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Capturing Teacher Priorities: Using Real-world Eye-Tracking to Investigate Expert Teacher Priorities across Two Cultures

By McIntyre, N.A., Jarodzka, H., & Klassen, R.M.

TEACHER'S gaze patterns could reveal the different priorities expert teachers and novice teachers might have in their classrooms, according to a recent study published in *Learning and Instruction*.

Using eye-tracking glasses, McIntyre and colleagues investigated how gaze proportions might be different for teachers of different expertise and culture, indicating differences in teachers' priorities. Twenty secondary school teachers from Hong Kong and twenty secondary school teachers from the United Kingdom participated in this study. Teachers were considered as expert teachers if they had six years' or more experience, were selected by their school leadership as experts in teaching, had professional membership within the field of teaching, and scored highly in performance ratings.

Teachers' gaze proportions were measured during questioning (information seeking) and lecturing (information giving) in normal timetabled lessons, for their gaze frequencies on the students, student materials, teacher materials and non-instructional regions (such as door, windows). The findings were as follows:

- Regardless of culture, expert teachers prioritized their gaze to students during both questioning and lecturing, while beginning teachers prioritized non-instructional classroom regions
- HK teachers prioritized their gazes to teacher materials while UK teachers prioritized it to non-instructional regions during lecturing
- HK expert teachers also used more teacher materials gaze than the UK expert teachers

The authors suggested that the finding of prioritization of gaze to students by expert teachers was consistent with other research since prioritization of students deepens students' understanding of the subject, emotional security, security with peers, and their interest in subject materials.

Source: Learning and Instruction, 60:215-224.

Infant Attention and Age 3 Executive Function

By Kraybill, J.H., Kim-Spoon, J., & Bell, M.A.

INFANT attention skills are significantly related to preschool executive function at age three, according to a new study published in *The Yale Journal of Biology and Medicine*.

One hundred and fourteen children took part in the study. Jessica H. Kraybill and colleagues measured children's attention at five months by using parental-report questionnaires and by assessing look duration and shifting rate while the children watched a video clip. Children's single longest continuous look and the number of shifts of gaze at the video were recorded. Shorter looking durations were taken as an indication of better information processing, and high shift rates typically represent better attention. The performance on four different executive function tasks for these same children was then measured when they were three years old.

Results indicated that:

- Higher attention at five months was related to higher executive function at age three (effect size = + 0.05).
- Child gender and maternal education were uncorrelated with performance on the executive function's tasks.

The authors suggested that the results supported the notion that attention span in infancy may serve as an early marker of later executive function.

Source: The Yale Journal of Biology and Medicine, 2019; 92(1): 3-11.

A Systematic Review of Teacher Guidance during Collaborative Learning in Primary and Secondary Education

By Van Leeuwen, A., & Janssen, J.

A SYSTEMATIC review of the role of the teacher during collaborative learning in primary and secondary education suggests that several types of teacher guidance can be positive. However, the challenge for the teacher is to support interaction between students without taking control of the moments in which opportunities to learn arises for students.

The review, carried out by Anouschka van Leeuwen and Jeroen Janssen, included both qualitative and quantitative studies (n = 66) conducted in primary and secondary schools, and looked at the relationship between the teacher's role and the processes and outcomes of collaboration among students.

The authors found that:

- Feedback, prompting, questioning, and transferring control of the learning process to students were all effective strategies for collaborative learning.
- In contrast, some aspects of teacher guidance were found negatively associated with students' collaboration, such as when teachers were too present or absent.
- Teachers' explanations and modeling behavior were not always contributive to students' collaboration.

The review concludes that when guiding collaborative learning, teachers should try to not only focus on the content of the task, but also on how students approach the task and the strategies they use for collaboration, and should let students know that help is available without imposing this help.

Source: Educational Research Review, 2019; 27: 71-89.

NEWSLETTER

Understanding Mathematics Anxiety: Investigating the Experiences of UK Primary and Secondary School Students

By Carey, E., Devine, A., Hill, F., Dowker, A., McLellan, R., & Szucs, D.

WHILE mathematics is often considered a hard subject, not all difficulties with the subject result from cognitive difficulties. Many children and adults experience feelings of anxiety, apprehension, tension or discomfort when confronted by a math problem. Research conducted by the Centre for Neuroscience in Education at the University of Cambridge examined the math performance of more than 2,700 elementary and middle students in the UK and Italy who were screened for math anxiety and general anxiety. Researchers then worked one-to-one with the children in order to gain deeper understanding of their cognitive abilities and feelings towards math using a series of cognitive tasks, questionnaires, and interviews.

Emma Carey and colleagues found that:

- A general feeling that math was more difficult than other subjects often contributed to feelings of anxiety about the subject, and teachers and parents may inadvertently play a role.
- Girls in both primary and secondary school were found to have higher levels of both math anxiety and general anxiety.
- Students indicated poor test results, or negative comparisons to peers or siblings, as reasons for feeling anxious.
- Secondary school students also indicated that the transition from primary to secondary school was a cause of math anxiety, as the work seemed harder and there was greater pressure on tests and increased homework.

The report sets out a series of recommendations, including:

- Teachers should be aware that math anxiety can affect students' math performance.
- Teachers and parents need to be aware that their own math anxiety might influence students' math anxiety.

- Teachers and parents also need to be aware that gendered stereotypes about math ability might contribute to the gender gap in math performance.

Reducing classroom pressure and using methods like free writing about emotions before a test could help to alleviate math anxiety.

Source: Centre for Neuroscience in Education, University of Cambridge, 2019.

The BUDL Effect: Examining Academic Achievement and Engagement Outcomes of Preadolescent Baltimore Urban Debate League Participants

By Shackelford, D.

JOHNS Hopkins University's Daniel Shackelford has conducted the first quantitative study examining the effects of participation in an extracurricular debate club during preadolescence on students' later academic and engagement outcomes, including entry to selective-entrance high schools.

Dr. Shackelford examined a 10-year sample of 2,263 4th to 8th graders participating in Baltimore City's Baltimore Urban Debate League (BUDL) between the 2004 to 2013 school years, comparing their standardized math and reading scores, attendance, and entry to selective-entrance high schools to 81,906 peers who did not participate in BUDL. Ninety-one percent of both groups were African American, and 96% of both groups received free and reduced-price lunch. Results showed that:

- Among the debate students themselves, preadolescent debate participation yielded more than a 6% increase in reading scores and a 4% increase in math scores on standardized testing.
- While debate inherently involves reading and might be accountable for increased reading achievement, Dr. Shackelford observes that debaters were 10% less likely to be chronically absent than non-debaters, and this increased engagement in school may have yielded the improvements in math scores.
- BUDL students were also more likely to attend a selective high school (E.S. = +0.122) or selective career tech high school (E.S. = +0.015) than to attend a traditional high school.

However, it is of note that these two groups were not matched at baseline: students who became debaters differed from controls prior to their participation in BUDL, with higher standardized test scores and attendance, so no true causal conclusion can be drawn from comparing groups.

Source: Educational Researcher, 2019; 48(3):145-157.

Parent-Teacher Meetings and Student Outcomes: Evidence from a Developing Country

By Islam, A.

ENGAGING parents in their children's education, both at home and at school, can be an effective and low-cost way of improving learning outcomes for students. A study published in *European Economic Review* examines whether academic achievement can be improved by increasing parental involvement through scheduled parent-teacher meetings.

Asad Islam conducted the randomized controlled trial in schools in two southern districts of Bangladesh. Seventy-six primary schools were chosen randomly from more than 200 in these regions, with 40 schools randomly allocated to the intervention group and 36 to the control group. Students in these schools all came from low socioeconomic backgrounds and a quarter of parents did not complete primary school.

The intervention involved monthly face-to-face meetings between parents and teachers over a period of two academic years. At each 15-minute meeting, teachers discussed with parents their child's academic progress and provided them with a report card for their child. Student achievement outcomes were measured using standardized test scores.

- Overall, test scores of students in the intervention schools increased by 0.26 standard deviations (SD) in the first year, and 0.38 SD by the end of the second year of the intervention.
- Also, students in the intervention schools had made improvements in their reading and writing abilities and general knowledge.
- Parents who attended the parent-teacher meetings reported that they felt encouraged to spend more time at home helping children study or do homework.
- Both parents and teachers also reported improved attitudes, behavior and confidence of their children.

The authors suggested that engaging parents was an important way to support students' learning, which was also cost-effective.

Source: European Economic Review, 2019; 111:273-304.

How Young Children Develop Agency, Numeracy and Literacy?

By Deans for Impact.

A NEW resource from Deans for Impact summarizes current cognitive-science research related to how young children - from birth to age eight - develop skills across three domains: agency, literacy, and numeracy.

It aims to give guidance to anyone working in education who is interested in understanding the science of how young children develop control of their own behavior and intentions, how they learn to read and write, and how they develop the ability to think mathematically.

For each domain, the report identifies key questions about learning and provides a short list of the principles from learning science that inform the answers to these questions. The resource then connects these principles to a set of practical implications for specific teaching strategies. For example, the report identified children regulate their behaviors by achieving the following:

- Remember their goals
- Suppress impulses and not respond to distractions
- Be able to change how they think and react to things.

Accordingly, the report made a recommendation to scaffold the ability of young children to self-regulate behaviors by striving for consistency and predictability. Use consistent schedules and involve children in plans for the day. The original research is clearly referenced for anyone wishing to find out more.

Source：TX: Deans for Impact: The Science of Early Learning, 2019.

Effective Professional Development for Teachers to Foster Students' Academic Language Proficiency across the Curriculum: A Systematic Review

By Kalinowski, E., Gronostaj, A., & Vock, M.

RESEARCH published in *AERA Open* examines the features needed for effective teacher professional development (PD) aimed at preparing teachers to support their students in mastering language expectations across the curriculum.

Eva Kalinowski and colleagues conducted a systematic review of studies of PD programs, published between 2002 and 2015, which aimed to support teachers to improve their students' academic language ability in different subject areas. Of the 38 studies they reviewed, all but one was carried out in the US. Eighteen studies used quantitative data only, three used a mainly qualitative approach, and 17 used mixed methods.

Although the researchers were unable to conclude which elements actually influenced the effectiveness of the programs analyzed, they found that all of the studies were effective to some extent, and shared many characteristics considered to be important in successful teacher PD across different subject areas. The forms of PD likely to show some effect for teachers and students in this area were:

- long-term intensive programs that included multiple learning opportunities aimed at elaborating and practicing newly learned knowledge and strategies
- provided practical assistance
- enabled and encouraged teachers to work together
- considered teachers' needs as well as students' learning processes and languages spoken at home

The authors suggested PD is a way that policymakers could influence and worth investing in.

Source: AERA Open, 2019; 5(1). First published online.

Early School Exposure, Test Scores, and Non-Cognitive Outcomes

By Cornelissen, T. & Dustmann, C.

IN the UK, children usually start elementary school in the academic year in which they turn five. However, because entry rules vary across local districts, some schools may defer entry for children born later in the year until the second or third term.

A new study by the Centre for Research and Analysis of Migration (CReAM) at University College London looks at what impact an earlier versus later entry into Reception has on students' cognitive and non-cognitive skills up until age 11 (their final year of primary school).

Christian Dustmann and Thomas Cornelissen analyzed information on more than 400,000 children born in 2000-01 who attend state schools in England and whose records are included in the National Pupil Database. This was combined with information on more than 7,000 children born in 2000-01 who took part in the Millennium Cohort study.

The researchers found that:

- Receiving an extra month of schooling before age five increases test scores in language and numeracy at ages five and seven by about 6-11%.
- But by age 11, the effects on test scores have largely disappeared.
- For boys from low socioeconomic backgrounds, the benefits of an earlier school entry are even greater. An additional term of schooling before age five reduces the achievement gap between boys from low and high socioeconomic backgrounds at age seven by 60%-80%.

The authors suggested their findings contributed to the debate over optimal school starting age.

Source: Centre for Research and Analysis of Migration, University College London, 2019.

Student Outcomes and Parent Teacher Home Visits

By Sheldon, S.B. & Jung, S.B.

