Learning Process Management Model Based on Formative Assessment

Ling Huang(✉) and Xing Fan

Department of Chemical Safety, North China Institute of Science and Technology, Langfang, China
{huangling,Xing.fan}@ncist.edu.cn

Abstract. Learning process management is an important part of teaching design, and formative evaluation is a vital means of learning process management. Based on the generalized instructional design theory, the learning process management model in view of formative evaluation is studied in this paper. The thought is put forward that learning process management needs to be comprehensively considered and systematically designed to revolve around teaching objectives, student analysis, teaching evaluation tools, intelligent platforms, teaching strategies, and teaching resources. At the same time, empirical research is carried out in the teaching process. The result shows that formative assessment is the realization process of teachers' data design, acquisition, and evaluation according to student's needs. It is also an effective model of data-driven learning process management.

Keywords: formative assessment · learning process management · system design · data

1 Introduction

In 2018, the requirement that college course teaching should especially strengthen the management of the learning process [1] was proposed in higher education in China. Teachers should choose teaching methods according to the course's nature. Aiming at the ability and knowledge assessment, the teacher should scientifically design diversified assessment contents and methods of courses, using examinations to assist teaching and promote learning, guiding students to self-management, actively learn, stimulate their desire for knowledge, improve learning efficiency and enhance their ability of independent learning.

The research on the learning process of students is carried out earlier abroad. Some scholars divided the learning behavior stage into the previous lesson, in class, and after class [2, 3]. They believe that the learning effect is directly proportional to the learning time [4], and directly involved with the concentration and quality of students in the learning process [5]. In addition, some studies consider that test scores do not reflect the abilities and experiences acquired by students in learning, and the student's learning progress should be tracked through evaluation [6]. Evaluation tools should be designed in the course teaching process to guide students to learn in various ways and increase

© The Author(s) 2022
V. Balakrishnan et al. (Eds.): ICMEIM 2022, AHSSEH 6, pp. 201–212, 2022.
https://doi.org/10.2991/978-94-6463-044-2_27

the interaction between teachers and students. Then the process of teaching evaluation results generated can promote the teaching and the learning [7].

Most domestic scholars think that teaching in the learning process should be student-centered and serve 'learning' [8, 9]. The intelligent teaching tools not only support students' individual needs for learning [10, 11] but also focuses on students' learning process in combination with learning process assessment and final examination [12]. The learning process of students determines the learning effect, and the process evaluation can estimate the learning quality of students more effectively. The data-driven learning process management model based on formative evaluation was expounded and practiced in this research.

2 Learning Process Management Belonging to Teaching Design

'Teaching' corresponds to teaching and instruction. Teaching emphasizes teachers' teaching to students, mainly including explaining teaching contents, eliciting students' reactions, and providing feedback and correcting. While instruction includes the teacher's lesson preparation (preparation of students, teaching materials, teaching methods), face-to-face teaching in class, measurement of teaching effect, diagnosis, remedy, and modification of teaching plan [13]. Instruction not only includes the 'teaching' of teachers, but also the 'learning' of students. Teachers should conduct teaching design in combination with students' situation, professional knowledge level, teaching experience, teaching attitude, and ability, and guide students to learn and keep the process effective and obtain satisfactory learning results [14, 15]. Therefore, the guided learning process should be included in the teaching design, and teachers should manage the teaching and students' learning process simultaneously.

3 The Role of Formative Evaluation in Learning Process Management

Formative evaluation exists in any stage of teaching, which can be a lesson, a chapter, or a learning stage [16]. It Guides students to complete the whole learning process through different assessment tasks designed for each stage. At the same time, the completion of the task also provides data for teachers to evaluate students' learning effects and improve teaching and learning process design. For example, test tasks generally were used for memorizing, grasping, and applying, while discussion and design tasks tend to develop high-order thinking and innovative ability. Combining the registered one's attendance at a lesson, the number of extracurricular studies, and the quantitative data on the relevant tests or discussions, the teacher can be clear about which students have problems in learning attitude, which students are good at low-level learning, and which students have strong innovative thinking ability.

According to the results, teachers can investigate and analyze the reasons from the aspects of teaching strategies and students. If it is a problem with a student's learning attitude or ability, teachers will enter the student's learning environment, and tutor or help them complete the learning process. If it is the problem of teaching strategy, teaching

content, or goal, the remedial design should be carried. Therefore, formative evaluation plays an important role in the management of the learning process by finding learning problems based on the data presented by students' learning process and then improving them in different ways.

