Postprint of Rain Classroom-Based Flipped Classroom Teaching for Science and Technology Information Retrieval Course

Authors: Li Ling, Chen Chao

Date: 2023-07-26T00:00:00+00:00

Abstract

[目的/意义] Educational models are currently undergoing a major transformation characterized by the deep integration of learning technologies and teaching. Actively adopting advanced teaching methods is an essential path for the reform and enhancement of traditional curricula. By summarizing the teaching practice of implementing a flipped classroom for the Scientific and Technical Information Retrieval course based on Rain Classroom, this study aims to provide a reference for teaching similar information literacy education courses.

[方法/过程] Using the empirical research method, this paper introduces the key points of course instructional design from aspects such as selection of teaching technology, orientation of teaching objectives, design of learning time, design of learning resources, design of practice exercises, and design of classroom activities; and evaluates the course effectiveness through the questionnaire survey method.

[结果/结论] The course implementation strengthened the practical application objectives of the course, enhanced student engagement, strengthened teacher-student interaction, enriched learning modalities, cultivated students' autonomous learning abilities and teamwork skills, and achieved favorable teaching outcomes.

Full Text

Flipped Classroom Teaching of Science and Technology Information Retrieval Courses Based on Rain Classroom

Li Ling[1,2], **Chen Chao**[1,2] [1] National Science Library, Chinese Academy of Sciences, Beijing 100190 [2] Department of Library, Information and Archives

Management, School of Economics and Management, University of Chinese Academy of Sciences, Beijing 100190

Abstract: [Purpose/Significance] Educational models are undergoing a major transformation through the deep integration of learning technology and teaching. Actively adopting advanced teaching methods is essential for reforming and upgrading traditional curricula. This paper summarizes the teaching practice of implementing a flipped classroom for science and technology information retrieval courses using Rain Classroom, aiming to provide reference for similar information literacy education courses. [Method/Process] Using empirical research methods, we introduce the key points of instructional design from the aspects of teaching technology selection, teaching objective orientation, learning time design, learning resource design, exercise design, and classroom activity design. The course effectiveness was evaluated through questionnaire surveys. [Result/Conclusion] The implementation strengthened the practical application objectives of the course, mobilized student participation, enhanced teacher-student interaction, enriched learning formats, cultivated students' autonomous learning and teamwork abilities, and achieved good teaching results.

Keywords: flipped classroom; Rain Classroom; information literacy; information retrieval course

---

1 Background

Offering information retrieval courses has been a common practice in university libraries in China for decades, playing a crucial role in cultivating students' information retrieval abilities, enhancing their information literacy, and strengthening their innovative capabilities. The University of Chinese Academy of Sciences (formerly the Graduate University of Chinese Academy of Sciences) has offered science and technology information retrieval courses since the 2006 summer semester. The curriculum now includes 10 courses: public required courses for engineering master's students across various disciplines and public elective courses for all master's students. Each course comprises 27 class hours and 1 credit, offered in both spring and fall semesters annually. The courses aim to help graduate students master essential science and technology information retrieval skills needed for scientific research, cultivate their ability to apply knowledge and work in teams, and enhance their capacity to identify, retrieve, analyze, and utilize information to solve practical problems, thereby improving their research capabilities in specific contexts and fostering lifelong learning skills. Additionally, information literacy education has been expanded to include innovation literacy education, with new courses such as "Science and Technology Trend Analysis," "Research Methods and Academic Paper Writing & Submission," and "Research Integrity and Ethics" that reflect innovative qualities and capabilities.

The most prominent feature of these courses is their strong practical orientation. Through over a decade of teaching practice, we have developed a student-centered, skill-focused, application-oriented, and practice-emphasized teaching philosophy. Following the principle of concise lectures with ample practice, instructors allow students more time to learn through hands-on experience, training them to solve literature retrieval problems in their professional fields using acquired knowledge.

Large-class teaching has long been a challenge for this course. With computer labs accommodating up to 156 students and typical teacher-student ratios of approximately 1:150, many students cannot promptly express viewpoints or receive feedback during class. Instructors struggle to adequately understand and assess each student's knowledge application and practical skills, making timely evaluation and feedback difficult. How to improve large-class teaching effectiveness has been a persistent problem that this course has continuously explored and sought to solve over the years.