A NEW study by Steven Sheldon and Sol Bee Jung from Johns Hopkins School of Education examines Parent Teacher Home Visits (PTHV), a strategy for engaging educators and families as a team to support student achievement. The PTHV model has three main components: (1) an initial visit in the summer or fall in which educators focus on getting to know the student and the family, (2) ongoing two-way conversation during the school year, and (3) a second visit in the winter or spring with a focus on how to support the child academically.

Four large urban districts from across the United States participated in the study. From each district, the researchers requested student-level data about demographic characteristics (e.g., gender, race) and student outcomes (e.g., attendance and standardized test performance). Additionally, districts were asked to provide data about the implementation of PTHV in their schools.

Key findings of the study were as follows:

- On average, schools that systematically implemented PTHV experienced decreased rates of student chronic absenteeism and increased rates of student English Language Arts (ELA) and math proficiency, as measured on state assessments.
- Students whose families participated in a home visit were less likely to be chronically absent than students whose families did not participate.
- For students, attending a school that was implementing home visits with at least 10% of students' families was associated with an increased likelihood of scoring at or above proficiency on standardized ELA assessments.

The authors suggested that the findings indicated the efficacy of school outreach to families as a strategy to improve both attendance and achievement, and the effects might apply to students who did not directly participate in the home visits.

Source: Johns Hopkins University: School of Education, 2018:11-30

ORIGINAL ARTICLE

How Does E-book Bag Promote Learning? Video Analysis Based on Classroom Recordings

Caimin Li

NENU Ideal Software Co., Ltd, Jilin, China

Abstract: With the popularity of mobile learning and the rapid development of internet, e-book bag has received increasing attention. However, recent studies rarely analyze the functional characteristics of E-book bag and its influence on teachers' instructing and students' learning from the perspective of classroom teaching application. In this regard, this study selected 20 sections of live e-book bag teaching video recorded in Changchun, China, and analyzed the functionality of e-book bag using Video Analysis on its following four dimensions: situation creation, knowledge construction, collaborative communication, and evaluation feedback. We concluded that e-book bag has three major functions: "resources and toolkits", "teaching interaction", and "teaching evaluation". Meanwhile, it provides support for active interaction between teacher and students, between students, and between students and learning contents as well. Therefore, the use of e-book bag satisfies students' individualized learning, supports the communication and cooperation between teacher and students, and helps students to construct knowledge in depth.

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***Keywords**: Mobile learning; E-book bag; Video analysis; Teaching live video*

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***Conflict of Interests:** None.*

Literature Review and Questions

THE e-book bag is a sub-model of intelligent teaching. It refers to a new teaching mode that utilizes information equipment, which can play an active role in guiding students for a series of learning behaviors. In recent years, studies have shown (Cho, et al., 2017) that educators look forward to triggering "teaching transform" by adding "digital technology elements" and adopting this transform to promote the development and enhancement of students' intelligent and advanced thinking skills. E-book bag, as an efficient and operative way of learning, has meaning in existence. The rise of e-book bag model not only narrows the basic differences between schools and teachers, but also reflects the principle of equal teaching deeply.

As far as existing research is concerned, current literature tends to interpret e-book bag as a carrier device or learning environment from the perspective of "tool view" or "environmental view" (Zhao & Zhu, 2009). The E-book bag mobile terminal can directly support teacher and students through the user information management system, and use the personal account to bind the relevant data in the e-book bag, such as: school records, e-books, micro-courses, and other resources and tools. In addition, in order to effectively update and share resources and tools, the e-book bag also has the function of resource management; teacher can prepare various resources and tools according to teaching contents and needs before lesson. When teaching, students can upload and download resources and tools quickly and easily.

As early as 2000, e-book bag began to be used in Singapore. Due to its limited functions and high promotion costs, it did not receive adequate feedback (Tang, et al., 2014). Currently, e-book bag has been becoming a multi-functional electronic device with information storage, recording contents and reading materials, promoting intelligent education, and has gradually been becoming an irreversible trend of the times and development needs. South Korea, the USA, Japan, European countries etc. have taken measures to reduce its cost, and promoted the use of e-books within their countries. At the same time, in China, e-book bag has also received increasing attention and has been given new vitality. Since 2008, along with the implementation of the projects introduced by Intel in the "One-to-One" Digital Learning Application Research Project, the leading company products in the field of e-book bag technology in China are Hanwang and Youxuepai. Hanwang's products mainly use its ink screen technology, which is better at protecting children's vision, and meanwhile Youxuepai's electronic screen technology facilitates the playback of courseware and audiovisuals.

In terms of application, scholars have done a more detailed theoretical analysis of e-book bag and its functionalities. Based on the existing research results, the function of e-book bag can be summarized into four categories: i) to support multimedia functionality, i.e. the text, audio, picture, video, etc. can be shared by the information device between the teacher terminal and the student terminal; ii) the learning management functionality, students can use e-book bag to manage and classify learning information independently; iii) the teaching management functionality. Teacher can dynamically

share the learning situation and learning characteristics of the students through the terminal, and take it as a classroom management assistance; iv) to support the interaction between teachers and students, to build a platform for exchanging and communicating between parents, students and parents, at anytime and anywhere (Martel, et al., 2006).

There are two distinct perspectives on the role of e-book bag in teaching exist. Some considered that e-book bag has a positive effect on learning. After active discussion regarding the role of e-book bag in teaching, it showed that, e-book bag not only enhances students' learning output at the cognitive and non-cognitive levels, effectively promote the development of students' cognitive level, but also improve students' learning attitudes, mobilize students' enthusiasm and promote students' personalized learning (Zhang, 2011). Meanwhile, through the visualization of the teaching contents, e-book bag creates a relaxed classroom atmosphere, improves student's participation in the class, and it is a good platform to promote the interaction between teacher and students while facilitating teacher to master the learning situation (Guan & Zhu, 2018).

However, others questioned the specific functionalities of e-book bag, and presented that disadvantages existed for its application in teaching, pointed out the potential negative effects in terms of health, internet addiction and cost (Zhu & Yu, 2011). First, the e-book bag cannot effectively integrate with the classroom, not only does not play its functionality ideally, but also may affect the child's writing ability and vision, and even cause the child to rely too much on the network and addiction (Liu, 2013). Second, in the case that e-book bag has not been popularized and lack of its resource library, the use of e-book bag cannot meet the needs of students well, and it has considerable costs, further increasing the pressure on the families to invest in education (Hu & Zhang, 2012).

In sum, most previous studies paid more attention to the results of the concept, but not that many practical researches focused on specific application of e-book bag in the intelligent teaching. From the perspective of methods, they belonged to academic analysis, but there are few evidence-based studies. From the research process, currently available studies could not clearly answer what happened in the process of using e-book bag, and could not reasonably and scientifically tell the impact of e-book bag on teachers' instructing and students' learning.

Therefore, this study focuses on the following issues:

1. How is e-book bag applied in teaching practice?
2. What role does e-book bag play in the teaching process?
3. How to make it work better according to the characteristics of e-book bag?

As thus we selected 20 videos that use e-book bag teaching according to above questions. Under the perspective of classroom video, we meticulously observed the real scene of the smart teaching classroom using e-book bag, used video analysis to explore how e-book bag affects teachers' instructing and students' learning in practice.

Research Design and Data Sources

Samples

Accordingly, we collected the teaching video cases from 20 elementary and middle schools in which e-book bag was applied in Changchun, China (**Table 1**). These schools included but not limited to: Changchun City Elementary School Affiliated to Changchun Normal University, Changchun City First Experimental Elementary School, Changchun City Lvyuan Elementary School, etc. The schools selected in this study have introduced e-book bag technology and applied it to their practical teaching. In addition, there are differences in the practical application of e-book bag in different disciplines, for example, for more perceptual liberal arts subjects such as Chinese that focuses more on the audible functionality of e-book bag, but for more rational science subjects such as Mathematics that focuses more on the visualization of charts. So the teaching cases selected in this study included both liberal arts and science. Therefore, the data were more scientific and comprehensive.

All the video data used in our study were recorded in class received permission from both parents and teachers. The ownership of the video was attributed to the schools where the videos were recorded. In the course of the research, we also obtained authorization from the schools indicating that the videos could be used for research and publication.

Research Method

In this study, we used video analysis to analyze selected teaching video examples. The video analysis method was to get the most direct and detail data of the teaching and learning process through reviewing the class teaching videos, and then deeply analyzed its specific influence on the teaching and learning between teacher and students. In China, video analysis has become an indispensable part of modern education. Yong (2015) proposed that analyzing teaching videos was extremely beneficial to teachers' reflection and promoted teachers' professional learning in the future. Hong (2017) showed that video analysis was different from other teaching methods, and it made the science curriculum more visual and provided students with a perceptual understanding. Wang (2018) showed that video analysis should be analyzed from four aspects: teaching content, audio-visual presentation, guiding interaction and rhythm. However, most traditional video analyses were not that in-depth in contents, in overall, it was not that easy to observe the specific facts and phenomena in detail. In addition, the sample size was small, and the traditional video analyses have certain errors in the experimental results (Guo, et al., 2019).

Most video analysis methods generally analyzed classroom teaching videos from four aspects: teaching contents, audiovisual presentation, guiding interaction, and rhythm. However, few focuses on these four aspects to help students create scenarios, construct knowledge, communicate and evaluate feedback. Under the scenario creation mode, teacher can flexibly use language or modern teaching tools to create a familiar situation that is easy to be understood, and thus stimulate students' imagination, thinking and emotions, and promote their interests and creativity. Former Soviet educator

Table 1. Twenty Class Teaching Videos in Elementary and Middle School in Changchun, China.

	Grade	Subject	Contents	Teaching Methods	Video#
Elementary School	3rd	English	Unit Text: Family	Teacher Explanation, Audio Reading	01
	4th	Math	Average Value	Explaining Interaction, Drawing, Animation	02
	4th	Chinese	Text "Viewing the Tide"	Teacher Explanation, Courseware Display	03
	4th	English	Unit Text: Time	Teacher Explanation, Audio Reading	04
	5th	English	Oral Audiovisual Practice	Q&A Between Teacher and Students, Group Interaction	05
	5th	Chinese	Text "Poplar Tree"	Explain Interaction, Courseware Display	06
	5th	Math	Polygon Area Calculation	Explain Interaction, Video Presentation	07
	6th	English	Unit Test Explanation	Answering Questions, Audio Analysis	08
	6th	Chinese	Appreciation Of Poetry	Teacher Explanation, Courseware Display	09
	6th	Math	Position and Direction	Course Explanation, Courseware, Drawing	10
Middle School	7th	Math	Quadrilateral Review	Answering Questions, Courseware Display	11
	7th	Geography	Chinese Terrain	Teacher Explanation, Animation, Picture	12
	7th	History	The Dynasty Replacement of Xia, Shang and Zhou	Explain Interaction, Video Playback	13
	8th	English	English Grammar - Past Continuous Tense	Answering Questions, Courseware Display	14
	8th	Physics	Particles and The Universe	Teacher Explanation, Animation, Picture	15
	8th	Politics	Rights and Obligations	Teacher Explanation, Courseware Display	16
	9th	Chemistry	Burning Condition	Teacher Explanation, Experimental Interaction	17
	9th	Geography	Global Climate Type and Distribution	Teacher Explanation, Video, Animation	18
	9th	Chinese	Reading Comprehension	Answering Questions, Courseware Display	19
	9th	Math	Binary One Function	Teacher Explanation, Animation Display	20

Note: All videos were 45 minutes long.

Markalenko said: "Teachers should take the initiative to establish an external environment that evokes the necessary mental state, perceptions, emotions, motivations, and motivates their actions in the learning process" (ITL Research, 2010). For knowledge construction, it emphasizes the initiative of learners, after a series of receiving, reflecting, and questioning, it can organize the knowledge they have learned and absorbed them into their own knowledge reserve (Chang & Sheu, 2002). For collaborative com-

munication, it is cooperation through learning experience and information and resource exchange (Zheng & Zhang, 2012). For evaluation feedback, it refers to the feedback of learning results to teachers, so that teaching and learning can be regulated timely (Guo, et al., 2013).