4 Learning Process Management Model Based on Formative Assessment

The formative evaluation runs through the whole learning process, focusing on the feedback, correction and improvement process, and final output of students after being input. Therefore, formative evaluation is a bridge between teachers' teaching and students' learning, and an effective tool for teachers to guide and manage students' learning process. The effectiveness owes to the mature formative evaluation based on systematic thinking. It is an integrated assessment with the teaching objectives, student analysis, teaching evaluation tools, intelligent platform, teaching strategies, and auxiliary support of teaching resources. Through this platform, the tasks designed are used for guiding students to complete high-quality learning processes. The learning process management mode driven by formative evaluation data is shown in Fig. 1.

4.1 Teaching Objective

The connotation of the teaching objective is that the curriculum should be high-level, innovative, and challenging [17]. Taking the course 'water pollution control engineering' as an example, the high-level teaching objectives require students to master the basic theory of sewage treatment, improve their abilities (research, design, operation, and

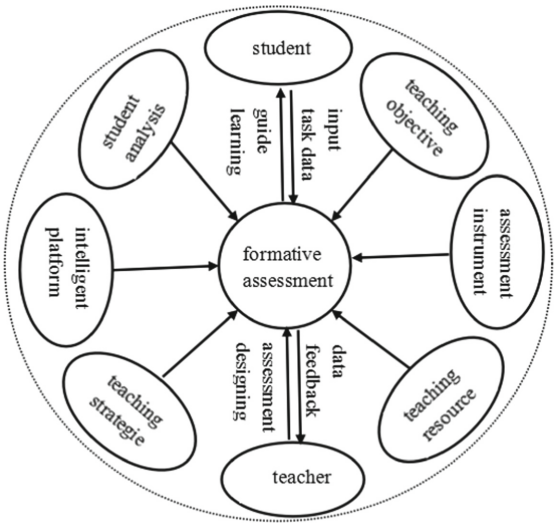

Fig. 1. The learning process management mode driven by formative evaluation data (Owner-Draw)

systematic thinking) and quality (team cooperation, environmental protection, and risk management) at the same time. Innovation reflects the cutting-edge development trend and the characteristics of the times of the course. In addition, the innovation of the teaching form can change the student's learning mode; and fully train their ability to break through the traditional thinking and deep learning ability. The challenge is to cultivate students' strong ability and confidence to think independently and solve difficulties.

From the operational level, Teachers can use observable behavior verbs to express the teaching objectives of each chapter, which is convenient for teachers and students to measure and evaluate [13]. As far as this lesson is concerned, the objectives can be expressed as follows: (1) be able to grasp, memorize and state some relevant concepts, theories, advantages and disadvantages of processes, and applicable conditions; (2) Be familiar with the use of theories and procedures for designing water treatment structures or selecting relevant equipment; (3) be able to determine more suitable treatment process according to the given water quality and treatment requirements; (4) The relevant frontier development and analyze innovations direction can be understood; (5) be able to solve the practical problems in the application of a certain process or method; (6) According to the complex sewage quality, different process schemes can be selected and designed by-self. Even the existing process schemes with poor treatment effects can be analyzed, modified, and realized.

Objectives (1) and (2) belong to low-level learning objectives, which should generally exist in any chapter. (3), (4), (5), and (6) belong to high-level learning objectives, which should be determined in combination with the chapter content. The low-level and high-level objectives can be designed and integrated into various teaching resources and evaluation processes. Teachers inform students of the teaching objectives before class, then guide students to identify, explore and solve problems through the form of assessment tasks, and transfer the basic theories and ability to their own knowledge structure. In the implementation of formative evaluation, students can naturally complete learning from low-level to high-level [18].

Therefore, the measurement of the process evaluation to the students is whether the teaching objectives are achieved, and the design of other auxiliary links is based on this.

4.2 Student Analysis

4.2.1 Knowledge and Skill Analysis

Students' conditions (knowledge, skills, hobbies, attitudes, learning motivation, and other peripheral factors related to learning) directly affect the learning effect. In Ausubel's learning theory, learning is a process in which learners use the original knowledge structure to interpret and understand the new content to be learned and form their own knowledge structure [19]. Therefore, it is an important part of learning process management to analyze what knowledge and skills the students have before accepting the learning task and the relationship between them and the knowledge to be learned.

