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Student-generated content in college teaching: content quality, behavioural pattern and learning performance

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Abstract This study investigates the quality of course content, behavioural patterns of students and learning performance in teaching of student-generated content (SGC). A total of 49 third-year university students in educational technology participated in this study. By combining the methods of questionnaire, lag sequence analysis and interview, the study found that (1) SGC quality was acceptable, (2) SGC process has 14 significant behavioural sequences, and (3) students developed their knowledge and capability and were satisfied with SGC-based teaching approach. In addition, this study revealed problems and proposed suggestions for SGC-based course teaching. Finally, implications for course teaching in colleges, the limitations and future research plan were presented.

Keywords behavioural sequence, college teaching, knowledge co-creation, student-generated content

Introduction

Global higher education faces enormous challenges and competition in the information age (Marginson, 2006), particularly in developing countries. Literature indicates that most university courses in China remain teacher centred and the students are only silent, passive recipients of knowledge (Jin & Cortazzi, 1998; Yao, 2007). Although various technologies are continually integrated into course teaching, the existing circumstances of college teaching remain unchanged.

The instruction system comprises four fundamental elements, namely instructor, learner, teaching material and teaching media (He, 2002). Reforming college teaching is a complex and systematic process and requires full structural changes. Aside from the variation of media technologies, the teaching and learning content should also be modernized to satisfy the need to cultivate more specialized talents in the 21st century (Wang & Chang, 2007).

User-generated content (UGC) has gained popularity over the last decade with the proliferation of Web 2.0 technologies. UGC refers to any form of content, such as wikis, blogs, video and images, which is created by common users of an online system or service (Moens, Li, & Chua, 2014). Several large and popular websites (e.g., YouTube, Wikipedia, Twitter and Connexions[1]) have adopted UGC to constantly create resources.

UGC provides a new idea to change the production method of teaching content, and provides opportunities for students to use the Internet to acquire, share and collaboratively develop course content in the learning process. Lee and McLoughlin (2007, p. 2) argued that 'a move toward student-generated content (SGC) has the potential to change higher education for the better through increasing student participation and

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knowledge construction'. The main purpose of SGC is to constantly develop knowledge by sharing and moulding the unique knowledge structures of students (Lee & McLoughlin, 2007). College students can create and generate ideas, concepts and knowledge.

The knowledge creation metaphor of learning indicates that learning is a process of developing collaborative-shared objects and artefacts (Paavola & Hakkarainen, 2005). Under this metaphor, SGC can be considered a typical process of co-creating knowledge objects in the course. A knowledge object is a precise way to describe the basic unit of content to be taught (Merrill, 2000). SGC has the potential to improve current college teaching, stimulate the creativity of students and reform the production of teaching materials. How to integrate SGC into college teaching is a new research topic and deserves attention to explore.

Literature review

Technology-enhanced teaching in universities

In the information age, technology is becoming a required element and playing a more important role in college teaching and learning. In general, technology-enhanced teaching in universities comprises two major types, as detailed below.

Traditional multimedia teaching (TMT)

Teachers often combine various forms of media, such as audio, graphics, animations and video, to improve instruction in multimedia classrooms. TMT is a kind of technology-enhanced face-to-face instruction and most commonly used in universities. Numerous studies indicate that multimedia teaching can effectively (1) enhance teaching efficiency (Riley & Pace, 1997), (2) promote active learning and facilitate student comprehension of knowledge (Stoloff, 1995), (3) stimulate learning interest and motivations (Erwin & Rieppi, 1999), and (4) enhance the self-efficacy and attitudes of students (Susskind, 2005). In recent years, several researchers investigate how teaching is conducted more effectively and efficiently in smart classrooms (Huang, Hu, & Yang, 2015; Manny-Ikan, Dagan, Tikochinski, & Zorman, 2011; Yang & Chen, 2013) because of the popularity of such classrooms, which is a kind of advanced, intelligent and humanized multimedia classroom (Huang, Hu, Yang, & Xiao, 2012).

Online teaching (OT)

With the rapid development of the Internet and learning management system (LMS) (e.g., Blackboard, Moodle and Sakai), OT began in distance education in the late 19th century (Oliver, 1999). In OT, teachers often conduct instructional activities, such as delivering materials, assigning homework and guiding students through LMSs (Coates, James, & Baldwin, 2005; McGill & Klobas, 2009). In fact, OT can be divided into two subcategories based on whether face-to-face teaching is integrated. One is almost online teaching (AOT), and the other is hybrid teaching (HT). For AOT, OT dominates the entire process of course instruction without any face-to-face teaching, whereas HT combines OT and traditional face-to-face teaching.