The above-mentioned four dimensions relate to the interaction between students and learning contents, between students and students, and between students and teachers. They are the mainframes that support the overall teaching activities. We used video analysis method to analyze the videos recording the use of e-book bag from these four dimensions: scenario creation, knowledge construction, collaborative communication, and evaluation feedback. So as to get to know how the e-book bag influence teachers' instructing and students' learning, and how it promotes the development of students' abilities.

In the processing video data, we recorded the behavioral activities of teachers and students in the classroom in each video, and then organize the video data according to corresponding dimensions to obtain preliminary analysis results. In order to ensure the robustness of the analysis results, six months after the initial analysis, we conducted a second analysis of the video materials, compare the similarities and differences between the two analysis results, and drew consistent conclusions. Finally, the video materials were further inspected and extracted until there were no new findings and conclusions to ensure the validity and saturation of the data.

The Teaching Activity Coding and Application

We herein carefully reviewed the videos selected from 20 lessons, recorded the student's learning activities in the teaching practice regarding the use of e-book bag, divided from the two aspects of learning behavior and cognitive activities, and then followed the dimensions according to the role played by each behavior. **Table 2** is based on the key teaching behaviors involved in the coding development of classroom teaching behaviors on using e-book bag from the four dimensions mentioned above. Referring to the coding system listed in **Table 2**, the teaching activities between teachers and students in each dimension were described in detail, especially the learning activities of students. We thus came to the application and role of e-book bag in teaching practice, and summarize its functional characteristics.

Results

The Use of E-Book Bag in Teaching Practice in Four Dimensions

Through the selection of 20 cases, we analyzed the application of e-book bag in teaching practice in four dimensions. Two classic cases were selected for general representative discussion. In case #1 (Video 02) in the picture below, the school was conducting an e-book-bag-based experiential learning based on the "average score" of the fifth grade Mathematics. This case effectively used the interactive teaching technology

Table 2. "E-books Support Smart Classroom Learning Behavior" Code.

Dimensional Structure Model	Behavioral Participation	Cognitive Participation (Discovery, Conception, Induction, Choice, Evaluation)
Situation Creation	1. Watch the content of the presentation 2. Explain the scene information in the courseware resources 3. Watch the video or listen to the audio to understand the situation 4. Practice or experiment in the classroom 5. Use terminal multimedia to participate in classroom questioning, test, answer and alter screen presentation	1. Understand the content of different presentations (text, video, animation, audio, etc.)） 2. Recall information related to the information obtained 3. Associate with external environment or data
Knowledge Construction	1. Comment with public editing tools 2. Optimize own results based on the results of others 3. View related information resources such as study cases (use resource information such as study cases, e-books, etc.) 4. Choose the appropriate learning resources and tools 5. Search for relevant information resources with search tools 6. Extract important information from resources (using public editing tools, notebooks, etc.) 7. Integrate information and make learning works (using characterization tools such as mind maps) 8. Use the subject inquiry tool to operate and summarize the problem solving process (using discipline tools such as virtual experiments) 9. Students acquire and analyze information or data by doing experiments and searching.	1. Interpret, reflect, and correct their own results 2. Modify, refine, and integrate information resources 3. Create new information 4. Analyze, reflect, and absorb the results of others
Collaborative Communication	1. Respond to questions raised by teachers, etc. 2. Initiate a hand-lifting speech, etc., ask the teacher 3. Ask the teacher through an online communication tool 4. When altering screen, use annotations to explain with teachers, share and exchange learning results. 5. Alter screen demo to share your learning outcomes 6. 6. Communicate issues, share resources, and discuss results with communication tools	1. Raising conflicts with cognition 2. Explain and illustrate 3. the constructed knowledge to others
Evaluation Feedback	1. Teacher initiates evaluation invitation, student evaluation 2. Evaluate the results and performance of others with features such as 'Like' 3. Negotiate solutions with voting, communication, etc. 4. Propose information that is inconsistent with cognitive structure 5. Use online tests to test learning outcomes 6. Real-time monitoring of learning progress	1. Analyze, reflect, and evaluate the performance of others 2. Analyze and evaluate learning resources and tools 3. Organize, classify, analyze, synthesize, and evaluate data or information 4. Analyze, reflect, and summarize problem solutions 5. Analyze and reflect on learning outcomes 6. Rethink the problem provided by the teacher 7. Reflect on the performance of their owns or others

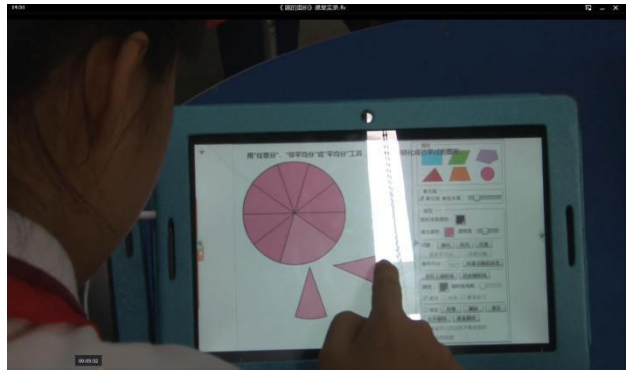
through the application of multimedia. It created a more suitable environment for students to provide support for their learning, thus promoting the school's internal special discipline construction and resources sharing between teachers and students, and it helped improve the efficiency of students' learning at school. From this, the most direct application of e-book bag in teaching is experiential learning.

Through the analysis of Video case #2 (**Snap Pictures 1 and 2**), under the guidance of the situation and teachers, students used the combination of information and technology to carry out a series of teaching interactions such as questions, exams, answers, and screen presentations. Combining all the video cases, we found that teacher visualized the questions by the e-book bag, drew the attention of students in the class, and clearly demonstrated the process of teachers' questions. Through the problem of immediate visualization and the encouragement of teachers, they brainstormed immediately, responded to teacher's problems actively, and answered teacher's questions according to the prior-reading materials in the e-book bag. The teacher altered the screen and interpreted vividly the concept of "equal division" through various charts. These interactions, without exception, enhanced the connection between teachers and students, so that students could improve their learning efficiency in terms of cognitive attitude, participation, and motivation, etc. From the video, we also felt intuitively that students were influenced by subjective initiative and individual thinking. They were attracted by novel e-book bag, fully mobilized visual and auditory senses, concentrated on listening to the teacher and constantly "storage-consolidation-practice" knowledge in their minds. These series of behaviors showed that with the full use of e-book bag, teachers could successfully stimulate students' imagination, thinking and emotions, and improve their interests and create a good learning atmosphere.

Under the knowledge construction dimension (**Figure 1**), the e-book bag supported students' self learning, gave students the opportunity and right to arrange their own learning activities and realize knowledge management. For example, in Video 03 (24'32''-30'47''), Video 07 (28'45''-34'37''), Video 11 (24'22''-36'47''), the teacher shared the specific classroom learning materials to the class through the e-book terminal, and students prepared and digested by themselves and asked questions, discussed and solved questions in group, and finally submitted the group discussion to the e-book bag. The teacher evaluated and shared the process and results in the class. It showed that the use of e-book bag in teaching stimulated greatly the autonomy of students' learning, promoted students to learn independently and collaboratively, and provided them with channels for individualized learning habits. This method allowed them to develop their own thinking while learning relevant knowledge, and achieved the development of both aspects, so that they could learn happily, actively and collaboratively, and finally they could be more suitable to the society. Therefore, the promotion of teaching technology, the improvement of teaching level and the construction of teaching environment through e-book bag can help teachers to impart knowledge better, as thus achieving the purpose of strengthening teaching quality. As the concept of intelligent education is deepened and applied to practice, the e-book bag can mainly support three modes: teachers' teaching, students' self-cooperation and intelligent star teaching. E-book bag

Snap Picture 1. Students are Investing in E-Book Bag Learning. (Video 02, 8'45''–11'50'')

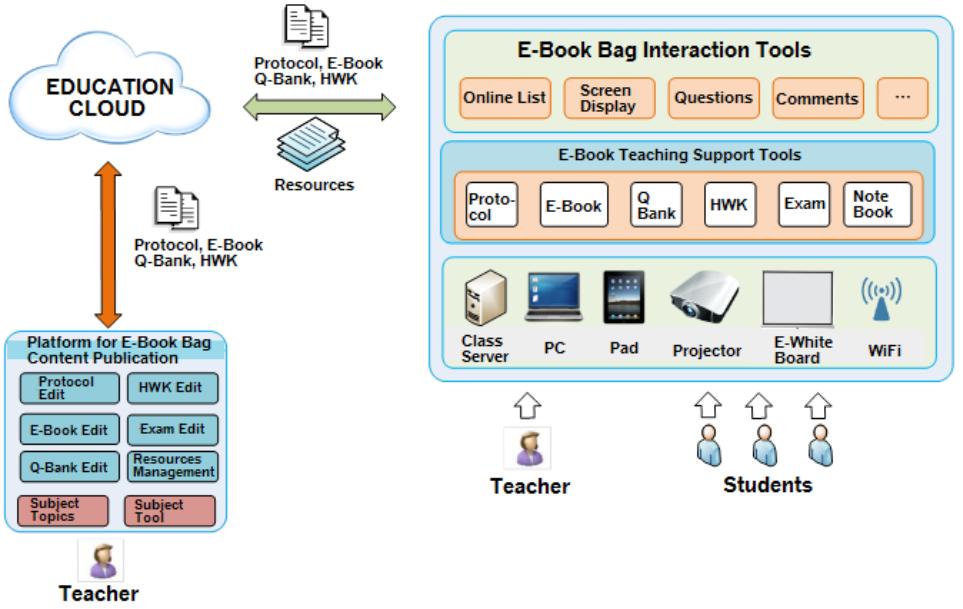
Snap Picture 2. Real Shots of Students Using E-Book Bag for Learning. (Video 02, 15'23''–17'46'')



can also effectively help teachers to carry out related activities to improve the quality of teaching and materialize specific teaching methods and provide students with better quality learning resources and high-tech teaching platform. The learning efficiency in class has been improved by e-book bag. Based on this, the helpfulness and function of the e-book bag for knowledge construction is obvious and effective for both teachers and students.

In order to do as much as possible, it is necessary to scientifically arrange planned teaching and personalized learning activities. In Video 13 (8'22''-15'17''), the History teacher used the teaching method of playing related video materials to guide students to understand the dynasty replacement of the dynasties of Xia, Shang, and Zhou by watching the video as a relatively easy way to obtain information. This can help the seventh grade students establish the concept of dynasty in the history learning. From this, the use of technology and information to promote the improvement of teach-

Figure 1. Experiential Learning Activity Model Supported by E-Books.



Note: Q-Bank, Question Bank; HWK, Homework.

ing quality, teachers can be better able to take measures against the status quo, improve teaching, and design corresponding session in class according to the actual needs of students, i.e., finding the optimal solution for class teaching. Through promoting the development of personalized education using scientific arrangement of the teaching and personalized learning activities, more students have the opportunity to conduct personalized learning. In addition, this method can also promote students' learning outside of the classroom.

Case #2 (Video 18) was collected on-site in the second phase of the National Information Technology and Teaching Integration Showcase and Training Event.

In the collaborative communication dimension, e-book bag provided a benign development platform for the exchange of learning between teacher and students, and between students and students. From the recorded Video 18 (17'25''-19'46'') (**Snap Picture 3**), it could be visually found that students could achieve the interactive teaching in class through the e-book bag, the teacher used the online listing function to display and view students' online situation, check students' hand-raising situation, the submitted questions, and altered screen presentation. The teacher could share pictures for everyone. Students could use the editing tools on the tablet to comment on the pictures, express their opinions, and send the pictures they have back to the teacher. The teacher could select excellent works from the review pictures sent by the students to explain. For the selected pictures, the students can like, save, or enlarge the view; the

Snap Picture 3. Live Recording. (Video 18, 7’25’’–16’56’’)

teacher can let the author student of the picture explain the pictures on the tablet side, the big screen will synchronize the presentation process. It can change the teaching normality in the past, re-establish the interaction between teachers and students, and ensure the effectiveness of classroom teaching. Through the use of e-book bag for teaching, teachers can better provide convenient mobile services, help simultaneous presentation of teaching resources, including instructions, courseware, and homework.