To strengthen practical application components, all courses are taught in computer labs. However, the poor interactivity of large-class teaching remains a prominent issue. Therefore, in the fall semester of 2018, we conducted a teaching experiment integrating new educational technologies into the "Computer Science and Technology Information Retrieval Course" (hereinafter referred to as "this course"). Building on the original curriculum design, we comprehensively reformed teaching content, activities, and methods by adopting flipped classroom and Rain Classroom technologies. This study summarizes this teaching practice and its effectiveness evaluation, aiming to further improve instructional design, enhance teaching effectiveness, and provide reference for colleagues engaged in similar information literacy education.

---

2 Teaching Technology Selection

With the rapid development of internet technology and the widespread adoption of mobile smart devices, information storage and dissemination methods have undergone tremendous changes, and educational models worldwide are experiencing a major transformation through the deep integration of learning technology and teaching [1]. Actively adopting advanced teaching methods is the only path for reforming and upgrading traditional curricula.

2.1 Integrating Flipped Classroom into Course Teaching The flipped classroom model breaks traditional teaching sequences by shifting from "teaching first, learning second" to "learning first, teaching second." It restructures student time across "pre-class, in-class, and post-class" phases, transforming classroom time from one-way knowledge transmission to interactive activities such as discussions and sharing [2], thereby strengthening knowledge internalization and achieving instructional innovation. In recent years, the effectiveness of flipped classrooms has gained increasing recognition in the educational community. Research surveying over 100 schools implementing flipped classroom projects across more than 20 cities in China demonstrated positive effects on stimulating student interest, cultivating autonomous learning and cooperation abilities, promoting thinking skill development, fostering practical capabilities, and improving academic performance [3].

The decision to integrate flipped classroom concepts into this course design was based on four considerations: (1) **Student profile**: Graduate students, as a group capable of autonomous and inquiry-based learning, possess the ability to engage in flipped learning. (2) **Course nature**: As a highly practical course emphasizing hands-on effectiveness, science and technology information retrieval is well-suited for flipped teaching. (3) **Learning resources**: This course has excellent educational resources available to provide rich learning materials for flipped learning. (4) **Student needs**: Securing more class time for practical application, case explanations, and interactive discussions responds to requests and suggestions from elective students and truly implements the course's practice-oriented teaching philosophy.

2.2 Implementing Flipped Classroom Through Rain Classroom Implementing flipped classroom in a class of over 150 students urgently required solving the interactivity problem of large-class teaching. Adopting advanced teaching tools could provide necessary technical support for flipped classroom implementation. After preliminary research and experimentation, this course decided to adopt Rain Classroom, a smart teaching tool co-developed by XuetangX and Tsinghua University's Online Education Office [4].

Rain Classroom integrates advanced information technology into PowerPoint and WeChat, connecting teachers' and students' smart terminals and covering every teaching 环节 from pre-class to in-class to post-class. It helps improve the efficiency and effectiveness of flipped classroom implementation in terms of teaching resources, activities, management, and evaluation: (1) **Teaching resources**: Supports PPT creation, question pushing, and mass announcements, delivering content through multiple display methods. (2) **Teaching activities**: Enables online quizzes, red packet rewards, bullet comments, and in-class submissions, ensuring every student can participate in classroom activities within limited time. (3) **Teaching management**: Provides comprehensive data collection and analysis for refined and personalized teaching management and guidance. (4) **Teaching evaluation**: Obtains student feedback through functions like in-class submissions and "I don't understand" buttons, allowing timely adjustment of flipped classroom strategies.

3 Course Instructional Design

3.1 Teaching Objective Orientation This course first established its teaching objective orientation: focusing on graduate students' literature review for thesis proposals and entry into specific research topics. Instruction revolves around key knowledge points throughout the entire process of "proposing research questions → defining information needs → selecting information sources → developing retrieval strategies → evaluating and screening information → effectively acquiring information → efficiently managing information → rationally utilizing information" (see Figure 1 [Figure 1: see original paper]). The curriculum integrates various important information resources, services, platforms, and tools in the computer science field through theoretical learning and practical training, enabling students to comprehensively apply acquired knowledge to creatively solve various problems in literature retrieval and utilization, thereby supporting their research projects. By strengthening practical application components, the course cultivates and enhances students' information literacy, critical thinking, teamwork, and innovation abilities.