At present, AOT is widely used in open universities, such as the Open University of UK, the Open University of China and Athabasca University, but rarely used in common colleges and universities. Substantial research related to AOT in distance education has been conducted from the aspects of pedagogics (Anderson & Dron, 2010), instruction interaction (Abrami, Bernard, Bures, Borokhovski, & Tamim, 2011; Ding & Li, 2009; Hillman, Willis, & Gunawardena, 1994), role and competency of the instructor (Beaudoin, 1990; Williams, 2003) and teaching strategies (Zhang, Wang, Jiang, & Ye, 2010). In recent years, AOT has begun to emerge in common universities because of the proliferation of xMOOCs (Massive Open Online Courses) (Martin, 2012).

HT aims to cancel the divide between traditional and online instructions (Young, 2002). HT combines the advantages of face-to-face teaching and distance teaching with the power to satisfy various teaching needs, improve teaching quality and obtain economic benefits (Qi, 2008). Face-to-face instruction is dominant in most courses, whereas OT is auxiliary. Past studies have identified the positive influence of HT on the learning outcomes of students (Dowling, Godfrey, & Gyles, 2003; Hughes, 2007; Pereira et al., 2007), and heavily promoted this HT method in universities (Yu, Lu, & Chen, 2005). Although scholars found several problems with HT, such as more time consuming (Willson, 2008), technology hiccups and a sense of feeling lost in cyberspace (El Mansour & Mupinga, 2007), this method remains the most promising teaching method in universities in the current situation.

Overall, regardless of the method adopted, most teachers tend to design and implement teaching and learning activities surrounding the preset course content while neglecting the power and initiatives of the student in creating learning content. According to theories of generative learning (Wittrock, 1992) and construction of knowledge (Banks, 1993), teachers encourage students to participate in the creation of course content collaboratively and build knowledge by deep interactions. New approaches to technology-enhanced teaching from the perspective of generative content should receive more attention in future research.

Student-generated content

Education researchers have investigated the possibility of integrating UGC into teaching and learning in recent years because of its advantages in interactions and participations. SGC refers to content that is dynamically and spontaneously generated by students in the learning process (Lee & McLoughlin, 2007). Students can create substantial amounts of learning contents within a short time frame.

Much research on SGC is conducted in wiki-type systems, such as MediaWiki,[2] Hdwiki,[3] DokuWiki[4] and MoinMoin,[5] because of the essence of collaborative writing and ease of use in wiki systems. Wheeler, Yeomans, and Wheeler (2008) analysed the advantages and constraints of using typical wiki systems to promote collaborative learning of college students using SGC. They suggested that the benefits outweigh the limitations while using SGC in college teaching. Philip, Unruh, Lachman, and Pawlina (2008) asked students to co-create patient cases in a gross anatomy course with the support of an online knowledge-sharing portal utilizing MediaWiki. The results showed that the SGC method could enhance student competence regarding patient write-up and oral presentation. Li and Liu (2010) developed an online course integrated with face-to-face instruction to support hybrid learning using Semantic MediaWiki.[6] They indicated that SGC facilitated collaborative knowledge construction and maximized resource sharing and utilization.

Although many scholars tend to adopt wiki-type systems or tools to perform SGC, several problems have been identified in the process of using SGC such as the lack of group management and activity monitoring. Several studies focused on the development of new kinds of collaboration systems to improve support for students to co-create course content (Li, Dong, & Huang, 2011; Tan, Yu, & Lv, 2011; Wang & Turner, 2004; Yang & Yu, 2013a). Aside from co-creating course content, the process of creating questions, learning issues and discussions are also performed in SGC. Studies (Bates et al., 2012; Chin & Brown, 2002; Dolmans, Schmidt, & Gijselaers, 1994; Van Den Hurk, Wolfhagen, Dolmans, & Van Der Vleuten, 1999) have been conducted to investigate the effect of SGC on student engagement and learning performance. They found that SGC could enhance student engagement and improve student learning achievement compared with the traditional teacher-centred teaching approach. However, the analysis of the quality of generated content and the student behavioural pattern is neglected in these studies.

Learning analytics (LA) aims to observe and understand learning behaviour to enable appropriate interventions by the collection and analysis of usage data associated with student learning (Brown, 2011). LA can provide a new perspective to understand how students actually learn and interact in the online environment. In recent years, researchers have begun to use the method of lag sequential analysis (LSA) (Sackett, 1978) to analyse online learning behavioural patterns in different contexts, such as discussion forums, role-playing games and mobile learning (Hou, Sung, & Chang, 2009; Hou, 2012; Lan, Tsai, Yang, & Hung, 2012). However, student behavioural patterns in the context of SGC have been unexplored and remain unclear for researchers and teachers. Therefore, this study attempted to investigate behavioural patterns of college students in the process of SGC.

Method

This study primarily aims to investigate the quality of course content, behavioural patterns of students and learning performance while adopting SGC in college teaching. The three research questions are as follows:

- Can the students collaboratively produce high-quality course content guided by the instructor?
- What kind of behavioural pattern exists in the process of collaboratively creating course content?
- What are the learning performance and satisfaction levels of students in SGC-based course teaching?