The principle, process operation, structure design, relevant equipment, and combination of physical, chemical, and biochemical methods for treating pollutants in sewage are mainly described in 'Water pollution control engineering'. The basic principles of physics, chemistry, and biological methods have been preserved in the original knowledge structure of students. In this course, the application of these principles to sewage

treatment and the relevant application theories derived on this basis are researched. Before the class, the teacher will design a review and test to guide the students to review the old knowledge. Then new knowledge is obtained in the class. The students can gradually establish a professional knowledge system, cultivate systematic thinking, and make the learning process run smoothly.

In addition, 'What kind of wastewater is suitable for what process' and how to achieve the best results by engineering treatment methods are challenging learning tasks. They require high-level thinking and ability training that students do not have temporarily. Therefore, teaching strategies such as discussion, application, and process analysis should be selected and appropriate evaluation tools should be combined to evaluate learning performance.

4.2.2 Learning Dynamics Analysis

Graduation destination is an important point for students learning attitude and motivation. The learning motivation maintained in courses studied well is ensuring smooth learning, job searching, and pursuing advanced studies for students [20]. Taking this course as an example, first, this course is not only one of the core degree courses of major, but also a compulsory subject for postgraduate entrance examination and the employment direction. Secondly, students are generally more interested in events or knowledge that are closely related to reality. In the formative evaluation, it is necessary to set up more dilemma analyses and ability evaluations for solving practical problems, so as that increase students' enthusiasm and motivation for learning.

This requires the active cooperation of teaching resource preparation, teaching strategy (more structure design and process analysis after class) design, and evaluation tools. Finally, in the teaching strategy, students are designed to complete tasks in groups to give play to the advantages of group learning, that is, good student learning demonstration and fighting spirit stimulation.

4.3 Intelligent Platform

The learning environment is the conditional support that students have when they learn the knowledge and skills of the course. In recent years, the intelligent learning environment has developed vigorously, mainly including learning resources, intelligent platforms (tools), learning communities, and teaching communities [21].

Learning community refers to the group of interaction, cooperation and communication formed voluntarily among students. All activities and results of students in the whole learning process are faithfully recorded by the intelligent platform [9]. Students can find learning problems by themselves according to the recording process. On the other hand, the teacher community can know learning resources access, the quality of discussion and completion of homework, as well as the score of regular quizzes and stage test through the system log data of the platform. They analyze the learning status represented by various data, and use evaluation tools to measure the adequacy and effect of students' learning at any time, and adjust the task design and guide the learning direction on this basis, realize data-driven learning process management.

The popularization of intelligent platforms promotes the transformation of the teaching paradigm from 'driven by experience' to 'driven by data' [22]. The intelligent platform selected in the learning environment can be one or several kinds of combined use, or it can be combined with synchronous communication tools (such as QQ, we chat, etc.) or websites [23].

4.4 Assessment Instrument

Formative assessment needs an assessment instrument to evaluate students' daily learning effects and the completion of teaching objectives. The results of the evaluation are the data of formative evaluation, which form every student's digital networked E-Portfolio, in which the development of students' learning process can be completely recorded [24].

The assessment of students' learning attitudes can be quantified by the number of sign-in and learning times based on the intelligent platform. Most of the low-level learning task assessment methods are quantifiable objective tests, and the score data can directly reflect the students' memory and understanding of knowledge.

When examining the student's high-level abilities, comprehensive discussions, reports, mind maps, or small-scale design tasks to show the learning and research results are designed as assessment tasks usually. These tasks can be evaluated with the gauge or evaluation form. The gauge is a two-dimensional table, in which the horizontal is evaluation grade, and the vertical is various evaluation indexes considered. Each index has detailed standards corresponding to a different grade. An evaluation form is a form organized by questions or evaluation items. Each of these has a corresponding score [25]. All of them can be designed for evaluation emphasis, which is suitable for grading and assessing the completion of subjective tasks. The data of grading evaluation quantifies the comprehensive learning effect and ability of students, in order to reflect the attitude and effort of spare time learning.