3.2 Learning Time Design With only 27 class hours to be completed within 9 weeks (3 hours per week), classroom time is clearly insufficient to achieve the above teaching objectives. Based on flipped classroom concepts, some learning content was extended to students' fragmented pre-class time for autonomous learning, securing more class time for case explanations, hands-on practice, interactive discussions, and teamwork sharing activities to better promote knowledge internalization and cultivate students' creative application abilities.

Considering students' heavy academic workload and concerns that flipped classroom models might occupy too much extracurricular time [5], this course selected only key content for flipped learning and comprehensively controlled the total "pre-class, in-class, and post-class" workload, limiting weekly extracurricular learning tasks (including pre-class and post-class assignments) to 1-3 hours. By subdividing knowledge points and creating video resources such as "Learning Guides," the course helped students independently select knowledge points based on their existing foundation and learning ability, enabling them to use fragmented time for learning anytime and anywhere, reducing ineffective learning time, and improving efficiency.

3.3 Learning Resource Design This course provided abundant flipped learning resources, including various types of text/image and video resources created by instructors or collected from the internet. These resources, with their distinct characteristics, complemented and integrated with each other to form a flipped classroom learning resource library meeting diverse scenario-based learning needs, as shown in Table 1 .

Table 1. Comparison of Various Learning Resource Types

Resource Type	Characteristics	Advantages	Disadvantages
PPT Courseware	Comprehensive and systematic content	Short production cycle	-
Papers	-	-	-
Books	-	-	-
Reports	-	-	-
Standards	-	-	-
New Media	-	-	-
Micro-courses	Short learning time, knowledge point-based	Lively and engaging language	-
Live Broadcasts	-	Short production cycle, strong timeliness	-

3.3.1 Text/Image Resources The main characteristic of text/image resources is their comprehensive and systematic content, enabling students' extended learning. Resources provided include not only instructors' PPT courseware and selected journal articles, books, reports, and standards, but also new media resources such as WeChat public accounts closely related to course knowledge points. For the knowledge point of "reference writing and identification," pre-class materials included both the national standard "GB/T 7714-2015 Rules for Bibliographic References" [6] and a WeChat article titled "Interpretation of the New National Standard GB/T 7714-2015 for Bibliographic References" [7]. While the former was systematically comprehensive, the latter, with its lively language and rich illustrations, received more attention and welcome from students. New media resources are highly timely and suitable for learning new content, as many databases and tools release updates through public account articles, becoming the latest learning resources pushed to students.

3.3.2 Video Resources Video resources are vivid and highly suitable for flipped classrooms. MOOCs and micro-courses focus on knowledge point explanations with short learning times, facilitating students' use of fragmented time. Live broadcasts have short production cycles and strong timeliness, making them convenient for providing the latest learning content.

This course adopted both self-produced and online video resources. The advantage of self-produced videos is that content completely aligns with course teaching, with duration controlled at 5-10 minutes, perfectly matching flipped learning requirements. However, the disadvantages include long production cycles and poor timeliness. The authors once spent considerable effort recording MOOC courses on Endnote and standard literature retrieval, but due to interface updates, only small portions remained suitable for current teaching. To avoid heavy lesson preparation burdens, we focused on fully utilizing open educational resources by specifically collecting and organizing relevant MOOCs, micro-courses, and live broadcast videos online. Through processing steps such as knowledge point identification and "Learning Guide" creation, these were transformed into high-quality learning resources suitable for this course, enriching the flipped classroom teaching material library.

For Endnote literature management software teaching, we used Clarivate's micro-course videos [8] and created a matching "Endnote Video Learning Guide" for course knowledge points. To intuitively demonstrate its production process, this paper excerpts part of the "Literature Import Techniques" content (see Table 2) for illustration. Table 2 identifies key elements including video titles, duration, contained knowledge points, and their start times, with notes specifying applicable scenarios and operation points for each knowledge point. These knowledge points were then thematically clustered to form a complete "Learning Guide" for students. The "Learning Guide" provides great convenience for students to flexibly and independently select video learning content. Students can also continuously supplement the guide's content to form personal knowledge repositories, systematizing scattered knowledge points.