In this study, learning performance specifically referred to learning gains including the development of course knowledge and related learning capabilities. We measured learning performance and student satisfaction on this new approach mainly via perception questionnaire and group interview. We performed LSA to explore the behavioural patterns of knowledge creation. LSA is mainly used to examine whether certain human behaviour followed by another behaviour occurs with statistical significance (Hawks, 1987). In recent years, the generalized sequential querier (GSEQ) is used to analyse the behavioural sequences of users (Hou, 2012; Hou et al., 2009; Lai & Hwang, 2015; Lan et al., 2012). Thus, we adopted GSEQ 5.1[7] as the analytical tool to evaluate student behavioural sequence.

Participants

One teacher and 49 third-year educational technology university students from Jiangsu Normal University participated in this study. The teacher, aged 32 years with a doctoral degree, was skilled at conducting OT using LMS, as well as a young scholar in the field of mobile and ubiquitous learning research.

Among the students, 13 were male (26.53%) and 36 were female (73.47%). Their average age was 21.57. All participants were randomly assigned to 12 groups. One group had five students and the rest had four students each. Each group recommended a leader to organize and coordinate the learning tasks. Each participant in this study had a laptop computer and at least 2 years of experience with online learning.

Background of the course

This study was conducted in one optional course, namely Theory and Practice of Mobile Learning, with two credits. All participants were enrolled in the course. The main purpose of the course was to help students fully understand the basic knowledge related to mobile learning, such as concept and features, theoretical basis, development history, resource and activity design, and available platforms. This course adopted a blended instruction method (Oh & Park, 2009), which combined face-to-face classroom teaching and online learning.

Classroom teaching was conducted in a traditional multimedia classroom equipped with one computer, one projector, two microphones, one projection screen and a set of stereo equipment. An online cooperative learning environment, learning cell system (LCS)[8] (Yu, Yang, Cheng, & Wang, 2015), was used to support the generation of course contents and the implementation of online learning activities.

Featured by multiple interactions, collaborative content editing, group management and activity monitoring, the main target users of LCS are college teachers and students, as well as primary and secondary school teachers. In this study, the teacher could assign learning tasks to groups, release course notifications, supervise activities in progress and provide guidance and comments. Students could create course contents collaboratively and interact through multiple ways, such as through annotation, comment, post and share functions.

All data on learning behaviour were stored automatically in the backend database of LCS for further LSA.

Instruments

In this study, the qualities of all the knowledge objects created by students were evaluated by the teacher and the researcher who specializes in mobile learning using the same evaluation criteria. In addition, several questionnaires were adopted to examine the perception of students on their learning gains and satisfaction.

Evaluation criteria of knowledge objects

Yang and Yu (2013b) proposed an evaluation index system of generative learning resource, which contained five indexes, namely content, structure, normalization, instructional value and liveness. They also developed an assessment scale with 22 items and good reliability (Cronbach's $\alpha = 0.92$) based on this index system.

In this study, we selected the first four key indicators (Table 1) and adopted a more concise scale (12 items, Cronbach's $\alpha = 0.89$) (See Appendix I). Each item was evaluated using a 5-point Likert-type scale. For example, if 'the logic of content is very strong' for an item, then the possible responses were 'strongly agree (5 points)', 'agree (4 points)', 'neutral (3 points)', 'disagree (2 points)' and 'strongly disagree (1 point)'.

All the knowledge objects were assessed separately by two experts with at least 3 years of research experience in m-learning using the concise evaluation scale.

Table 1. Quality Criteria of Knowledge Objects

Indicator	Description
Content	To evaluate whether the content of knowledge object is intact, accurate and logical
Structure	To evaluate whether the structure of knowledge object is organized clearly and reasonable
Instructional value	To evaluate the teaching value of knowledge object, such as the learning objective setting and learning activity design
Normalization	To evaluate whether the citations and references are consistent and accurate

Prior to the evaluation, the two raters negotiated the scoring details to guarantee high consistency. The inter-rater reliability was 0.81 ($p < 0.01$). We used the average grade of the two raters as the final score of each knowledge object because of the high consistency of scoring.

Perception questionnaire

The perception questionnaire (See Appendix II) was created to examine the perceptions of students on their learning gains and satisfaction on this new approach. This questionnaire consisted of two categories, namely 'satisfactions (4 questions)' and 'learning gains (10 questions)'. The questionnaire used a 5-point Likert-type scale (Cronbach's $\alpha = 0.77$). For example, for the item 'through this course, I found my information integration ability was improved', the possible responses were 'strongly agree', 'agree', 'neutral', 'disagree' and 'strongly disagree'.

The perceived satisfaction questionnaire was adopted from Chu, Hwang, Tsai, Tseng, and Judy (2010), with a revised Cronbach's $\alpha = 0.76$. We created the perceived learning gain questionnaire (Cronbach's $\alpha = 0.83$) to investigate the knowledge acquisition and capability development of students, such as information retrieval and integration, cooperation, and expression.