In the evaluation feedback dimension, through Video 04 (37’38’’-43’21’’), Video 08 (46’56’’-49’51’’), Video 13 (25’32’’- 38’27’’) and Video 19 (22’32’’-45’27’’), etc., it was known that the e-book bag supports both teachers and students to view, publish and share instructions, courseware, and assignments on the mobile side. Teachers could review assignments on the mobile side, added personalized comments to each student; viewed the textbooks, teaching reports and progress, and teaching situation, including daily preparations and interactions in the class. Students can participate in the theme activities, upload works, and exchange discussion, assignment details and reports on the mobile side. In the actual recording, we can intuitively get connection between teachers and students through e-book bag. The following picture showed the statistical distribution of the e-book bag in classroom interaction (**Figure 2**). It can be seen from this chart that teachers can guide students to summarize the achievements, reflection and suggestions of the theme activities, and publish the results on the platform. Students can test their learning results through the teaching process.

Through the analysis of the selected teaching recorded video, we could find that the e-book bag fully utilizes scenario creation, knowledge construction, collaborative communication and evaluation feedback and other functions in the specific classroom practice and learning as well as in the collaborative application of the theme activity.

Figure 2. E-Book Bag Classroom Interaction Distribution Statistics.

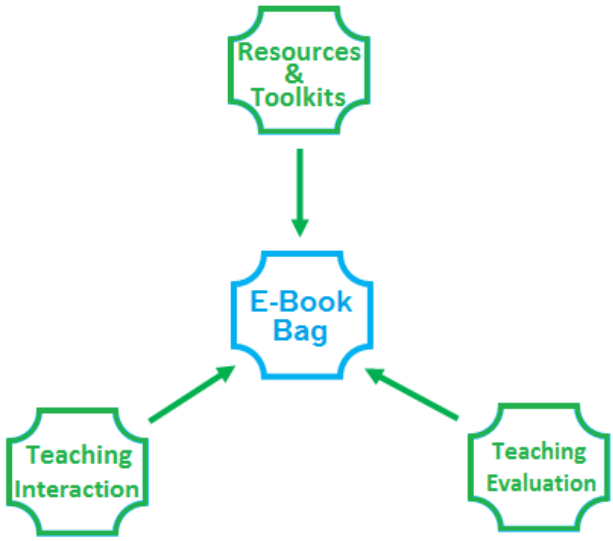
The Role of E-Books in the Teaching Process

Based on the records and analyses of the application of e-book bag in classroom practice and their respective role in the above four dimensions, the role of e-book bag in the teaching process can be summarized as following three categories in **Figure 3**: "resources and toolkits", "teaching interactions", and "teaching evaluation".

The Role as the "Resources and Toolkits"

Resources and tools were different forms of learning after processing, and were the main environmental conditions for teachers and students to complete knowledge construction. Whether at teacher's terminal or at student's terminal, resources and tools

Figure 3. Three Functions of E-Book Bag.



included resources such as study cases, e-books, and micro-courses as well as related teaching tools and subject tools based on learning objectives, individuals, contents, styles, and scenarios. In addition, in order to effectively update and share resources and tools, resource management function was also set up to upload and download resources and tools conveniently and quickly. Students could choose and download independently the various resources and tools that teachers prepared for them before lesson. The study case was used to support the student's self-directed learning, allow students to complete a preliminary understanding of knowledge. E-book bag was media-based and can not only present knowledge contents, but also enable students to interact with learning contents. For example, the micro-courses, was short and succinct, which could help students to learn key points of knowledge in a targeted manner. Therefore, paperless work is convenient for students to answer, but also convenient for teacher to manage and check.

The Role in Teaching Interaction

Specifically, interaction refers to online and in-class communication between teacher and students, students and students. With regard to online communication, the teacher terminal and the student terminal allow communication anywhere and anytime. The intelligent classroom supported by the e-book bag advocated the teaching philosophy of "teacher-leads, student-centered", so the teacher terminal and the student terminal have different functional modules. Classroom interaction was dominated by the function of the teacher's terminal. It included: screen demo, raise hand list, listen carefully, ask questions, screen broadcast, share pictures, collect pictures, send and receive files, vote, monitor, screen pen, lock, group management and other functionalities.

Supporting Role of Teaching Evaluation

Evaluation helped to promote teachers' reflection on teaching and students' reflection on learning. It mainly included functions such as testing, analysis of the situation, evaluation of the classroom, and soliciting opinions. Among them, the analysis of the situation and the solicitation of opinions are unique to teacher's terminal. The test and the evaluation are common to both terminals of teacher and students. Among them, the test is a way for students to conduct self-evaluation. From the test results, the teacher could extract information about students' learning situation and propose corresponding improvement. The analysis of the learning situation was to analyze students' participation and achievements in the class, and helped teachers to assess students' learning situation. The classroom evaluation was initiated by the teacher's terminal, and the teacher and students conduct self-evaluation of their performance, respectively. The solicitation of opinions was initiated by the teacher terminal, and the students used the "like" functionality to vote on the learning outcomes of other students.

These three functions of the e-book bag greatly supported the role and effect of the teaching scenario creation, student knowledge construction, the collaborative communication, and evaluation feedback of teachers and students.

The Role of E-Book Bag in Interactive Teaching

We could clearly receive the results of the observation of 20 smart classroom teaching records from the aspects of scenario creation, knowledge construction, collaborative communication and evaluation feedback. It was also found that students learning under the premise of applying e-book bag, they achieved a good effect of interactive teaching and their learning often had higher learning efficiency. It could be seen from the code of **Table 2**, "The behavior of e-book bag supports intelligent classroom learning that in the smart classroom", and the interactions between students and teachers, students and learning contents occurred under the support of e-book bag, its characteristics are:

First, the interactive and evaluation functionalities of the e-book bag were used in the interaction between students and teachers. With the support of the e-book bag environment, teachers guided students to think independently, ask questions, share results, and learn to reflect. Throughout this process, students are required to use the technical environment for communication and reflection.

Second, the interactive, evaluation, resources and tools functionalities of the e-book bag were used in the interaction between students. With the support of the e-book bag, students and their peers identified the subject of inquiry, and negotiated solutions and used resources and tools to express their opinion. It was worth mentioning that when students encountered problems, they could use the communication tools to consult with their peers (either in the same group or in different groups). Although there was less online communication in the class, building and utilizing a learning network was one of the skills that students must have. Meanwhile, when evaluating the perfor-

mance or learning outcomes of peers, they used the evaluation function in the e-book bag to vote for the students or learning outcomes that they thought were the best, and optimized their learning outcomes by reflecting on others' learning outcomes. Throughout the process, students were required to use the technical environment for communication, collaboration, and reflection.

Third, the resources and tools and evaluation functionalities of the e-book bag were used in the interaction between students and learning contents. The learning contents were mainly presented in the form of digital information resources. Students needed to select appropriate learning resources and tools according to their learning needs, and completed the self-construction through interacting with digital information resources and tools; for instance, we used the study case to obtain the knowledge information of the new course or used the virtual experiment tool to summarize the knowledge information of the experimental process, and finally integrated the obtained information together to complete the learning task. We also created relevant information, and completed the process of constructing information from the preset information through the process of acquiring, modifying, refining, and integrating. At the same time, students used evaluation function (online and other ways) to reflect on their learning outcomes. Throughout this process, students were required to use the e-book bag environment for self-construction and reflection.

Fourth, e-book bag had multifaceted roles in promoting smart learning. As far as the intelligent classroom teaching and learning under the support of e-book bag was concerned, the behavior of "learning" and the behavior of "teaching" were manifested in the form of "behavior pairs" in which symbiosis coexisted; in other words, the intelligent classroom teaching activities are composed of multiple "behavior pairs" in a certain logical order.

Discussion

Gu (2018) and Zhong (2011) showed that e-book bag had a positive effect on learning and could promote students' learning. From our observation and analyses of the specific learning behavior in the recorded videos of the application of the e-book bag, we drew the same conclusions as Gu and Zhong did. On the one hand, the e-book bag can fully mobilize students' enthusiasm for learning, and promote students' independent and individualized learning. On the other hand, the use of e-book bag is also conducive to strengthening communication between teachers and students and forming a benign interaction. Given the e-book bag has the function of "resources and toolkits", it will effectively create real-life task situations, activate students' cognitive experience, and embody abstract concepts with interactive resources such as synchronous experiments and rich media e-textbooks. Although doubts exist regarding the specific functionalities of e-book bag and even negative effects there, we considered that as long as the students are correctly and actively guided to use e-book bag, its beneficial effects will be much greater than the possible negative ones. Therefore, we believe that the support

role of e-book bag for intelligent learning is mainly reflected in the following three aspects: learning mode, interpersonal interaction and cognitive process.

Meet Students' Individualized Learning

Individualization, as its name implies, is uniqueness, while individualization in learning means that students can do self-selection according to their unique learning needs. Chabert et al. (2006) found that the rich resources and tools in the e-book bag could customize the learning plan suitable for them according to the different learning styles, knowledge levels and the specific learning situation. In our study, we observed that students could use e-book bag to select different forms of resources according to their learning style, such as text, pictures, micro-courses, etc., and also could select different levels of learning tasks according to their cognition level, like basic, promotion, or expansion task. Moreover, Gao (2011) and Qian (2012) also pointed out that the application of e-book bag to teaching had mobilized the enthusiasm of students, promoted the individualized learning, broke through the limitations of time and space, extended in-class learning to after-school, helped to develop self learning plans, completed self-learning contents, and expanded knowledge. In the process of self-selection, students' individualized learning was realized, which avoided the situation that students' learning situation was seriously differentiated and the teaching methods could not meet their learning needs.

Support Teaching Interaction and Cooperation

Interaction and cooperation are the characteristics of the e-book bag environment. It provides a platform for students to communicate, enhances interpersonal dialogue and interaction, and promotes knowledge for exchange and sharing. Liu (2013) pointed out that various resources and tools could satisfy the multi-dimensional interaction between students and teachers, between students and learning contents, and help to complete cooperative learning in the process of interaction. The media-containing characteristic, openness, and relevance of resources make them be three-dimensional, which not only presents learning contents, but also supports interactive activities such as student annotation and experiment. In our study, we observed that both students and teachers created "brainstorm" through interaction with available resources, and completed "collision of ideas" with the classroom interaction (voting, sharing pictures, etc.). After class, when students encountered problems during the self-studying process, they sought help from teachers and classmates through online communication tools to solve problems. Using the e-book bag environment, teachers and students also carried out inquiry activities in a planned and targeted manner to jointly solve the real problems. The teacher-guided students' subjective learning atmosphere was strong, and the participation of teachers and students in the classroom and the interaction between them outline the basic situation that shows a two-way classroom and "dual subjects".

Support and Promote Knowledge Construction

Knowledge construction is the interactive result of cognitive experience and environment. The rich resources of e-book bag create real-life task situations and activate students' cognition. With the help of synchronous experiments, media-enriched electronic textbooks and other interactive resources, the abstract concept can be embodied to form a chain of knowledge convergence and adaptation. In the learning process, students use the public editing tools to mark and record resources any time, make notes, and refine key knowledge points. After learning, students use the cognitive tools such as mind maps to sort out what they learned, summarize the learning results, and share them with teachers and other students through the online communication tool or classroom interaction function, by which they test their own views that differ from peers, and then make correction, absorb the essence of others, and promote knowledge sharing.

A difference exists between e-book bag-supported intelligent teaching and traditional teaching. This difference is majorly from the teaching methods. As Donovan (2007) indicated that intelligent teaching was more vital between teachers and students, and between students, and enabled knowledge to be transferred and communicated better. In comparison, traditional teaching oftentimes uses a boring and indulgent "instillation learning" method, from which teachers unilaterally output knowledge, and then students are lack of vitality. E-book bag focuses on the use of digital and internet resources. The pictures and videos of the e-book bag are more likely to attract students' attention, which contributes to students' learning, and to teacher's instructing, and receives instantaneous feedback from the students.