Table 2. Endnote Video Learning Guide: Literature Import Techniques

Video Title	Duration	Knowledge Points	Start Time	Notes
Building Your Personal Library	05 17	Creating Personal Subject Library	02 30	File→New
5 Methods for Literature Import (Part 1)	06 29	Importing from Databases	03 18	Using WoS as example
5 Methods for Literature Import (Part 2)	04 12	Importing Foreign Language Literature	00 20	Using CNKI as example
5 Methods for Literature Import (Part 3)	11 41	Importing Chinese Literature	00 51	Download small plugin
5 Methods for Literature Import (Part 4)	07 09	Importing from Web Pages	01 40	2-level folders
		Importing Local Literature	02 50	PDF Handling

Video Title	Duration	Knowledge Points	Start Time	Notes
		Single PDF Import	00 40	Find Reference Update
		Batch PDF Import	02 10	51 literature types
		Automatic PDF Folder Import	00 20	
		Incomplete Literature Import	00 46	
		Online Retrieval Import	01 50	
		Manual Literature Addition	03 03	

3.4 Exercise Design Exercises in this course run through the entire teaching process of pre-class, in-class, and post-class, divided into three types: pre-class checkpoint quizzes, in-class rush-answer questions, and post-class tests. These three exercise types differ in design purpose, difficulty level, knowledge point coverage, and depth, as shown in Table 3 .

Table 3. Comparison of Three Exercise Design Approaches

Aspect	Pre-class Checkpoint Quizzes	In-class Rush-answer Questions	Post-class Tests
Design Purpose	Guide pre-class autonomous learning, identify problems and misconceptions	Understand student learning status, promote classroom participation	Review and consolidate learned knowledge, assess learning effectiveness, stimulate in-depth learning
Knowledge Point Coverage (%)	60-70	Follow classroom content closely	90-100

Aspect	Pre-class Checkpoint Quizzes	In-class Rush-answer Questions	Post-class Tests
Knowledge Point Depth	Intermediate	Basic	Advanced

3.4.1 Pre-class Checkpoint Quizzes For content where students already have some foundation, this course typically uses pre-class checkpoint quizzes to guide students in completing video and text learning tasks. For example, in the "CNKI Pre-class Checkpoint Quiz" design, the topic "Computer Network Security" was used to simulate real application scenarios, with interlinked questions set according to practical operation steps to guide students to complete pre-class learning tasks while practicing on computers, discovering their own problems and misconceptions, and stimulating active exploration interest. To reduce student burden, pre-class checkpoint quizzes are generally completed within half an hour, with moderate difficulty and knowledge point coverage and depth set at intermediate levels. Through Rain Classroom's backend data, instructors can grasp each student's learning status and facilitate advanced learning through Q&A interactions and case discussions in class.

3.4.2 In-class Rush-answer Questions To improve student classroom participation, this course fully utilizes Rain Classroom platform functions, setting up in-class rush-answer questions in almost every session. These questions are released to students' WeChat through Rain Classroom, using time-limited responses to increase attention, red packet rewards to promote efficient learning, and bullet comments to encourage timely opinions. These measures effectively promote effective and timely communication between teachers and students and among students. For example, based on students' pre-class learning of reference writing and identification, in-class rush-answer questions ask students to identify references excerpted from papers in *Chinese Journal of Computers*, *Journal of Software*, ACM Digital Library, and IEEE databases, covering various reference types including books, journal articles, conference papers, dissertations, patents, and standards. The rush-answer format activates classroom atmosphere and promotes efficient communication.

3.4.3 Post-class Tests For more complex learning content, post-class tests are used to promote review and consolidation of in-class material. For example, regarding Endnote usage skills, post-class tests cover 90%-100% of knowledge points from instructors' PPT courseware and pre-class text and video materials, with questions not following the same order as in-class teaching. The main purpose is to guide students to systematically review and consolidate learned knowledge points, independently identify problems and gaps. Simultaneously, it enables instructors to understand student learning status through Rain Classroom's learning data analysis and provide targeted answers to existing problems during course reviews.

