effect, bilateral market, sematic network, deep learning, etc. Aiming at these two problems, the teachers assigned the homework of case preparation in advance to each student in the next unit of "E-commerce product and service" and include the mutual evaluations into personal assessment. In addition, the introduction material of such terminology as channel conflict, GMV and Pearson similarity computing appeared in the next unit are uploaded to the platform a week in advance, to help students better learn the unit of "e-commerce product and service" and facilitate the development of this course.

Research and Discussion

The feasibility and effectiveness of the SPOC-based flipped classroom teaching model driven by curriculum ontology were verified through computer experiment and questionnaire survey. First, a technical evaluation experiment was designed to evaluate the quality and construction efficiency of the curriculum ontology, aiming to prove the effectiveness and efficiency of the automatic construction technology for the curriculum ontology. Then, questionnaire survey and statistical analysis were performed to analyze the effects of the ontology-driven SPOC flipped classroom teaching model on the learning attitude, capacity enhancement and satisfaction.

Effectiveness Analysis of Curriculum Ontology Construction Technology

Ontology quality evaluation. The curriculum ontology quality was evaluated through absolute and comparative analysis of indices. In absolute analysis, the auto-constructed ontology quality index was calculated based on the standard term set; in comparative analysis, the auto-constructed ontology quality index was contrasted with the manually constructed ontology quality index. The evaluation indices were selected around the concepts and relations of the ontology, including the translatability coefficient γ ($\gamma=N1/|C|$), the scale coefficient φ ($\varphi=N1/|T|$), and the relation coverage η ($\eta=R/N$*100%) (Tong, *et al*., 2016). γ and φ expresses concepts, while η characterizes relations (N1 is the number of concepts in auto-constructed ontology that match with those in the standard term index; $|C|$ is the total number of concepts in the auto-constructed ontology; $|T|$ is the total number of concepts in the standard term index; R is the total number of relations in the auto-constructed ontology.).

The experiment was targeted at the leading textbook Electronic Commerce (Turban, *et al*., 2016). After converting the textbook contents into plain text, the author removed the code fragments in the textbook database in a semi-automatic manner. Through manual proofreading, a domain database was generated. Then, the database contents were tagged by Word2vec, and pre-processed to yield 15,495 clauses. After content analysis, 296 terms were selected and combined into a term set. The term set was approximately viewed as the standard term set, because it covered all chapters and sections of the course and transcended the limits of the threshold. Next, the author searched the CNKI database with the keywords of "e-commerce", "curriculum ontology" and "ontology construction", and compared the resultant ontology with the curriculum ontology of Electronic Commerce manually constructed by references (Bai *et al*., 2014). The results of the comparative analysis experiment are listed in Table 5.

Table 5
Comparative Analysis of Ontology Quality

Construction method	Our approach	Traditional mothod
Amount of concepts *N*	204	392
Amount of relations *R*	132	194
Amount of concepts in the standard term index*T*	296	759
Amount of matched concepts *N*1	187	215
Translatability coefficient γ	0.917	0.548
Scale coefficient φ	0.632	0.283
Relation coverage η	64.70%	49.50%

In terms of translatability coefficient, the actual coefficient value was greater than 0.917 because the calculation of the 204 ontology concepts covered non-term attributes like "business ethics" and "international trade". This means the ontology is closely related to the discipline. Under the effect of the δ threshold, the scale coefficient had a relatively low value. The set threshold $\delta(\delta=10)$ aims to identify the high-frequency vocabulary in the selected domain. Thus, the selected words were representative and indirectly reflect the important and difficult knowledge in the domain. The value of the scale coefficient (0.632) indicates that the constructed ontology is small in scale and large in knowledge granularity. However, the small scale and high granularity do not undermine the domain integrity of the ontology. A large-scale and low-granularity curriculum ontology can be obtained simply by adjusting the threshold value.

According to the comparative analysis results, the manual construction technology relies heavily on the subjective experience of the creator in terms of hit rate, relation coverage and scale. In contrast, the automatic construction technology outperforms the manual construction technology in concept extraction. A possible explanation lies in the threshold adjustment function in automatic construction technology, which increases the hit rate with a smaller concept scale.