According to the Constructivism Learning Theory (Chen, 2019), the application of e-book bag in the teaching practice at elementary and middle schools had greatly enhanced students' participation in learning, and the construction of knowledge constitutes a process of participation of teachers and students. The construction of knowledge requires participation of both teachers and students, so students are no longer passive recipients, but independent active learners. E-book bag provides powerful support for the transformation of the knowledge view and the teaching relationship, and is conducive to transferring teaching mode from teacher-centered to student-centered. When the students' willingness to explore is mobilized, learning itself may become an incentive factor, making students' learning more based on intrinsic motivation rather than external pressure. From the Self-Determination Theory (Jeno, et al., 2019), internal motivation often leads to better output performance, so this is one of the reasons why the use of e-book bag can promote student learning.

Research Deficiency and Research Enlightenment

Our study was based on the 20 teaching practice videos of e-book bag use in Changchun, China. Through video analysis, we recorded and analyzed the actual application of e-book bag in real teaching process, and drew above-mentioned conclusions regard-

ing e-book bag's beneficial effect on students' learning. However, the limitations need to be acknowledged.

Although we selected 20 videos as the sample size, and they were from 20 elementary and middle schools in Changchun, China, the geographical coverage of the samples was a limitation. Therefore, the results may not represent the overall situation of the e-book bag application in domestic classroom teaching.

For each selected video, it only had 45 minutes of recording, which just was a fragment of one regular class teaching. In addition, given teacher's supervision and guidance in the class, the use of e-book bag would be more proactive. As the function of e-book bag has been doubted and questioned (Hu & Zhang, 2012; Liu, 2013; Zhu & Yu, 2011), they pointed out the negative impact of e-book bag on students' learning, including health, internet addiction, and cost. Although these negative effects are subtle and unconscious, and need to be observed for a longer period of time. Therefore, just in a 45-min long teaching video, we were unable to conduct research and discuss the drawbacks of e-book bag far deeper.

In sum, the application research of e-book bag based on classroom recordings fully utilized the advantages of e-book bag, built up a supportive environment for intelligent teaching, and integrated information technology with all aspects of education and teaching, as thus had education information tool become an essential way for teachers' instructing, students' learning, and teaching management. E-book bag helps to support teachers' intelligence being materialized and distributed, exercises their instructing level, and improves their teaching quality. For students, e-book bag helps them to carry out independent and individualized collaboration to get extensive learning, and enhances their innovative ability in acquiring knowledge and training skills, so that they can learn in an easy, happy, and active way with high quality and efficiency. Therefore, e-book bag has a far-reaching and long-lasting effect on students' autonomy, innovation, and quality learning, and can be promoted nationwide experimentally. However, it needs to be kept in mind that e-book bag, as an electronic product, will inevitably produce some negative impact on students. So in order to reduce the potential negative impact, teachers and schools are responsible for actively guiding students to use e-book bag in a right way at right time. In the future, studies on the function of e-book bag should focus more on its potential drawbacks, and use larger sample size to obtain a more complete and representative understanding.■

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ORIGINAL ARTICLE

Practice and Exploration of Cultivating Students' Critical Thinking by Using Problem-Based Learning

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Abstract: Currently, the English teaching at elementary schools in China is generally lack of training of students' thinking ability. However, critical thinking is the most important and valuable ability for learning. In order to develop students' critical thinking skill, teachers introduced problem-based learning into English teaching at elementary schools by taking three stages as setting prior-, during-, and post-reading as an example, explored students' critical thinking ability through creating a questioning atmosphere, setting up a thinking platform, and improving the quality of problems. Our practical performance showed that problem-based learning can significantly improve students' thinking quality.

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THE "English Curriculum Guideline for Compulsory Education (China, 2011 Edition)" pointed out that English curriculum at the compulsory education stage has dual characteristics of both instrumentality and humanity. In terms of instrumentality, English course undertakes the task of cultivating students' basic English literacy and developing students' thinking ability. That is, students are able to acquire basic language knowledge, develop basic skills of English listening, speaking, reading, and writing, and get the basic ability of communication with others in English. Furthermore, it promotes the development of thinking ability, and lays the foundation for future English learning and other relevant courses in English (China Ministry of Education, 2012).

At present, China has the largest English learning population at elementary schools and instructors of elementary English. Over the years, China's elementary English teaching reform has made great progress. In each sized city (large, medium or small), internet and multimedia have become popular in teaching, and the instructing methods in class are diversified. However, from various reasons, our conception, system, structure, education mode, contents and methods all are relatively lagging behind. The traditional teaching mode still dominates the class, which emphasizes majorly on teaching methods but not learning methods, on asking students questions but not evoking thinking, on concluding but not the processing, and on transferring knowledge but not developing ability. For taking elementary English reading comprehension as an example, students' participation looked implemented, but the fact is that students' learning was constrained, which often displayed in a one-way verbal communication as "teacher asks, and then students answer", a model with less efficient in cultivating students' thinking ability.

Currently, critical thinking has been widely set up as one of the goals of education, especially of higher education. As indicated by Roche (2015) that students cannot passively accept information in the process of learning, but actively and initiatively think, and proactively analyze what they learned to form their own attitudes and perspectives. Bringing critical thinking into elementary English class, not only meets the requirements of the new curriculum guideline for English education, but also helps students develop good thinking habits from an early age.

Problem-based learning is a widely used teaching mode in higher education in Europe and the USA. It is a relatively new teaching mode with a core idea to establish a student-centered learning environment, through setting up questions based on students' real life and experience, guiding them to explore new knowledge and solve practical problems. Actual practice showed that this mode can effectively cultivate students' critical thinking and improve their ability to solve problems (Xia et al., 2014).

This study took problem-based learning as the key and entry point for cultivating innovative thinking ability in class. We used the teaching cases in the textbook of English (The People's Education Press, China, same below), and explored strategies and methods for cultivating students' critical thinking in elementary English reading comprehension and improving their thinking quality.

Prior Reading – Based on the Theme, Creating a Questioning atmosphere

The prior-reading section is crucial to the entire comprehension teaching. Activating students' background knowledge related to the topic of the story can effectively improve students' understanding. At present, the prior-reading activities designed by most teachers are relatively simple, such as by cutting into the animation in a short period of time and asking "What is the story talking about?" etc. to let students think. Although this method can quickly get to the topic, it lacks the vitality of thinking because of the shortage of interaction between teachers and students, and among students. If the teacher can stand on the topic of the reading text, let students raise their interested questions based on the topic, or engage in the interaction based on the topic, it will activate students' thinking and enhance their linguistic expression and thinking ability.

Promote Interaction with Topics and Create Opportunities for Questioning

Class teaching should provide students with the opportunity to exchange and interact, so that they can constantly exchange their ideas and realize a collision of ideas. Each unit of the English is topic-based. Prior reading the text, teachers can adopt Problem-based learning, let students carry out independent communication around the topic, and gradually cultivate their awareness of questioning.

For example, "Unit 2 *My Week*" Volume 1 in textbook of the fifth grade is based on a student's one-week schedule. In the Reading and Writing section, the title is "Robin's Advice", and it discusses the daily arrangement of Yifan Wu. Prior reading, the teacher can guide students to observe their own curriculum and encourage them to guess the teacher's favorite workday.

The teacher showed his/her own curriculum (**Table 1**):

Table 1. Teacher's Curriculum.

	Monday	Tuesday	Wednesday	Thursday	Friday
1			English	English	English
2	English	English	English		
3		English			
4	English	English	English	English	Arts
5				English	
6	Arts				

T: Boys and girls guess, what is my favorite day?
S1: Monday.
T: Why?
S1: Just a guess.

Then, the teacher guided students to pay attention to the curriculum and obtain more information through questions.

T: You may ask me some questions to get the idea.
S2: What subject do you like?
S3: How many lessons do you have on that day?
S4: What do you usually do?
S5: Which one do you like, English or art?
S6: Do you have two classes that day?
……

The prior-class questioning activity based on the topic as a main line can activate students' knowledge reserve, and mobilize the enthusiasm of the whole class. The teacher gives each student the opportunity to ask questions. The students develop their thinking ability and language expression ability via a positive circle of questioning, answering questions, and re-questioning. This kind of activity can not only pave the way for learning new contents, but also give the initiative to students.

Promote Interaction Stirs up Doubts Using Pictures

If teacher always asks questions during the learning process followed by students answer, this process will make students be passive learners over time. To let students learn how to question, it is not simply a matter of time to ask questions, but to require teachers to conduct training and guidance strategically (Li & Yan, 2016). Before reading the text, teacher can let students observe the text picture, understand the background of the story, and guide students to ask questions about the story to stimulate the students' interests in further reading.

The Fourth Grade Volume II of Unit 3 *Weather* is based on common weather and corresponding event arrangements. The Reading and Writing section is a text of a postcard genre that describes the weather and suitable activities in Sydney and Beijing. Before start reading, teacher first presents the text illustration (see **Figure 1**) that retains the name and signature of the letter, and then instructs students to observe the illustration and ask questions.

Under the guidance of the teacher, students can ask meaningful questions based on the picture information, for example: Where is John? Where is John's father? What's the weather like in Australia? Is it hot in Australia? Can John go swimming? ... Problem-based learning can not only fully exercise students' verbal ability, but also enable students to predict and associate text content, stimulate students' curiosity and desire for knowledge, and enable students to form reading expectations, thus students can actively read stories, answer their own questions. Once students develop the habit of asking questions and learn how to ask, the possibility of asking questions in class will become bigger (Chen & Wang, 2009).

Figure 1. Illustration That Retains the Name and Signature of the Letter.

During Reading – Focus on Strategy Guidance and Build a Platform for Thinking

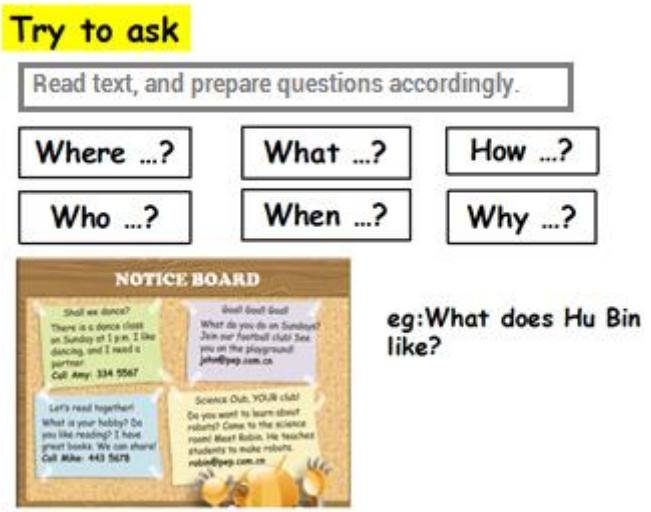
During reading, teachers should give students time to think independently. In addition, teachers should presuppose the difficulty encountered by students when asking questions, including giving students some expressive support, as well as guiding the generative problems in the questioning process. For example, what interrogative words should students use for questioning? What are the dimensions for students to question? How to make students who lack of learning ability can also ask simple questions? During reading, if the teacher wants to give students the opportunity to question, they should promote students' thinking to participate in the learning activities.

Focus on Interrogative Words and Build a Thinking Frame

Teachers can capture students' questions focusing on the text in the teaching, and use infiltration questioning skills, such as providing keywords, to build a questioning frame and to cultivate students' critical thinking ability.

For example, the Sixth Grade Volume I text book Unit 5 *What Does He Do?* The theme of this unit is a common occupation, the Reading and Writing section is an article about hobbies, dream careers, and jobs. Teacher can guide students to question after presenting the text background, and provide the students with some special interrogative words such as who, where, what, how, etc. (see **Figure 2**). In order to allow students who are lack of learning ability to participate in, the teacher can guide students

Figure 2. Providing Students with Special Interrogative Words.



to work together and give an example of the problem: What does Hu Bin like? This allows students with different learning levels to question the text.