3.5 Classroom Activity Design

3.5.1 Group Learning Activities This course emphasizes cultivating students' teamwork abilities, forming learning groups of 4-6 students who collaboratively complete group learning tasks to create an atmosphere of joint exploration and mutual inspiration. For example, in Web of Science teaching, group learning activity requirements (see Table 4), video learning resources, and Learning Guides were released pre-class. In class, instructors systematically explained important knowledge points through application cases and required group members to complete group assignments within a time limit.

Table 4. Group Learning Activity Requirements

Element	Requirement
Activity Theme	Creating Web of Science Usage Tips
Learning Materials	Pre-class video learning materials, in-class case examples
Activity Requirements	Summarize key knowledge points from this section, conduct practical exercises based on the group's selected topic, explain retrieval strategies, processes, and results
Tools Used	Mind mapping software such as Xmind, Baidu Brain Map, etc.
Time Requirement	Complete and submit within the current class session, present in next class
Output Format	Mind map + PPT

Successful group learning activities depend on careful design of the following aspects: (1) Releasing group activity requirements and learning materials through Rain Classroom pre-class to enable adequate preparation and division of labor; (2) Instructors explaining important knowledge points and application scenarios through cases in class to attract students' focused attention; (3) Requiring mind map format for assignments to promote thorough discussion and highly condensed collaborative outcomes; (4) Time-limited completion to improve group learning efficiency and reduce extracurricular workload.

3.5.2 In-class Sharing Activities In-class sharing activities involve 3-5 groups per session obtaining opportunities through rush-answers, with each group limited to 5 minutes. For example, for group collaborative CNKI practice assignments themed "This Sharing is Sweet," activity requirements were released pre-class through Rain Classroom, and in-class evaluations of sharing presenters were conducted through Rain Classroom's voting function to increase classroom fun and stimulate participation enthusiasm.

3.5.3 In-class Interactive Activities In each class session, instructors' PPT slides are synchronized to students' mobile devices through Rain Classroom, fully utilizing functions such as bullet comments, submissions, and red packet rewards to achieve effective interactive communication between teachers and students and among students in large classes of over 150 students, thereby improving classroom participation and teaching effectiveness.

---

4 Implementation Effect Evaluation

After the course, to further understand implementation effects and students' comprehensive experiences, a questionnaire survey was conducted using Wenjuanxing online platform, with 126 valid responses collected.

4.1 Students' Perceptions of Learning Task Volume

4.1.1 Pre-class Task Completion Rate As shown in Figure 2 [Figure 2: see original paper], a total of 88.1% of students could complete over 75% of tasks according to instructors' requirements (53.97% completed over 90% of tasks, 34.13% completed over 75% of tasks), while only 4.76% completed less than half of the learning tasks. This indicates that pre-class learning task volume basically matched students' actual situations, with most students able to complete pre-class flipped learning tasks as required. The relatively good completion rate, despite graduate students' heavy academic workload, benefited from careful design and selection of learning resources and methods. However, since this course is not a required major course, requiring more extracurricular learning time is unrealistic. Therefore, future instructional design should further refine learning content selection to improve pre-class task completion rates.

4.1.2 Time Spent on Extracurricular Tasks As shown in Figure 3 [Figure 3: see original paper], a total of 87.3% of students could complete learning tasks within 3 hours per week on average according to instructors' requirements (7.94% spent 0-1 hour, 61.9% spent 1-2 hours, and 17.46% spent 2-3 hours on extracurricular tasks). Only 11.11% spent 3-4 hours, and 1.59% spent more than 4 hours on extracurricular tasks. This demonstrates effective control over students' extracurricular learning time. In the future, we can track time spent on each extracurricular task and make corresponding adjustments to task quantity and difficulty.

4.1.3 Time Allocation Between Group and Independent Learning This course conducted rich group activities (in-class group learning, in-class group sharing, and extracurricular group assignments) while also assigning individual learning tasks (pre-class autonomous learning, completing exercises, and hands-on operations). Survey results showed that 63.49% of students spent 50% or more time on group learning (41.27% had a basically 1:1 ratio, 22.22% spent significantly more time on group learning), while 30.95% spent significantly more time on independent learning, and 5.56% were unclear about their time allocation. Students' time allocation between group and independent learning is shown in Figure 4 [Figure 4: see original paper].