4.5 Teaching Strategies

The teaching strategy includes preparatory activities, presentation of teaching information, provision of practice and feedback, discussion of problems, tests, and after-school activities around the learning objectives. The teaching strategy determines the assessment task mode of formative evaluation. Students with strong autonomous learning ability can plan and evaluate their own learning spontaneously, but students with weak ability and poor self-discipline only do these occasionally, not to speak of strategies [26]. Therefore, it is necessary for students that tasks designed by teachers guide their autonomous learning.

In view of the teaching objectives and engineering nature of the course 'water pollution control engineering', the teaching strategies can include review and test of the learned knowledge, presentation of classroom teaching information, design of in-class and after-class tests, question discussion, stage test, group work (structure design, process design display), homework (knowledge point summary or problem answer), reading articles and final examination. This strategy combination guides students to complete all learning steps, monitoring, and evaluation in different periods of each class. The instructor can obtain the data on students' learning process, depending on which the

teacher can adjust Implementing regulations of teaching strategy at all times. So the whole learning process can be managed.

4.6 Teaching Resources

Teaching resources are teaching materials used by teachers and students synchronously and the assessment task of auxiliary learning. Teaching resources are uploaded to the intelligent platform at the beginning of teaching to facilitate students throughout the learning process. The learning resources of this course include electronic textbooks and reference books, courseware, professional specifications, and design manuals, MOOC resources, courses video recorded by teachers suitable for students' abilities, and some auxiliary video resources. Besides these, various test questions, assignments, design assignments, demonstration assignments, specific issues to be discussed, and expansion resources required all belong to teaching resources. All resources revolve around the teaching strategy and are carefully designed to help students achieve the learning effect.

The above analysis shows that the data-driven learning process management mode of formative assessment needs accurate and representative data output from the students. So, the analysis of students and the learning environment is the foundation. Moving around teaching objectives, the teacher design diversified tasks combining teaching strategies, teaching resources, and assessment instrument and upload them to an intelligent platform. According to the rich and diversified data feedback in the formative evaluation of students, teachers or students can improve their teaching or learning duly to achieve the management of the whole learning process.

5 Practice of Learning Process Management Based on Formative Assessment

5.1 Design of Learning Process Management Scheme Based on Formative Evaluation

According to the model shown in Fig. 1, taking the first chapter of 'water pollution control engineering' as an example, the practical scheme design of the learning process management mode is shown in Table 1.

According to the scheme, the formative evaluation data of Chapter I come from six kinds of evaluation, including video viewing, learning times, sign-in times, testing (before class, during class, and chapter testing), homework, and discussion recorded in an intelligent platform. Because the data of presentation assignments will only be obtained after the whole course were completely over, the formative evaluation data of chapter I did not include this part. Combined with the teaching objectives and encouraging students to learn more after class, the evaluation weights of these six forms were 20%, 20%, 2%, 33%, 15%, and 10% respectively.

5.2 Application of Formative Assessment Data in Learning Management

The data based on formative assessment includes behavior quantitative data of students' learning attitude and effort (sign-in, video watching, learning times) and quality assessment data of students' task completion (homework, examination, discussion, and report).

Teachers should analyze students' learning problems represented by various evaluation data combinations of formative evaluation, then find out problems in time through data feedback, and guide students to complete the learning process effectively.

The practical data in this chapter show that all students except one can reach the standard of four evaluation methods. Three of them (sign-in, video watching, homework) are designed for low-level learning goals, so it is not difficult for most students to achieve them. In addition, the examination time is short, and most of the questions are set up for memory and understanding of knowledge points. Due to the proportion of high-level questions being relatively small, most of the students can pass the examination. The qualification of these four items indicates that the learning management of low-level learning is relatively successful.

However, in the learning times and discussion evaluation, a large proportion of unqualified students appeared. Learning times reflect students' efforts to achieve high-level learning goals. Students need to study teaching resources in depth before they can obtain ideal results in discussions. The two are closely linked. In order to improve the two unqualified evaluation items, teachers can set more hierarchical thinking tasks according to the discussion topics or increase the scores of high-level application questions in the section exam to remind students to pay attention to the depth of learning. In the

Table 1. Practical Scheme Design of Chapter I (Owner-Draw)