Student and teacher interview

At the end of this course, three groups with a total of 12 students were randomly selected for group interview about student attitudes and suggestions to the SGC-based course teaching. Moreover, the instructor was also interviewed to investigate the perception of teacher on this new teaching approach.

A researcher conducted all the interviews, which were transcribed using a recording pen (Lenovo Group Limited, Beijing, China). Each student group interview lasted about 45 min, whereas the teacher interview lasted 30 min. The interviewer completed the transcriptions, and then another researcher checked the transcriptions to ensure accuracy.

The student interview outline included the following three items: (1) What is your attitude towards SGC-based course teaching? (2) What did you learn from this course? (3) Please give your suggestions regarding the improvement of this new teaching approach. The teacher interview outline included the following two items: (1) Please describe your teaching experience in this course briefly; (2) What do you think of this new teaching approach?

Procedure

The course with three lessons each week lasted for 12 weeks. The detailed implementation is as follows. The teacher introduced this new teaching approach and discussed the course plan and learning needs with the students during the first week. The entire class was randomly divided into 12 groups. After the first class, each group was required to post their anticipated learning goals and learning contents in a discussion forum created by the teacher in LCS. The teacher analysed all the posts and constructed a course content map as the syllabus. The map was uploaded to the discussion forum to determine the views of students. Following student, the final syllabus was determined.

From weeks 2 to 11, the teacher adopted SGC method to implement course teaching. The detailed teaching plan is shown in Table 2. Figure 1 shows the procedure of SGC-based course teaching.

Before each class, the teacher would divide the teaching contents into small subjects. Each subject represented a specific topic in the area of mobile learning. In general, these topics were published in LCS at least 5 days ahead of the next class. These subjects were assigned to different groups. Then, group members discussed their content creation plan led by the group leader. Next, the students were organized in small groups to collaboratively create knowledge objects in

Table 2. Teaching Plan of This Course

Topic	Subtopic	Week
Course introduction (1 week)	Introduce and discuss the course plan, investigate the learning needs of students	1
Overview of m-learning (1 week)	The development background of m-learning	2
	The definition and characteristics of m-learning	
	The development phases of m-learning	
	M-learning and digital learning	
	M-learning and ubiquitous learning	
	M-learning and smart learning	
	Domestic research on m-learning	
	Overseas research on m-learning	
Theoretical basis of m-learning (2 weeks)	Distributed cognition theory	3
	Informal learning theory	
	Situated cognition and learning theory	
	Connectivism theory	4
	Activity theory	
	Experience learning theory	
Development of m-learning platform (2 weeks)	Introduction to the main mobile operating systems	5
	Investigation and analysis of m-learning platform	
	The trend of m-learning platform	
	The development technologies of m-learning platform	6
	The prototype design of m-learning platform	
Design of m-learning resources (2 weeks)	The definition and characteristics of m-learning resource	7
	Existing problems of the construction of m-learning resource	
	The design principles of m-learning resource	
	Analysis of typical m-learning resources	
	The mainstream developing tools of m-learning resource	8
	The trend in m-learning resource development	
Design of m-learning activities (2 weeks)	The design principles of m-learning activity	9
	The design patterns of m-learning activity	
	Case analysis of m-learning activity	
	Design new m-learning activities	10
Course review (1 week)	Student reviewed the course and prepared for the final exam	11
Course examination	The final examination was conducted	12

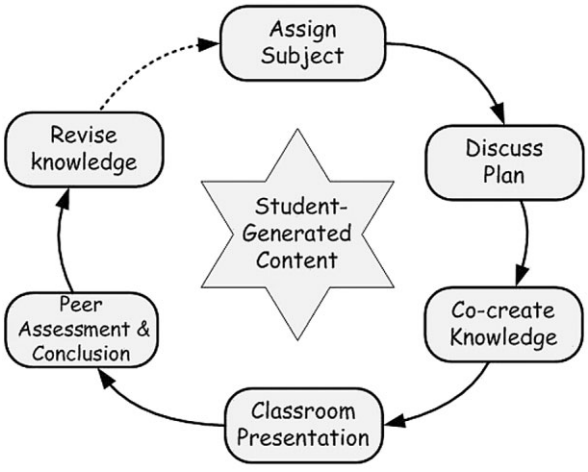

Figure 1 Procedure of SGC-Based Course Teaching

LCS. In the process of co-creating knowledge, we adopted the method of three-phase cooperation learning (TPCL) proposed by Yang, Li, Guo, & Li (2015). TPCL comprised two intra-cooperations and one inter-cooperation. In the two intra-cooperations, students created and revised their own knowledge object collaboratively. In the inter-cooperation, students mainly provided suggestions and comments to knowledge objects created by other groups. Before the next class, the students were also required to review the knowledge objects of other groups and comment on the output of each group.