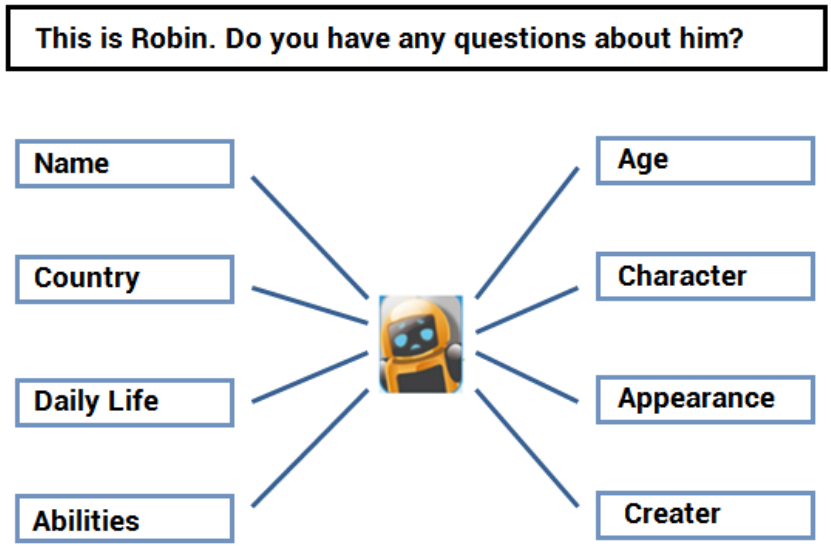
Since teacher provides appropriate support to students, the students have clear goals for the direction of the questions, so the thinking is more rational and logical. The use of group-based design to guide questioning can avoid problems that are meaningless or not in place (Kwan, et al., 2015). Inspired by the teacher, students raised the following questions: What does Sarah like? Where is Robin want to work? What does Hu Bin want to be? Who can be a scientist? What can you be if you like sports? ... From the actual class, the questions raised by students are in-depth, meticulous and valuable. If students' question is incomplete, the teacher needs to provide assistance in time. For example, when a student asks a question on half way, when he or she says: Where Robin work...? Although students encounter some obstacles when questioning, if the teacher consistently penetrates the questioning strategy in the class for a long time and continue to encourage, students will develop a habit of questioning.

Expand the Dimension of Thinking with Maps

As a learning strategy, mind map can promote meaningful learning, integrate them with new and old knowledge, construct a knowledge network, and enrich the knowledge structure so that they can grasp knowledge as a whole. In the process of cultivating students' questioning ability, teacher can use the mind map to guide students to raise questions from different angles and promote their active participation.

For example, the Fifth grade text book Volume I Unit 1 *What's He Like?* The theme of this unit is to describe the appearance and character of others. The Reading and Writing section is Yifan Wu's diary, which mainly describes the basic features of Robin. In teaching, students could be guided to understand the personal information of the person through questions. In order to let the students open their mind and activate their existing knowledge reserve and life experiences, the teacher first guide the students to think about the directions from which they can base questions on, thus enrich the content of the mind map (see **Figure 3**), and finally present the questions in a full dimension.

Figure 3. Teacher's Guide to the Directions of Questions.



The aid of mind maps makes students' Problem-based learning have a clearer direction of thinking, and thus trigger their divergent thinking (Nasution, et al., 2016). With the focus of thinking, after the students fully discussed in their group, they raised the following questions from different directions:

S1: What's his name?
S2: How old is he?
S3: What's he like?
S4: Who made him?
S5: Is Robin helpful?
S6: Who makes me finish homework?

After that, teacher and students modify, classify, and organize the questions they raised. In this process, the teacher also gives guidance method to the students. During the learning, the main line of using the mind map runs through the whole class. In generating and thinking training, the teacher and students jointly establish a bridge that links thinking and language learning.

Use the Scene and Having Fun of Thinking

Whether students can truly participate in communication and actively questioning in class depends largely on whether the situation created by teacher can stimulate students' expression desires and interests (Jaeger & Adair, 2014). In the class, teacher should create real and interesting scenes, and use this as the main line to achieve learning goals step by step.

For example, the Sixth grade text book Volume I Unit 3 *Where Did You Go?* The theme of this unit is a common holiday event. The Reading and Writing section is a conversation about holidays. The sentences used in the conversation are 'How was...? Where did you go? What did you do? etc. The teacher first starts from his/her National Day holiday, guides students to interview him/her, and provide some tips, such as the content of the interview, the sentence patterns that can be used (see **Figure 4**).

The teacher said to the students: I went to Beijing last National Day holiday. Do you have any questions about my National Day holiday? The teacher asked students to ask one or two questions which they were interested in first. The questions asked by the students are: Where did you do? Did you visit the Great Wall? How did you get there? etc. Then, the teacher asked a student to interview him/her through a series of different questions, and finished a completed and logical dialogue with the teacher.

Figure 4. Tips for Interview Questions.

S: Hi, Miss Wang. How was your National Day holiday?
T: It was great fun.
S: Really? Did you go travelling?
T: Yes, I went to Beijing with my family. We had a good time there.
S: How did you go there? By train or by plane?
T: By plane. We stayed there for five days.
S: Where did you go in Beijing?
T: We visited the Great Wall, the Palace Museum and the Summer Palace.
S: Sounds great! I visited the Great Wall last year. It was beautiful. Did you take photos?
T: Yes, a lot. I tasted many good foods, too.
S: Wow, did you eat Beijing roast duck?
T: Of course. It was delicious.
S: I know a lot about your holiday. Thank you.
T: You're welcome.

In the interview above, the teacher let the students perceive the interview process initially, demonstrated how to focus on the topic, how to question skillfully, how to undertake the topic, and then the teacher refined the elements of the interview and the questioning skills (see **Figure 5**). After that, the teacher let the students conduct interviews and learn how to questions and answer them through exchange and interaction with their peer partners.

Figure 5. Refine Elements of the Interview.

By presenting the basic steps and key points of the interview, the teacher let the students emphasize on the conversation. Students can internalize what they have

learned and conduct real communication with their peer partners. Students can initiate questions during the interview, listen carefully to each other, conduct effective questioning, and adjust questions appropriately. They can also turn the topic and end the conversation at the right time. In this activity, students have a deep understanding of the method of questioning and have fully trained their critical thinking skills.

Post Reading – Achieve Meaningful Communication and Improve the Quality of the Questions

The post-text reading section belongs to the language output section, which is an important part of reviewing and applying the content learned, and also a platform to show students' learning outcomes and reading results. In this session, teacher encourages students to change their perspectives and thinking deeply, so that students have the opportunity to interpret, examine, and dialogue the text in a personalized way to grasp the connotation of the text.

Encourage Independent Speculation and Deepen the Meaning of Students' Doubts

Elementary English teaching emphasizes on communication and dialogue. Therefore, how to create opportunities for students to express their opinions and develop their thinking skills has become an essential task of reading teaching. In the actual context, students often make a hard copy of the textbook when they express their words verbally, they are lack of thinking in the content, and it is difficult to form their own independent point of views.

For example, in the Sixth grade textbook Volume II Unit 2 *Last Weekend*, the topic is regarding how to tell what has happened in English. The Reading and Writing section is about the unpleasant experience of the Yifan Wu's family in a hotel. Instead of simply reading the performances, the teacher continues to use the Problem-based learning to guide students to think independently and ask their own questions. The following are some of the questions raised by students:

> *Group 1: How to choose a hotel before you check in?*
> *Group 2: What can Yifan Wu's family do after this? Maybe they can try to get a half price.*
> *Group 3: They were not happy. How can they try to be happy?*
> *Group 4: ...*

The teacher guides the students to express their questions freely after reading the story. On the one hand, students can get the opportunity to express their thoughts directly, and on the other hand, teacher can know students' understanding level of the text. This open-ended activity gives students an experience of discernment. Although their expressions contain grammatical errors, and even groups are expressed in a mix-

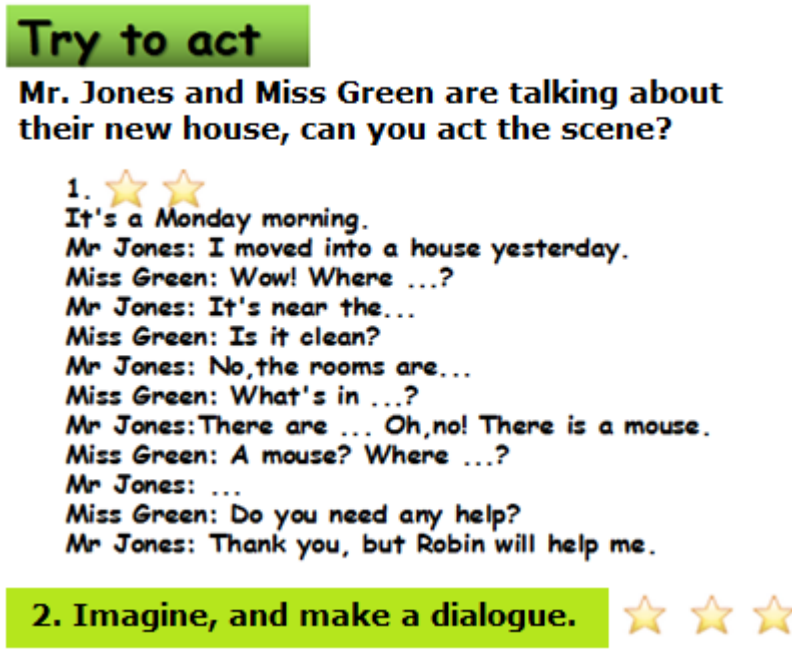
ture of both Chinese and English, students have the opportunity and the right to think independently. The teacher guides them to think further based on the questions they raised, and inspires students to think more deeply about the contents.

Change the Text Form to Increase the Depth of Student' Questioning

In elementary English class teaching, the teacher can enhance student's interest by respecting their learning experience, and by enriching the interaction in class. It is possible to activate students' awareness of language use autonomously, to promote the development of students' thinking, and to enable students to produce a dynamic and true verbal expression that reflects the value of the English curriculum (Hua, 2015). In the post-reading session, teacher should guide students to use English knowledge they have learned and reach consensus and understanding in communication.

For example, the Fifth grade textbook Unit 5 *There Is a Big Bed*. The topic is to describe the items in a room. The Reading and Writing section mainly describe the old house that Mr. Jones has just moved into. The text is presented in the form of reading comprehension. In the post-reading session, teacher changed the text form and created performance tasks (see **Figure 6**) to guide students in communication activities.

Figure 6. Teacher Creates Performance Tasks to Guide Students How to Talk.



The expression structure of this lesson is relatively simple. In post-reading consolidation session, if the teacher was simply to allow students to retell the text, it would be monotonous and boring, and additionally the student would not be able to grasp the major point of the text flexibly. In this post-reading activity, the teacher respected student's existing experience and differences in learning ability, and provided opportunities for students in different learning levels to create and edit conversations based on their understanding of the text. In the process of creation and editing, students can grasp the core issues, gather text details, and develop rich associations to make the characters live.

In reading comprehension teaching, whether it is prior, during, or post reading, Problem-based learning can be skillfully used before, during, or after reading, which is of great significance for cultivating students' critical thinking. However, Problem-based learning is still in the early stage in English teaching in China, and its use in English education in elementary schools is even rarer. Due to lack of resources, this study still has some shortcomings.

In short, critical thinking can stimulate and maintain students' interest in learning, and create an ideal and more realistic environment. The cultivation of students' thinking in English reading comprehension teaching in elementary schools cannot be separated from the in-depth interpretation and creative use of the text by the teacher.■

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ORIGINAL ARTICLE

How to Achieve a Balance between Teacher-Lead and Student-Independent Inquiry in A Digital Class? - A Case Study Based on Chinese Middle School Mathematics Teaching

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Abstract: How to integrate digital information technology into classroom is not only a challenge, but also a test for both teaching and learning. Getting involvement of digital information technology into classroom extends students' learning in time and space, and alters teachers' teaching status. However, how can we achieve a balance between teacher-led and student-independent inquiry in a digital classroom? I hereby used "Reviewing the Image and Nature of Quadratic Function" as an example, compared and recorded the behavioral performance and results of teachers and students in an experimental comparison, and found that both teachers' leading and students' independent inquiring were indispensable, and a balance between them was a must-be goal if a maximal teaching effectiveness was expected.

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***Keywords**: Digital Class; Teacher's leading; Student subject; Teaching implementation*

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***Conflict of Interests:** None.*

Background and Problems

WITH the deepening of classroom teaching reform in China and the continuous improvement of private education, the digital classroom model has been extensively studied, the traditional classroom has been quietly subverted, the subjective position of students has been becoming more prominent, and teachers' leading role seemed to be gradually weakened (Chen, 2018). Has the teacher's dominant position in the digital class been shaken? How should teachers position themselves in a digital class? How to plan and organize digital class teaching? In order to answer these questions, the relationship between teachers' instructing and students' learning should be re-explored.