Ontology construction efficiency evaluation--the construction duration was taken as the evaluation index for ontology construction efficiency. For the automatic construction technology, the major time consumers are resource acquisition, concept extraction and relation mining. Therefore, the duration of these three steps was calculated separately in the ontology construction efficiency experiment. The experimental results are displayed in Table 6.

Table 6
The Duration of the Main Processing Steps in Automatic Ontology Construction (Seconds)

Course	Resource acquisition	Concept extraction	Relation mining	Total
Introduction to e-commerce	773	6.9	14.7	794.6
e-marketing	611	5.3	11.7	628
e-commerce security	494	4.5	8.9	507.4
Supply chain management	547	4.2	9.5	560.7
Electronic payment and settlement	571	4.8	12.5	588.3

As shown in Table 6, the resource acquisition consumed the longest time, followed in descending order by relation mining and concept extraction. This is because the resource acquisition involved multiple processes, such as the discovery of web resources, the crawling of webpage information, the storage of downloaded resources, and the updating of data content. It is also learned that the automatic ontology construction technology can create the ontology of a course in an average of 10 minutes, much faster than the manual construction method. Suffice it to say the automatic technology maintains an obvious edge over the manual technology in working efficiency.

Evaluation of CKO-SPOC Flipped Classroom Teaching Model

After a semester of SPOC flipped classroom teaching of the course of E-commerce, questionnaire survey was conducted to 42 students from class 16-1, who are majored in international economics and trade at the end of the semester. There are 15 male students and 27 female students. 42 questionnaires were distributed and 42 valid questionnaires are collected back. The questionnaire mainly surveyed students' cognition of the flipped classroom, learning attitude, teaching application, etc.

1. Study on the cognition of our teaching model--after a semester of flipped classroom teaching,25.15% students state that they are very fond of the current flipped classroom teaching mode, 47.62% of them prefer this kind of teaching mode, 21.32% of them like this teaching mode and only a few students don't like this teaching mode, suggesting that the application of SPOC flipped classroom teaching mode in this course is conductive to their understanding and acceptance of this course.

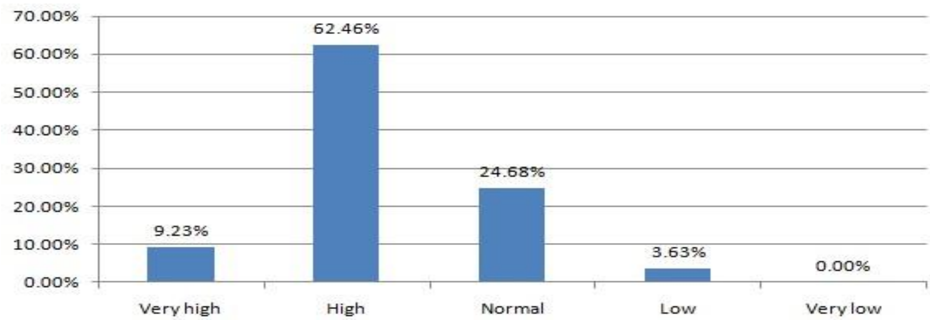

Figure 5. Student learning efficiency in the proposed model.

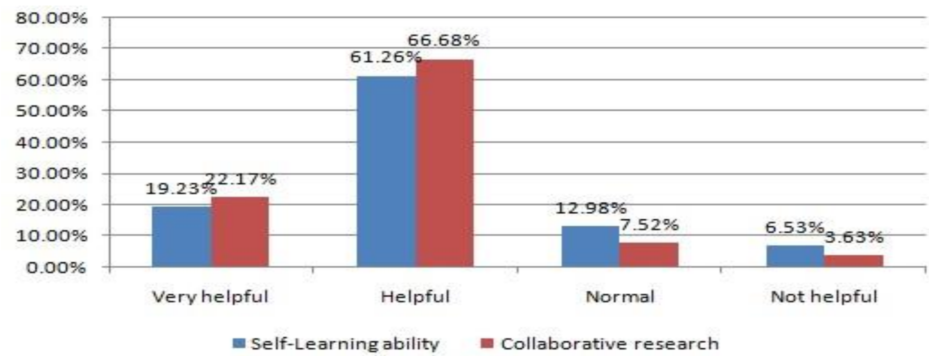

Figure 6. Benefits of the proposed model on self-learning and collaborative research.