Each group would provide a short presentation (approximately 5 min) on their own topic in class. Students in other groups could ask questions and obtain answers from the reporter and his or her team members. For select significant and ambiguous

Table 3. Coding Scheme of User Behaviour

Code	Behaviour	Explanation
EC	Edit content	Users edit content of the knowledge object
ED	Edit metadata	Users edit and improve the metadata of the knowledge object, such as title, tags, classification and abstract
IC	Invite collaborator	The creator invites other users to be collaborators of the knowledge object
SC	Score	Users rate the knowledge object according to his or her overall evaluation
CM	Comment	Users provide comments to the knowledge object about its content, structure or specification
PS	Post	Users discuss in the forum
AN	Annotate	Users record notes or propose suggestions on certain specific sections of the knowledge object
SH	Share	Users share the knowledge object with others by recommending it to other communities

questions, the teacher would explain further or ask students to discuss face-to-face. At the end of the class, the teacher provides a summary and a holistic evaluation on the knowledge creation, class presentation and online interaction. After the class, the students will revise and improve the knowledge objects based on the comments and suggestions from the teacher and other groups.

On week 12, the students reviewed all the learning contents in this course and prepared for the final exam. The students could ask any questions related to the course both online and offline, and the teacher attempted to resolve each question and provide specific guidance. Moreover, the student and teacher interviews regarding their perceptions on this new teaching approach were conducted.

Data collection and coding

Qualitative and quantitative data were collected in this study including online interactions of students, behaviour logs of students, perception questionnaire, scores of knowledge objects, and student and teacher interviews.

The behaviour logs of students were used to conduct LSA to identify significant behavioural sequences during the process of knowledge creation and student interaction. Interaction indicated all the actions of comment, annotation and post, which were the three main channels of student discussion in LCS. Each action (e.g., post, reply to a post) was considered an interaction. Interaction time, representing the degree of student discussions, referred to the total number of student interaction on each knowledge object. The knowledge object scores were used to evaluate the qualities of knowledge objects and for correlation analysis with student engagement data. The perception questionnaire data were used to evaluate the learning gains of students through descriptive analysis. The student and teacher interview data were mainly used to determine attitudes and suggestions of participants towards the SGC-based course teaching through initial content analysis.

During the process of collaborative authoring, various kinds of user behaviour occurred, and any behaviour was recoded in LCS. In this study, we focused on investigating the behaviour directly related to knowledge authoring and knowledge sharing when new knowledge objects were created. In this case, eight kinds of user behaviour were finally selected to conduct the sequential analysis. The coding scheme is shown in Table 3. All behavioural categories were identified automatically and did not require manual coding. Therefore, the behavioural sequence codes were objective without considering the coding reliability.

Results

Qualities of knowledge objects

Students created 29 knowledge objects in this course. Table 4 shows basic information on these knowledge objects. On average, students would improve the content continually for over a month for each knowledge object. Many revisions and discussions (i.e., comment, post and annotation) occurred in each

Table 4. Descriptive Statistics of Knowledge Objects

	Evol_time	Revision	Comment	Annotate	Post	Contributor	Length
Maximum	49	199	76	16	14	19	20 621
Minimum	15	41	35	2	0	8	3340
Mean	36.52	85	49.34	8.66	3.10	11.69	8801.41
SD	11.18	37.44	10.17	3.80	3.89	2.02	4374.08

Evol_time = last revised time – creation time, the measuring unit is day.

knowledge object. Approximately a quarter of the students contributed (i.e., revision) to the development of each knowledge object.

Two raters evaluated the quality of 29 knowledge objects following the criteria. Table 5 shows the evaluation results. Overall, the quality of knowledge objects generated by students was good and acceptable ($M = 3.99$). The scores in four dimensions were all approximately four points.

Correlation analysis was conducted to identify the relationships between the interaction and content length, and between the interaction and quality of the knowledge object. Table 6 indicates significant and positive correlations between the user interaction times and the content length ($r = 0.483$), as well as the quality of knowledge objects ($r = 0.629$).

Distribution and sequence of student behaviour

First, the frequency distribution analysis of student behaviour was conducted. Among 3442 behaviour codes, the percentages of different operant behaviour are shown in Figure 2.

The most frequently occurring behaviours are CM (comment, 39%), SC (score, 30%) and EC (edit content, 19%). The results indicate that when users entered the page of one knowledge object, they were particularly prone to edit contents, discuss issues surrounding certain topic and grade knowledge objects. Students can conduct online discussions and exchange ideas in three ways, namely through comment, annotation and post functions, on the page of knowledge object in LCS. Figure 2 indicates that students in this course preferred to use the comment area at the bottom of the page to communicate compared with the annotation tool and discussion board.

Next, LSA was conducted to identify the significant behavioural sequences in the SGC process. Each knowledge object was treated as the basic unit. User behaviour related with knowledge co-authoring and knowledge sharing attached to the knowledge object were coded based on their temporal order. Table 7 shows the results of the adjusted residuals. If Z-value of a sequence is greater than 1.96, then this sequence has statistical significance (Bakeman & Gottman, 1997).