Teaching objective			
low-level objective: (1) Understand and master the classification and hazard of pollutants in wastewater, applicable water quality, discharge standards, basic treatment methods types, and processes; (2) Understand the process flow grading, in which what kind of pollutants are treated. high-level objective: (3) Be able to determine the grade of a treatment process flow according to the given wastewater quality and discharge standards; The existing process can be graded.			
objective analysis	low-level objective (1) basic knowledge point learning	low-level objective (2) integrative studying based on objective (1)	high-level objective (3) close contact with the practice and challenging learning
student analysis/ learning process	• classification, hazard, and water quality standard of pollutants have been learned/reviewed before class; • dealing with methods and processes not learned/classroom learning and review after class	processes flow not learned/classroom learning and review after class	insufficient understanding of 'wastewater quality, discharge standards and treatment methods of various industries at current stage' and lack of systematic thinking, integrated application ability, and innovation consciousness/after-school learning and improvement
intelligent platform	interacting and recording the whole process by the 'Xuexitong' platform		

(*continued*)

Table 1. (*continued*)

Teaching objective			
teaching strategy/selection purpose	• watching the video of what learned and testing before class/reviewing & guiding students to check and fill the vacancy • giving lessons and classroom tests/explaining and understanding the learning effect	• giving lessons/explaining • classroom test/understanding the learning effect and analyzing the reasons for losing points and guiding students to study deeply in time • homework/summarizing systematic knowledge points with the mind map • section test/supervising and urging review, testing results	• discussion/giving an industrial wastewater process, guiding students to discuss the intention and substitutability of each treatment process unit • homework & report/investigating the pollutant indicators, discharge standards, and relevant treatment methods of different industries' wastewater in groups, and designing the treatment process by themselves. a group of PPT will be presented at each subsequent class. 'Industrial wastewater quality, discharge standards, and treatment process flow' is helpful for establishing system thinking; 'Process comparison and new process application' is high-level thinking training, process comparison is the cultivation of speculative ability, and new process application reflects innovation consciousness and challenge
evaluation instrument/data	• times of sign-in, learning, and watching video from the platform/quantitative data to test students' learning attitude and effort • test questions (before, during, after class, chapter)/specific scores quantifying students' mastery • homework rating/mind map rating (four indicators: correctness, perfection, structure, and conciseness) • discussion rating/quantification of quality evaluation (three indicators: attitude, originality, and ability to apply knowledge) • Homework report rating/quantification of quality evaluation (four indicators: content, PPT, narration, and team cooperation)		
teaching resources	video/courseware/test questions/discussion topic and evaluation form/report theme and evaluation form/expanding articles and books (for researching and learning)		

discussion, teachers can appropriately strengthen guidance. For example, the difficulty level of discussion content is raised gradually, different discussion topics are matched to different groups, the participation of students is expanded, and the instant discussion is changed to the second classroom discussion according in order to make students prepare well. Through such measure adjusting, the pass rate of students in the two evaluations

of learning times and discussions in the subsequent chapters has been greatly improved. Most students have achieved the high-level learning objectives of the course.

Finally, the reason why a special student failed in the course video, homework, and examination was the student's slack attitude caused by his family. Through timely communication, with teachers, the student also passes the formative evaluation in the following chapters.

6 Conclusion

'Student-centered' course teaching reform is the general trend of higher education, and students' learning process is an integral part of teaching. Formative assessment is the realization process of data designed, obtained, and evaluated by teachers according to the teaching objective and the needs of students. The content of the task and expression significance of data should be systematically studied based on six aspects, such as teaching objectives, student analysis, intelligent platform, assessment instrument, teaching strategies, and teaching resources. Thus, the data from formative assessment should be practically applied to learning process management. Teachers can analyze the consistency of learning results and learning processes of student groups and individuals, and can specifically analyze the gap between students' learning degrees and learning processes with assessment data. At the same time, data can indicate directions for the improvement of learning process guidance methods and task planning formulated by teachers. Formative assessment is an effective model driven by data learning process management.

Acknowledgment. This work has been partially funded by the higher education teaching reform res-earch and practice project of Hebei Province (project number: 2018GJJG475). At the same time, assisting with the Teaching Reform Project of North China Institute of Science & Technology (project number: HKJG 202221) is gratefully acknowledged.