The innovation of teaching conception should be at the forefront of the digital class teaching reform. Teaching conception indicates teacher' basic point of view that formed during the teaching practice, and the relatively stable thoughts and concepts formed based on this (He & Tian, 2015). Theory in general stems from practice, so as to the renewal of teachers' teaching conception that also comes from continuous reflection in the teaching practice. Digital classroom practice and exploration can help teachers to recognize them from the real world and to change their attitude towards teaching activities (Ding, 2018).

Our school stands at the front edge of education reform, and leads the exploration of digital classroom in practice. We collected rich experience in practice and put forward the theory of Student-Based Wisdom Classroom. The middle-school Mathematics team of our school carried out a seminar on the theme of "How to Realize the Balance between Teacher-led and Students' Independent Inquiry in Digital Classroom" using the course of "Review of the Image and Nature of Quadratic Functions" as an example. We explored following problems: How to fully demonstrate the leading position of teachers in a digital class while ensuring the subjective position of students? How should teachers use information technology to collect and provide feedback to students' problems? How should teachers use information technology to solve students' problems in a timely and appropriate manner?

The latest revision of Mathematics Curriculum Standards mentioned that the contents of mathematics should reflect students' real situations, conducive to students' experience and understanding, and thinking and exploration. Teachers should motivate students' enthusiasm for learning, stimulate their mathematical thinking, and encourage their creative thinking. Students' learning should be a lively, active and individualized process (Robinson, 2018). For mathematics learning, students are the masters, and teachers are the organizers, guiders and collaborators. "How students learn" largely depends on "how the teacher instructs". Our study on the basis of "Review of the Image and Nature of Quadratic Functions" was exactly the practical case for exploring the relationship between teacher leading and student independent learning in digital class, which possesses practical implementations for digital classroom teaching.

Research Plan and Proposal

Research Design

This study was conducted in all students in two parallel 8th-grade classes. The participants in both classes were 48 each. No significant difference in the cognition level and learning ability between the two classes. Teachers had a harmonious relation with students. This study was designed to follow the steps below:

1. Select topic.
2. Learning survey.
3. Identify research questions.
4. Classroom teaching discussions.
5. Focus on classroom practice.
6. Record teaching behavior.
7. Feedback and improvement.
8. Collection and analysis, induction and reflection.

Research Topic

The quadratic function is one of the crucial functions of the middle school mathematics. It has its unique properties by combining quadratic equation to function. Changing the unary quadratic equation $ax^2+bx+c=0$ to the quadratic function $y=ax^2+bx+c$, first, $y=ax^2+bx+c$, from the perspective of numbers, no matter what value being taken for the independent variable x, there is unique corresponding y to each x, so realized a transition from finite to infinite. From the perspective of shape, countless pairs of coordinate points (x, y) form a parabola. The concaving direction, symmetric axis, vertex, maximum or minimum value, and increasing and decreasing properties, all these are the key and difficult points for students to overcome.

Learning Situation Analysis

From the eighth-grade, students begin to contact the concept of function. On the one hand, they were constrained by the intuitive thinking of the elementary education. On the other hand, the abstract thinking has not yet developed. So they expressed fear and even resistance to the problems related to the function. They do not know what function is, and what the function can be used for, and so how they know to learn function. Therefore, no matter from the preparation of knowledge, psychology, and ability, they do not know the direction and methods of how to learn function effectively.

Research Steps

Base on the analysis of student's learning situation, and to carry out the study effectively, the following steps were determined:

1. Collect learning problems, such as the error-prone points and the causes for quadratic function learning;
2. Research and discuss the classroom teaching, determine the teaching objectives and difficult points, and design classroom teaching session;
3. One topic, several repeats. In brief, a teacher from the group first have a "diagnostic teaching" according to the contents, with the other group members as the listeners, and then collect consultation and feedback after the class and propose amendments for improvement, and then repeat the teaching.
4. Form model lesson as the reference for others.
5. Imitate the model teaching, promote development of the same course type, and implement mutual-assistant observation. The steps are: i) Team members agree on the theme and key points of classroom observation before instruction, and assign job task. ii) The observer needs to observe carefully and records the real situation with comments. iii) After class, a thorough discussion is organized by focusing on themes and key points. Recording teaching video is recommended. Iv) *Post hoc* adjustment and implement the improved measures in the follow-up teaching activities.

Focuses of Class Observation

1. How does the teacher use digital technology to motivate students' interest in learning?
2. How does the teacher know students' learning efficacy before and during the class?
3. How does the teacher lead the digital class and help those who are in need to internalize knowledge?
4. Through in-class test to see if students have mastered the key points they learned.

Implementation

First-round Teaching Scene

Teacher: Does any student remember the concept, image and nature of quadratic function? Ok, now, let's take a chance to review the knowledge map of the quadratic function presented by the group one. Please listen carefully and add missing points at any time.

.....

Teacher: Do you have any questions about the knowledge map of the quadratic function? What else do you need to add?

Students: No.

Teacher: Ok, please complete the time-limited tracking questions focusing on each knowledge point in the tablet. (The teacher sent the questions out to students' tablets)

.....

Teacher: Time is up, now let's check the uploaded results, and ask one of you to tell the reason why you did like that.

Student: Because the general form of the quadratic function is $y=ax^2+bx+c$, and given it passes through three points: (-1, 0), (3, 0), and (0, -3); so we can plug these three points in $y=ax^2+bx+c$, and get a=1, b=-2, and c=-3.

Teacher: So, what's your answer finally?

Student: Ooh, yes. The function should be $y=x^2-2x-3$.

Teacher: Thank you.

Teacher: Ok, now, please look at the next question, draw the curve line of the quadratic function $y=x^2-2x-3$, write out its concaving direction, axis of symmetry, vertex coordinate, and increasing and decreasing properties. (Teacher is walking around)

……

Teacher: Time is up. Let's have a student to show his work.

Student: The curve line of $y=x^2-2x-3$ is a parabola with concaving up, the axis of symmetry is x=1, the vertex coordinate are (1, -4), and it is increasing when $x<1$ and decreasing when $x>1$.

Teacher: According to your drawing, what conclusion can you get?

Student: The intersection of the parabola with the y axis is point (0, -3), and with the x axis are points (-1, 0) and (3, 0).

Teacher: Ok, good. In general, how can you determine the intersections of the parabola with both the x and y axes?

Student: Set x=0, then find y, we can get the intersection with the y axis. If set y=0, the find x, we can get the intersection with the x axis.

Teacher: Right, does anyone have anything to add?

Student: The intersections of the parabola with both x and y axes are exactly the three-point coordinates that were already given in the question stem. So we don't have to draw a curve line.

Teacher: Yes, but do you need to draw the curve line for getting the axis of symmetry and vertex coordinate?

Student: No, we can get them by calculation.

Teacher: So, now, what's role does the quadratic curve line have in helping us understand its nature?

.....

Classroom Feedback and Problems

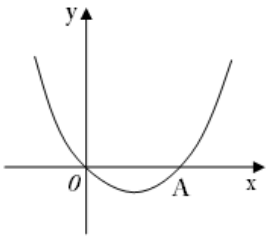
After the lecture, we conducted a classroom test survey of the 48 students in the first class. The feedback was as follows (**Table 1**).

Problems:

1. Students' self-organization of the knowledge map was not deep enough.

Prior the lecture, students' self-review of the basic knowledge of the quadratic function had little effect. During the lecture, they could not do further internalization of the knowledge independently, and the review efficiency was low.

Table 1. In-Class Test Feedback.

Test Contents	Correct Answer #	Correct Percentage
As the coordinate curve shown, parabola $y=x^2+bx+c$ passes the original point and intersect with x-axis at point A (2, 0). 		
Q1. Find the quadratic equation.	42	87.5%
Q2. Find the coordinates of the intersections, axis of symmetry, vertex, and increasing and decreasing properties.	36	75%

2. Students still did not understand the association between quadratic function images and properties.

Although students remembered the concept of the quadratic function clearly, it was not that thorough. Their understanding of the quadratic curve stayed only at the beginner's level as it was a parabola; especially the features of the quadratic curve were not formed deeply in mind. Although they knew the method how to find the intersections of the parabola with the coordinate axes, they could not judge the position of a point whether it is the intersection of the parabola, which indicated that they did not combine both numbers with the curve when they were reviewing of the curve and nature of the quadratic function.

3. Students were lacking of eager for active learning and mathematical thinking.

When reviewing the quadratic knowledge map or the connection between its curve and nature, students mostly were led by the teacher, and there was no desire to actively explore. The independent status of students was not obvious, but teacher's leading position was too prominent.

4. The function of the tablet has not been used totally.

First, teachers only used tablet to send questions to students and checked their answers, of which belongs the basic function of physical projector. Second, teachers did not take advantage of the beneficial function of tablet to help students understand the abstract knowledge in a concrete way. This was another reason for the low efficiency of classroom review.

Discussion for Teaching Improvement

After finding the reason for the class failure, the team members conducted an in-depth research and discussed the following issues to strive to apply what they found to the digital classroom.

What Aspects of the Digital Classroom Should Teachers Lead?

In the digital class, students' learning was no longer limited only in the lecture, but also including prior, during, and post the lecture (Wu, 2018). Through tablet, students can learn anytime and anywhere, which means their learning pathway is increased. We need to catch up the progress of technology, and take a full advantage of the digital teaching. Students can learn by themselves, and what teachers can do is to help and guide them consume and digest what they cannot understand. By careful observation, we thought further raised questions as: i) Can digital technology help students to learn independently before lecture? ii) Can digital technology improve students' learning efficiency in the class? iii) Under what circumstances do they need teachers' help? iv) How can we show them the valuable teaching resources? After discussion, we reached the following consensus:

(1) Self-learning before the lecture needs teacher's guidance. For example, prior to the lecture, teachers can guide students to display the basic shape and nature of quadratic function at the back scene.
(2) The classroom interaction needs feedback timely and teacher's guidance if appropriate. For example, students can submit answers to the system, and the system will automatically collect and provide with statistical graph of their responses to teachers for better decision-making.
(3) Some individual problems need teachers' individualized help. For example, during the lecture, if found some students were unable to submit answers in time, and then teachers could give them appreciate help.
(4) Class content extension needs teachers' expansion. In the digital class, teachers can supplement extra teaching resources anytime to improve the efficiency of class learning.

How Should Teachers Lead the Student-independent Digital Class?

First, teachers publish a self-learning list of tasks on the tablet to guide students to learn independently before lecture. The self-learning list of tasks was designed by the teacher following the study guide (topics, objectives, preview navigation, classroom display), learning tasks (through watching the micro-courses, textbooks or other resources). Each specific task should reflect each key point that was presented in corresponding questions, including necessary resource information like super links.

Second, teachers create a classroom interaction environment with equal communication. Teachers create a learning atmosphere that is both easily controlled and relaxed, of which includes such as personal response, group discussion, group presentation, and group competition, etc., helping students internalize what they have learnt. In

the digital class, by sending learning resources on the tablet, a positive learning environment was established to promote students' self-exploration and induction. For instance, in the dynamic demonstration of quadratic function, teachers can know students' understanding of the function via instructing them on the symmetry of the parabola and its increasing and decreasing properties, and give them guidance, correction, and interpretation in time.

Third, teachers should pay their attention to each student, especially to those under the average. Given each student's ability is either high or low, and also different in the basis of knowledge. Oftentimes, incorrect learning habits are the major reason for those under the average. For these students, teachers should assign hierarchical learning tasks prior to the lecture and tell them the key points in advance. For example, in preparing the autonomous learning task of the quadratic function, teachers can design questions based on the conception, coefficient determination method, vertex and axis of symmetry, etc.

For students who are really difficult to participate in the self-exploration of classroom interaction, teachers should give them guidance in time, and send micro-courses or photo resources to the tablet, such as teachers' lecture video, clear problem-solving steps, and concise notes, etc., and let them watch repeatedly to catch the points.

In The Digital Class, How Can Teachers Effectively Solve the Common Problems of Students?