We extracted 14 significant sequences to develop a visual behavioural transition diagram (Figure 3). The sequences that reached significance during co-authoring and sharing knowledge were EC→EC, EC→IC, EC→PS, ED→EC, ED→SH, IC→EC, IC→ED, SC→CM, CM→SC, PS→PS, PS→SH, AN→EC, AN→AN and SH→PS (see Table 3 for the definition of the codes).

Learning gains and satisfaction

The average score of student self-evaluation on learning gains was 4.00 ($SD = 0.39$). In the aspect of knowledge acquisition, the average score was 3.99, whereas the capability development was 4.00. The results implied that students in this course believed they gained developments in both knowledge and capability

Table 5. Results of Quality Evaluation

	Content	Structure	Instructional value	Normalization	Overall
Maximum	4.75	5.00	3.00	3.00	4.50
Minimum	3.25	3.50	4.67	4.67	3.50
Mean	3.97	4.19	3.91	3.95	3.99
SD	0.47	0.51	0.41	0.36	0.35

Table 6. Results of Correlation Analysis

		Length	Quality
Interaction times	*r*	0.483**	0.629**
	p	0.008	0.000

**$p < 0.01$.

(e.g., information integration ability, cooperation ability and expression ability). In addition, the result of satisfaction survey showed that students were satisfied with the new SGC-based teaching approach ($M = 3.74$, $SD = 0.61$).

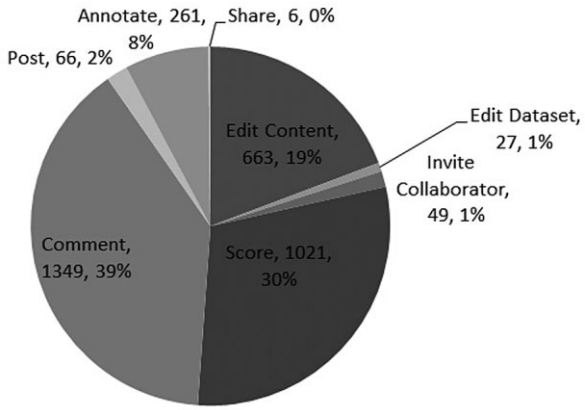

Figure 2 Percentages of Different Behaviour

Discussion

Quality of course content and the control strategy

The present study indicated that SGC was feasible for college courses. College students are able to co-create knowledge objects guided by the instructor. Table 5 indicates that the course content created by students had a satisfactory quality. In the SGC process, students undoubtedly created the main body. They are both the creators of content and the consumer of content. Through group cooperation and multiple interactions, the knowledge objects could be improved continually. The instructor also has an important role in this course. He became an organizer, a director and a supervisor of the SGC activities. According to Wheeler et al. (2008), teachers 'should act as moderators rather than instructors, and may need to restrain themselves from direct action, in order to promote free and democratic development of content according to the principles embodied in the "wisdom of the masses".' Students can seek help from the instructor online and offline.

Table 7. Adjusted Residuals Table (*Z*-Scores)

	EC	ED	IC	SC	CM	PS	AN	SH
EC	23.00*	0.58	10.16*	–5.80	–16.92	2.33*	1.54	0.03
ED	5.14*	–0.44	1.06	–2.49	–2.13	–0.71	–0.73	10.09*
IC	2.64*	28.35*	0.40	–3.61	–2.97	–0.97	–0.91	–0.27
SC	–15.85	–3.28	–4.56	–17.03	36.58*	–4.50	–9.14	–1.46
CM	–6.83	–3.17	–3.46	23.34*	–14.40	–3.39	0.70	–0.86
PS	0.29	–0.70	–0.97	–3.14	–3.52	19.00*	1.90	2.96*
AN	2.42*	–1.44	–0.91	–0.55	–7.64	0.96	11.94*	–0.64
SH	1.23	–0.19	–0.27	–1.46	0.02	2.96*	–0.64	–0.09

*$p < 0.05$.

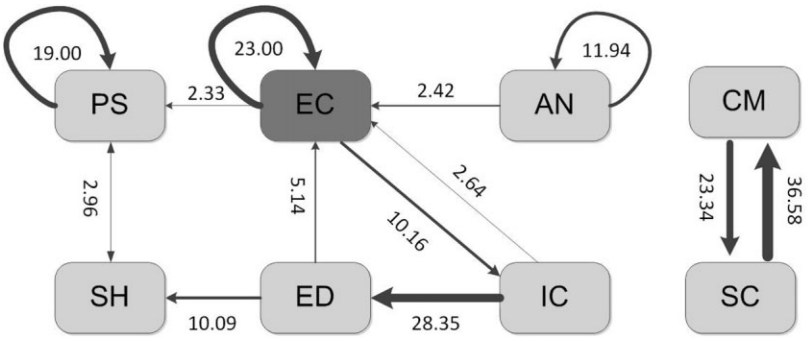

Figure 3 Behavioural Transition Diagram Node: behavioural category; number: *Z*-value; arrowhead: transitional direction; thickness: significance level.