As shown in Figure 5, more than 60 percent of students thought their learning efficiency is high through flipped classroom learning.

According to the survey (Figure 6), compared with the traditional classroom, CKO-SPOC flipped classroom plays a positive role in cultivating and improving students' self-learning and collaborative research ability.

In addition, survey on the promotion of the teacher-student communication and traditional teaching reform by the flipped classroom was carried out. The results show that 74% of students are satisfactory with the CKO-

SPOC flipped classroom, 19.16% of students feel quite satisfactory, 59.86% feel satisfactory and 14.32% feel average.

Table 7
Proportion of Students in Different Score Sections

	90-100	80-89	70-79	60-69	<60
CKO-SPOC	20.51%	54.24%	21.86%	3.39%	0%
Traditional SPOC	11.43%	48.57%	24.29%	13.50%	2.21%

Table 8
t-Test Results on the Independent Samples of the Final Exam Scores of Two Types of Classes

	N	Mean	Std. Deviatio	T	df	Sig(2-tailed)
CKO-SPOC	40	86.85	11.685	2.05	80	0.032
Traditional SPOC	42	77.54	11.242			

2. Comparative analysis of course scores--class 16-1 is taken as the CKO-SPOC flipped class and class16-2 is taken as the traditional SPOC flipped control class. The proportion of students in different sections of the final grade was counted (as shown in the Table 7, Table 8) to learn the change of number of students at different sections of the final grade. In addition, independent sample t-test was carried out to the grade to explore the teaching effect of CKO-SPOC flipped classroom.

It can be seen from the table that the CKO-SPOC flipped classroom teaching mode can effectively improve students' grade and reduce the proportion of students falling into the low score section. First, it can be seen from the graph of number of students in different score segments that the proportion of students who get more than points increased by 14.75 percentage point. Second, the independent sample t-test results show that the average score of class SPOC is 86.85, which is 9.31 points higher than that of the control class (77.54). When t(80/2) equals to 2.05, the value of p is 0.032, showing that the scores of the students of the two classes were significantly different at the 0.05 level. It is learned from the data analysis that the scores of students under the SPOC flipped classroom teaching mode are higher than the scores of students under traditional teaching mode.

Conclusion

The proliferation of new teaching models (e.g. MOOC, SPOC, flipped classroom and micro-classroom) has promoted the surge in the amount of curriculum teaching resources. Many problems have emerged in universities amidst the massive amount of heterogeneous teaching resources, such as the outdated management of curriculum resources and the low degree of automation. In this background, university teachers are faced with increasing workload, poor timeliness of teaching contents and backward teaching methods.

This paper attempts to solve these problems from the perspective of the big data. First, web mining and association rules were adopted to collect and integrate curriculum resources, draw the knowledge maps of the selected course, and set up corresponding databases. Then, the automatic ontology construction method was created based on the ontology theory, and applied to form the curriculum knowledge ontology. After that, the ontology was integrated with SPOC, flipped classroom and other new teaching model, forming the curriculum ontology-driven SPOC-based flipped classroom teaching model. Finally, the author carried out a comparative analysis, and proved that the proposed ontology construction technology outshines the manual construction technology in concept hit rate, relation coverage, scale and efficiency. The proposed teaching model was also applied to the actual teaching of the Electronic Commerce course. The practice demonstrates that the designed teaching model enriches the materials of the traditional SPOC-based flipped classroom teaching, deepened the students' understanding of the new e-commerce models, and enhanced their overall abilities like autonomous learning and collaborative research.

The future research will keep track of the students' learning trajectories, and establish a personalized curriculum resource recommendation model based on user personas, aiming to enhance the individuality and flexibility of the ontology construction technology. The highly individual and flexible technology will accelerate the shift towards the curriculum ontology-driven SPOC-based flipped classroom teaching model. Moreover, the author will attempt to group the students based on their pre-class learning outcomes, set specific teaching objectives for each group, and realize group-specific teaching in the classroom.

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