References

1. Ministry of education. Opinions of the Ministry of education on accelerating the construction of high-level undergraduate education and comprehensively improving talent training capacity [J] Bulletin of the Ministry of education of the people's Republic of China, 2018 (9): 7
2. Bennett S. Learning behaviors and learning spaces[J]. Libraries and the Academy, 2011, (3): 765-789.
3. LI Wei, LIU Chang. An empirical study on the correlation between college students' learning behavior patterns and learning effects[J]. China Youth Research, 2006 (11): 39-43.
4. MERWIN J C. Historical Review of Changing Concepts of Evaluation[M]//TYLER R L. Educational Evaluation; New Roles, New Methods; The Sixty Eighth Yearbook of the National Society for the Study of Education, Part. Chicago: University of Chicago Press,1969:6-25.
5. PACE C R. Achievement and the quality of student effort [DB/OL]. https://files.eric.ed.gov/fulltext/ED227101.pdf.
6. XIE Xiaoyu, RAO Congman. Controversy on the assessment of student learning outcomes in American Universities[J]. Journal of Higher Education, 2019, 40(7):104-109.

7. GAO Wei, LI Ruichen, SONG Shuoqi. Research and enlightenment of the classroom observation Protocols for undergraduate STEM(COPUS)in American Universities[J]. Journal of Higher Education Research, 2020,43(2):66-74.
8. LI Xiaoping. The theoretical connotation and practical strategy of learner-centered[J]. Journal of Higher Education Research, 2021,44(1):1-7.
9. WANG Jian, WANG Wenli. To construct the key competence of students' development in classroom teaching[J]. Journal of Higher Education, 2018,39(1):70-76.
10. CHEN Mengqian, PENG Xilin. Reconstruction of college students' learning ability from the perspective of smart education[J]. Journal of Higher Education, 2020, 41(7):78-84.
11. CHEN Xi. Research on the development path of data-driven teaching reform in Universities[J]. Theory and Practice of Education, 2020, 40(33): 52-55.
12. ZHAO Zenghui, LIU Xingguang, HAO Peng. The construction and practice of multiple and mixed assessment mechanisms driven by curriculum informatization[J]. Chinese Journal of ICT in Education, 2019, (14): 31-34.
13. PI Liansheng. Educational Psychology (4th Edition) [M]. Shanghai: Shanghai Education Press, 2011.
14. CHENG Desheng. Discussion on teaching design based on learning process [J]. Jiangsu Education Research, 2008, (24): 20-22.
15. HONG Zhizhong, BIE Dunrong. Reform of University teaching and learning from the perspective of learning literacy[J]. Journal of Higher Education, 2020, 41(6):64-71.
16. PAN Jian, XIAN Fengrao. Difference between formative evaluation and process evaluation[J]. New Curriculum Research, 2018, (12): 4-9.
17. WU Yan. Constructing China 'golden course'[J]. China University Teaching, 2018 (12): 4-9.
18. YU Miaonan. The research of evaluation of higher-order thinking development in an intelligent learning environment[B]. Changchun: Northeast Normal University, 2016.
19. SUI Ping. Application of meaningful learning theory by D.P Ausubel in college English teaching[J]. Journal of Changchun University, 2014,24 (2): 282-284.
20. JIANG Lin, HAN Xibin, CHENG Jiangang. Analysis of the characteristics and learning effects of MOOCS learners[J]. China Educational Technology, 2013, (11): 54-59.
21. HUANG Ronghuai, YAN Junfeng, HU Yongbin. From digital learning environment to intelligent learning environment--the change and trend of learning environment[J]. Open Education Research, 2012,18(1): 75-84.
22. BAI Shengjian, ZOU Fengxing, LU Huimin. Teaching students by focusing on their diversities: student-centered teaching of Automatic Control Principle [J]. Journal of Higher Education Research, 2021,44(4): 101-105.
23. XI Peng, MA Ruixin, SHI Changsheng. Design and implementation of hybrid teaching characterized by live broadcasting[J]. Journal of Higher Education, 2020, (15):10-13, 19.
24. LI Xia. Application of developmental evaluation system based on e-portfolio in experimental courses[J]. SoftWare Guide, 2012, 11 (8): 192-194.
25. PENG Feie. Learning evaluation based on project-based curriculum--taking English project-based learning as an example[J]. Educational Information Technology, 2014, (6): 18-22.
26. NI Qingquan. An empirical study on the correlation between college English learning motivation, learning strategies and autonomous learning ability[J]. Foreign language World, 2010, (3): 30-35.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (http://creativecommons.org/licenses/by-nc/4.0/), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.