The self-organizing mode of collaborative authoring in Wikipedia (Forte, Larco, & Bruckman, 2009) is unsuitable for college courses. Wikipedia has a large population of users who participated in the improvement of entries. Thus, collaborative authoring with complete self-organization can ensure the content quality. However, several measures must be employed to control the quality in college courses. In this study, we combined a few strategies to enhance the quality of knowledge objects. First, we adopted the method of TPCL. Two intra-cooperations were helpful to create high-quality contents, while the inter-cooperation could generate various insightful suggestions. The inter-cooperation was also a process to create learning contents by other groups. Second, peer assessment was integrated into the SGC activity. Considerable research demonstrated the effectiveness of peer assessment in the teaching and learning of many subjects (Chetcuti & Cutajar, 2014; Gielen, Dochy, Onghena, Struyven, & Smeets, 2011; Van Zundert, Sluijsmans, & Van Merriënboer, 2010). In this study, any student could score and comment on the knowledge objects created by other groups online. Moreover, groups could rate the presentation and pose questions on each other. Peer assessment can motivate the students to try their best to improve the knowledge objects. Third, the instructor ensures the accuracy of the content. In this study, the instructor comments on the presentations of students in class and provides suggestions for improvement. Furthermore, the instructor often recommends certain related websites and academic papers to expand the vision and knowledge of the students.

A strong relationship existed between the interaction and quality as shown in Table 6. The interaction was a good predictor of content quality. Therefore, promoting the effective interactions among students should be a research focus to enhance the quality of knowledge objects in future SGC activities.

Drawbacks were identified via expert rating and content check. First, the normalization of citations and references should be strengthened by the methods to integrate the functionality of automatic inspection and the instruction of reference standard. Second, the design of learning activity in knowledge objects was not rich and flexible. Contrary to Wikipedia entries, the knowledge object must have instructional values. Students should complete the creation of instructional contents, as well as the design of learning activity to engage students. Certain support can be provided to assist students to design high-quality learning activities, such as design principles, templates and typical cases.

Student behavioural patterns and improvement

The results of LSA (Figure 3) indicated that the major online behavioural patterns of students in this course could be generally described as follows: (1) students tended to edit content repeatedly for a certain time (EC→EC, Z-score = 23.00); (2) when students have completed content editing, they might invite collaborators (EC→IC, Z-score = 10.16) to improve the basic information of knowledge objects (IC→ED, Z-score = 28.35) or return to content editing (IC→EC, Z-score = 2.64); (3) students often shared knowledge objects with other social sites or communities after revising the data sets (ED→SH, Z-score = 10.09); (4) students preferred publishing annotations and posts continuously in certain time period (AN→AN, Z-score = 11.94; PS→PS, Z-score = 19.00); (5) when students have completed the annotations, they tended to edit contents (AN→EC, Z-score = 2.42); and (6) students usually comment and score the knowledge objects successively (CM→SC, Z-score = 23.34; SC→CM, Z-score = 36.58).

Two significant behavioural paths, CM→EC and PS→EC, were missing in Figure 3, indicating that the students did not improve the content on time according to the suggestions and ideas generated in interactions after they completed the discussion. To promote the evolution (Sun, 2011) and externalization of knowledge (Holsapple & Joshi, 2002), the paths of CM→EC and PS→EC must be strengthened in the future via behaviour guidance strategies, such as pop-up messages, to remind users to improve resource content. In addition, CM→CM is another vital behavioural path that required reinforcement. To develop the higher order thinking (Lewis & Smith, 1993) abilities of students, in-depth, collaborative discussion is essential. Therefore, the design of comment area in LCS will be optimized to promote continuous discussions. For example, the hierarchical structure such as knowledge forum (Scardamalia, 2004) is used to create clear and smooth discussion thread.

Learning performance and student suggestions

SGC is not only a new method to construct course contents, but also a new learner-centred approach to course teaching. In this study, students were satisfied with their learning performance including knowledge acquisition and capability development. The average score in the final exam was 90.14 out of 100 ($SD = 7.36$). The instructor in the interview mentioned that 'compared with the course teaching last year, students in this semester have a higher motivation and engagement. Their achievement and the completion of each assignment were even better'. Several other studies also identified the effectiveness of SGC on student learning outcomes (Li & Liu, 2010; Philip et al., 2008). In addition, the instructor expressed a maladjustment towards SGC-based teaching approach in the first 2–3 weeks. As the experiment progressed, he gradually adjusted to this approach. The instructor required time for the role transformation.