In order to effectively solve the common problems of students, teachers should be intelligent enough to organize class interaction and good at guiding problem solving. The micro-course teaching method believes that internalization and expansion are the keys to digital class (Liu, 2014). Therefore, when reviewing the quadratic function, teachers can design questions with different levels to help students internalize and expand its curve shape and nature. In the basic part, the application of basic knowledge and basic skills are the key requirements. In the part of comprehensive application, the internal connections among various knowledge points are the essence. In the part of ability improvement, the logics, flexibility and innovation of thinking are the main points.

Teaching Scene after Adjustment

1. Communication within the group.

Teacher: Everyone, you reviewed The Shape and Nature of Quadratic Function last night. [*Blackboard writing: Reviewing the shape and nature of the quadratic function*] Now, let's first do a group communication, and then have a group report to see which group will be the better. Please take out your study sheets. I will give your 5 minutes to share the knowledge points you have reviewed in the groups. Are there any problems confusing? Be sure to record what you shared in the group.

2. Group presentation.

Teacher: Now it is group report time. Which group will be first? The other groups should listen carefully and be ready to add any time.

Group 1: After discussion, our group agreed that the best way to review the quadratic function is to draw the curve first, and then find the features belonging to the parabola, i.e., the intersections of the parabola with both x and y axes, the axis of symmetry, and the coordinate of the vertex. But we are still unclear with the increasing or decreasing characteristics.

Teacher: Good report. Now you know what you have already learned and what the difficulty is. Group 1 is confused about the increasing and decreasing characteristics. Which group can help them?

Student 1: We can explain it visually. For example, look at a parabola. If the opening is upward, on the left side of the axis of symmetry, the parabola goes down first, and then reaches to the lowest point; on the right side of the axis of symmetry, it goes up; so it looks like a canyon. On the contrary, if the opening is downward, on the left side of the axis of symmetry, the parabola goes up first, and then reaches the highest point; on the right side of the axis of symmetry, it goes down; so it looks like a mountain. In general, going up is increasing, and going down is decreasing.

Student 2: We can also explain that by observing the increasing or decreasing of a function, it should be viewed from left to right. [The student used the "Student Demo" function of the tablet to point from left to right with a stylus pen, and different colors appeared on the classroom screen]

Teacher: Pretty good understanding. Using examples and number-shape combination will help to understand the quadratic function easily. Do you have any other questions?

Student 3: What is the connection between quadratic functions and unary quadratic equations?

Teacher: Who knows about this?

Student 4: I know. From the textbook, if set the function value y = 0, the quadratic function becomes a quadratic equation.

Student 5: Can someone give an example?

Student 6: For example, the quadratic function $y=x^2-2x-3$, when $y=0$, it becomes $0=x^2-2x-3$, i.e., $x^2-2x-3=0$. [*Sending the function image drawn by the geometry board in the tablet, mark the point when y=0.*]

Student 3: Is this the connection between the quadratic function and the unary quadratic equation?

Student 7: Not exactly. The solution of the quadratic equation is the abscissa of the intersection of the quadratic function curve with the x-axis, and the ordinate of the intersection is 0. For example, the solution of $x^2-2x-3=0$ is $x1=-1$, $x^2=3$, so the coordinates of the intersection of the quadratic function curve and the x-axis are (-1, 0), (3, 0). [*Display the coordinates as the marker points.*]

Student 5: What if the quadratic equation has two equal solutions?

Student 8: Only one intersection point between the quadratic function curve and the x-axis.

Student 5: What if the unary quadratic equation has no solution?

Student 9: That means no intersections between the quadratic function image and the x-axis.

Teacher: Very good, your analyses are very clear, it is amazing. Do all of you understand it?

Student 10: I want to know if I can understand it in reverse.

Student 7: Of course, please see the curve [*The parabola curve on the tablet can be moved up and down*]. When I move the parabola and get two intersections points between the quadratic function and the x-axis, that means the quadratic equation has two unequal real number root, that is, $\Delta>0$. If only one intersection point between the quadratic function curve and the x-axis, that means the quadratic equation has two equal real number root, namely $\Delta=0$. If there is not intersection point between the quadratic function curve and the x-axis, that means the quadratic equation has no real number root, that is, $\Delta<0$.

Teacher: Thank you for the wonderful explanation. You all are the best explainers.

Teacher's Summary: The idea of combining numbers and shapes is essential in the study of functions. It is not that difficult to understand the nature of the quadratic function, and it depends on whether you understand the curve shape or not, and whether you can raise your own questions and summarize the rule. Therefore, if you have the rule in your mind, the curve shape will appear, and it is no longer difficult to learn the quadratic function.

Improved Teaching Compliance: Test and Analysis

After the lecture, we conducted a test survey of the 48 students in the second class who attended the lecture. The feedback is showed in the **Table 2**.

After continuous improvement of the classroom teaching, the teacher-led digital class has initially achieved the expected results. Undoubtedly, digital applications have indeed brought subversive changes to the classroom instructing (Sean, et al., 2019).

Our data indicated that an effective digital class must reach a balance between teacher-led and student-independent inquiry. From student's point of view, the teacher-designed self-learning list of tasks can guide students to predict the key points and difficulties of the class. Students are no longer afraid of group discussion, questioning and presentation in the class. From the perspective of psychology, teachers first let students have a sense of security for learning mathematics, and help them actively participate in the in-class internalization of knowledge. Establish a positive learning environment with teacher's leading, so that students are able to be managed easily and also provide with a relaxed and happy cooperation (Rojin, et al., 2018). In the interactive part of the lecture, students' thinking was quick and responsive, and they questioned and answered, and ordinary students also are willing to participate in. If questioning is the heart of mathematics, then student's thinking and debating are the blood of mathematics. At the

Table 2. In-Class Test Feedback.

Test Contents	Correct Answer #	Correct Percentage
If parabola $y=x^2+bx+c$ passes the original point, and intersects with x-axis at point A (2, 0).		
Q1. Find the quadratic equation.	48	100%
Q2. First evaluate the intersections of the parabola with axes, and then find the coordinates of the intersections, axis of symmetry, vertex, and increasing and decreasing properties.	44	91.6%
*Q3. *(Challenge yourself).* Draw a sketch curve of the parabola first, and then find the range of x to fulfill $x^2+bx+c>1$.	26	54.1%

same time, with the diversified learning resources in the digital class, the internalization and expansion of knowledge is no longer monotonous, but intelligent and innovative.

From teacher's point of view, the improved teaching results are ideal. The reason for success can be attributed to the guidance of the self-learning list of tasks to students' learning and the support of digital resources in the class. Our mathematics team felt that the process of designing self learning task list is a process of giving full play to teacher's leadership. In this process, teacher needs to know what questions students should learn independently. What methods can be provided to make students' self-learning more effective? What activities are innovative in class design? How do these activities link to self-learning? Only when a teacher seriously thinks about these problems and then designs the teaching process and organizes the classroom teaching, he can truly stimulate students' learning potential and lead student-based intelligent class.

Results and Conclusions

The advent of the digital technology has brought great influence on mathematics teaching. The traditional mode on the basis of textbooks between teacher and students can no longer meet the needs of current students (Zhang, 2017). We found that the future mathematics class needs to integrate with the information technology, and a balance between teacher-led and student-independent inquiry is necessary. Meanwhile, along with the confusion from teaching practice, we carried out this study based on digital class teaching. During the study, the renewal and innovation of teacher's instructing conception was inspired. During the discussion, we broke through the bottleneck of teaching thinking. With the help of information technology, we broke the limitations of time and space, explored the relationship between teaching and learning, and obtained useful results.

The aggregation of ideas and the collision of thoughts have the digital class teachers gotten more thoughts and refinements on their leading role. We had a further understanding on the teaching mode of the digital class, improved teachers' instructing skills and promoted students' independent ability, and realized development of both teachers and students.

The Teaching Mode of Digital Class Should Be Based on "Acquiring Knowledge before the Lecture, Internalization during the Lecture"

From the perspective of the whole teaching process, the teaching mode in the digital class can be regarded as the thread of teacher's design of the self-learning list of tasks for students. Organizing classroom interaction allows students to freely think through the use of rich learning resources on the basis of independent learning. The student's subjective position was preserved and the teacher-led position continued. Through this, teachers' prior-class preparation is no longer the same, the lecture is no longer in one tone, and the in-class instructing will not fall into a boring constant process, so there may be more classroom teaching accidents, which means that students are really involved in the class activities under the guidance of their teachers. How to find a perfect match between the teaching presupposition and the class generation that can really arouse students' active inquiry is worth paying attention. From our case study, we found that the key to digital class is that teachers can achieve an effective "guidance" in the teaching presupposition, i.e., how to guide students to effectively learn new knowledge and achieve it in a more effective way. At the same time, teachers are required to have their own unique insights in the instructing materials, have a deep understanding of the key and difficult points, and have a sufficient and diverse preparation. Only in this way, teachers can give effective guidance on students' questions and thinking during the lecture.

Appropriate and In-Time "Guidance" to Inspire Students

Through self-learning list of tasks, teachers can know students' understanding of knowledge and possible problems, including their learning styles and habits, thinking habits, learning obstacles and weak points, so that a targeted guidance can be processed on the points. How to "guide" is more conducive to the completion of the teaching purpose and more conducive to the development of their ability? In our case study, teachers solved students' problems via group communication and cooperation, focused on knowledge internalization and expansion, and then helped them form question series, from which the solutions to the problems could be more open. Therefore, when time is opened, students will have enough time to delve into their most doubtful questions; when the task is opened, it will meet students' needs at different levels, and lead them expand their learning breadth and depth; when the resources are opened, peer classmates will be the resources for cooperation and exchange, and the digital resources are really used; when the learning style is opened, some will like to think first, but some will like to discuss first; so students' abilities will be improved dramatically by doing, watching, and thinking (Major, et al., 2018). Especially during the class communication, students talked about the translocation of quadratic function curve to observe the number of intersections with the x-axis, which needs digital resources as the support.

Study Reflection

The digital resources may be lagging behind. When teachers prepare lectures, they often know what resources are needed to solve students' questions, but many of them were collected resources based on solving the preset problems. When the teaching resources prepared before lecture cannot meet the classroom accidental generation, the teacher will not create resources in time, so the knowledge internalization can only rely on students' understanding and teacher's guidance.

Teachers' knowledge level of information technology limits the creation and use of digital resources. In recent years, information technology has supported the development of class teaching rapidly, but teachers were usually engaged in teaching work at school, and were not sensitive enough to information technology. We suggest that schools with good financial support can provide teachers with multimedia courseware production skills, micro-course recording, video and audio software use and other courses to enhance teachers' interest in information technology.

There is no contradiction between the subjective position of the student and the leading role of the teacher. Learning and teaching are two inseparable parts in the digital class, and they intertwined prior and post the lecture. In the front, students are working on the self-learning tasks through various resources, and internalizing and expanding group discussion, presentation, and exchanges. In the back, teachers are helping students complete their tasks, guiding and tutoring them to internalize and expand their knowledge during the lecture.■

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Appendix

Self-Learning List of Tasks

Study Guidance
1. Project Name People's Education Edition Middle School Mathematics Review "Chapter 22 *Quadratic Function*"
2. Goal By watching the micro-video "quadratic function" mind map, the task of "autonomous learning task list" is completed to help students sort out the concept of quadratic function and its image and properties, and understand visually the connection between the quadratic function and the unary quadratic equation.
3. Learning method and recommendations Read the textbook P.55-P56 in the ninth grade volume I, understand the content of the review summary, review the questions based on the review and thinking session of the textbooks, watch the micro-video "quadratic function" mind map, and reach the goal of independent learning. If there is doubt, watch the video again and again.
4. Classroom learning form notice Self-study feedback - Assisting in inquiry - Consolidation and improvement - Induction summary - Lesson testing
Learning Contents
Complete the following tasks by watching the micro-course video: 1. What is the general form of the quadratic function? What form can I write? What is the connection between them? Please answer separately. 2. Please make an image of the quadratic function $y=x^2-2x-3$, and then generalize the nature of the quadratic function. 3. According to the image you made, please talk about the connection between the quadratic function and the unary quadratic equation.
Confusion and Advice
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