4.2 Student Usage of Rain Classroom Rain Classroom played a crucial role in the instructional design and implementation of the flipped classroom (see Figure 5 [Figure 5: see original paper]). 92.86% of students actively sent bullet comments or submissions to participate in classroom interaction; 87.3% used Rain Classroom to complete pre-class quizzes or preview courseware; 80.16% participated in in-class rush-answer questions to win red packets; 39.68% bookmarked questions they answered incorrectly or considered classic; 28.57% used the "I don't understand" button below PPT slides during class to reflect their learning status to instructors. Some students also reported login issues with Rain Classroom due to poor classroom network conditions, which should be addressed in the future to ensure equal participation opportunities.

4.3 Students' Comprehensive Perceptions and Suggestions on Flipped Classroom Design The questionnaire also investigated the implementation effects of various flipped classroom designs, including students' evaluations of their participation level, self-assessed ability improvements, and recognition of specific learning behaviors, while collecting comprehensive feedback and improvement suggestions through open-ended questions. Overall, students were receptive to the new teaching method and gave positive affirmation and evaluations to the flipped classroom integration. They considered the teaching format novel, interesting, lively, and highly interactive; appreciated the rich and diverse learning materials and approaches that improved learning efficiency and effectiveness; and believed the course cultivated autonomous learning and teamwork abilities, increased classroom participation and activity, and made learning enjoyable. Students also provided valuable suggestions for further optimizing course design, including organizing debate competitions, discussing "Endnote vs. E-study" and "Baidu Scholar vs. Google Scholar," and increasing opportunities for group assignment sharing.

Conclusion

The teaching practice of applying flipped classroom concepts to science and technology information retrieval courses based on Rain Classroom represents an initial exploration and attempt to integrate new teaching methods with instruction. In terms of teaching objective orientation, the course further strengthened its practical application characteristics. In learning time arrangement, content was extended to students' pre-class time, with more in-class time allocated to case explanations, hands-on practice, interactive discussions, and teamwork sharing activities. In learning resource design, the course fully utilized available educational resources, expanded learning content, and improved learning efficiency through subdividing knowledge points and compiling "Learning Guides." In exercise design, pre-class checkpoint quizzes, in-class rush-answer questions, and post-class tests were used to guide students in efficiently completing learning tasks and timely assessing learning effectiveness. In classroom activity design, group learning activities, in-class sharing activities, and enhanced interactive sessions were organized. The survey results demonstrated student support for adopting new teaching technologies and showed good teaching effectiveness. This course will improve upon identified deficiencies and problems based on student feedback to promote further optimization and perfection.

References

[1] Fang Xin. Preliminary exploration of applying "flipped classroom" based on "micro-lectures" in mechanical drawing teaching[J]. China After School Education, 2019(12): 145.

[2] Qi Yun, Zhang Shihui, Duan Jinju. University flipped classroom teaching design based on Learning Cell platform[J]. Research in Higher Education of Engineering, 2015(3): 184-188.

[3] Tian Aili. An empirical study on the effectiveness of "MOOC plus flipped classroom"[J]. Open Education Research, 2015(6): 86-94.

[4] Tsinghua University & XuetangX. Rain Classroom[EB/OL]. [2019-03-28]. https://www.yuketang.cn.

[5] Li Yan, Zhang Muhua. An empirical study on university students' MOOC and flipped classroom experience—Based on analysis of 231 online learning logs[J]. Modern Distance Education Research, 2015(5): 73-84.

[6] Subcommittee 6, National Information and Documentation Standardization Technical Committee. Information and documentation—Rules for bibliographic references: GB/T 7714-2015[S]. Beijing: China Standard Press, 2015.

[7] Journal of Practical Traditional Chinese Internal Medicine. Interpretation of new national standard GB/T 7714-2015 for bibliographic references[EB/OL]. [2019-03-28]. https://mp.weixin.qq.com/s/ MLSwY8oqZ5vQjb12n1hgZQ?.

[8] Clarivate. Literature management[EB/OL]. [2019-03-28]. https://clarivate.com.cn/e-clarivate/wos.htm.

Author Contributions

Li Ling: Responsible for instructional design and implementation, manuscript writing.

Chen Chao: Assisted with instructional design and implementation, participated in manuscript writing.

Note: Figure translations are in progress. See original paper for figures.