According to Bostock (1998), allowing students to create course content collaboratively and consult with teachers is consistent with constructivist theory. The contents generated by the students conformed to their needs, showing their greater interest in course learning. In the group interview, the students mentioned they liked to browse their own contents and the ones created by other groups.

Overall, the students held positive attitudes towards SGC and gained much from this course. The students also mentioned certain major benefits. First, they gained a comprehensive understanding of the mobile learning, including basic concepts, theories, platforms, learning resources and learning activities. Second, the abilities of cooperation and communication were enhanced significantly. According to several students, 'before this course, communicating with others is very difficult for me. However, with the progress of SGC activities, I feel much better at communicating with group members' (Student No. 3); 'Collaborative authoring can provide each student with opportunities to contribute their wisdom, which embodies the real value of collaborative learning and is helpful for strengthening our collaborative skills' (Student No. 7). Third, they became more confident in classroom presentation and dared to criticize and comment on each other. A student mentioned that 'peer assessment makes me willing to find "bugs" in the work of other groups, and gradually form the critical ability and awareness' (Student No. 9). Finally, they responded that the relationship between students and the instructor improved. Meanwhile, the cohesion of the entire class was strengthened through mutual evaluation and cooperation.

Problems were also identified in the interviews. First, most of the respondents thought the tasks in this course were slightly heavy for them. They suggested the time allocated for content authoring of each knowledge object should be extended. Second, the inter-group cooperation was unsatisfactory. They expected that the instructor could provide certain measures to promote inter-group cooperation. Third, they hoped to use mobile devices to participate more flexibly in the activities of content view, score and comment.

Conclusion

In this study, we investigated the quality of course content, behavioural patterns of students and learning performance in SGC-based course teaching. The major findings are: (1) SGC quality was good and acceptable; (2) 14 significant behavioural sequences were identified including EC→EC, EC→IC, EC→PS, ED→EC, ED→SH, IC→EC, IC→ED, SC→CM, CM→SC, PS→PS, PS→SH, AN→EC, AN→AN and SH→PS; and (3) students developed both knowledge and capability, and were satisfied with SGC-based teaching approach.

These findings can help improve current course teaching in colleges. The implications of this study are as follows: (1) college students have the ability to create course content collaboratively and teachers should consider the initiative and creativity of students in college teaching; (2) the approach of SGC-based course teaching is effective and worth replicating in other courses; and (3) group cooperation, multiple interactions and role transformation of the teacher are very important for the success of SGC-based course teaching.

Select limitations of this study are acknowledged. First, considering the absence of control groups, the results cannot be compared with those of the traditional course teaching method. Second, the methods of perception questionnaire and group interview cannot measure learning performance accurately. Third, we could not control offline interaction of student and

collect these offline behaviour data. In the future, we plan to (1) conduct an equivalent group experiment in other courses, (2) improve the measures of learning performance, and (3) investigate the effect of different teacher roles on the learning performance in SGC-based course teaching.

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Notes

[1]An open-access repository to create and store learning resources, homepage: http://cnx.org.
[2]https://www.mediawiki.org/wiki/MediaWiki.
[3]http://kaiyuan.hudong.com/.
[4]https://www.dokuwiki.org/dokuwiki.
[5]http://moinmo.in/.
[6]https://semantic-mediawiki.org/.
[7]http://www2.gsu.edu/~psyrab/gseq/Download.html.
[8]http://lcell.bnu.edu.cn.

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Appendixes

Appendix I Scale items of knowledge object assessment

1. The content of knowledge object is intact.
2. The description of knowledge object is precise.
3. The content of knowledge object is logical.
4. The knowledge object provides various extensible contents.
5. The structure of knowledge object is clear.
6. The structure of knowledge object is reasonable.
7. The content of knowledge object has instructional value.
8. The description of learning objective is consistent with the content of knowledge object.
9. The design of learning activities in knowledge object is appropriate and reasonable.
10. The references of knowledge object are marked clearly.

11. The references of knowledge object are marked accurately.
12. The references of knowledge object are marked in a consistent form.

Appendix II Items of perception questionnaire

Dimension	Item
Satisfaction	1. I think the SGC-based teaching is interesting.
	2. I think the SGC-based teaching enhances my learning motivation and interest in this course.
	3. I think the SGC-based teaching gives me more opportunities to think and communicate.
	4. I would like teachers to use SGC-based teaching in other courses.
Learning gain	5. I think I have achieved the learning objective of this course.
	6. I think I have learned much new knowledge in this course.
	7. I think I have mastered the key contents in this course.
	8. I think my cooperation ability has been enhanced in this course.
	9. I think my communication ability has been enhanced in this course.
	10. I think my information retrieve ability has been enhanced in this course.
	11. I think my information integration ability has been enhanced in this course.
	12. I think my literature reading ability has been enhanced in this course.
	13. I think my capability of academic writing has been enhanced in this course.
	14. I think my capability of analysing and solving problems has been enhanced in this course.