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Classroom Questioning Tendencies from the Perspective of Big Data

Abstract We are now living in an era of big data. From the perspective of data analysis of classroom questioning, the paper chooses three districts in City B that have significant differences. These are educationally developed District D, less developed District F, and developing District M. The study uses the stratified sampling method to choose from three different groups of teachers, namely novice teachers, competent teachers, and experienced teachers, by way of video case analysis, the Item Response Theory (IRT) model method, and the inductive and deductive method, to analyze the characteristics of teachers' classroom questions. It was found that: (1) In terms of open questioning, all three districts with their different levels in educational development need to improve open questioning levels among their experienced primary school teachers. In middle schools, novice teachers' open questioning tendency is significantly lower than that of qualified and experienced teachers; (2) From the quantitative study of three kinds of tendencies, the lowest level of the three tendencies in the classroom questions is problem-solving; (3) In the three districts, the experienced and qualified primary school teachers in the developing district has a prominent advantage in raising critical and creative questions, while in the middle schools, novice teachers generally have a lower level than qualified and experienced teachers in raising critical and creative questions. The results of the big data analysis enable us to draw a conclusion about teachers' value orientation

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regarding questioning in class. At present, they pay attention to the local value of classroom questioning, but ignore the overall value; pay attention to the instrumental value of classroom questioning, but ignore the objective value; and pay attention to the superficial value of classroom questions, but ignore the underlying value.

Keywords big data, classroom observation, classroom questioning, IRT model

Introduction

The current study identifies three points. Firstly, on the dimension of an open tendency of questioning, in all the three districts that have different levels of educational development, enhancement of the level of open questioning for experienced primary school teachers is needed. When it comes to teachers in secondary schools, novice teacher's open questioning tendencies are significantly lower than those of competent and experienced teachers. Secondly, findings from the quantitative examination of the three tendencies show that problem-solving is at its lowest level in classroom questioning. The low level remains so even in educationally developed District D. Thirdly, experienced and competent primary school teachers in less developed District F excel in raising critical and creative questions, while in the secondary schools, novice teachers generally show lower levels of raising critical and creative questions than competent and experienced teachers. Fourthly, the results of the big data analysis reflect teachers' value orientation of questioning in class in that the partial value of classroom questioning is stressed, while the overall value is ignored; the instrumental value of classroom questioning is stressed, while the objective value is ignored; the superficial value of classroom questioning is stressed, while the underlying value is ignored.

Raising Questions

As early as 2,000 years ago, teachers' questioning in the process of instruction was placed at an extremely important position in the "inspiring mode of teaching (literally, birth-giving-like teaching mode)" developed by Socrates. With the development and changes in theories and practice patterns relating to classroom

questioning, an inquiry-based learning mode gradually came into being in the process of classroom instruction. Focusing on questioning, inquiry-based learning is considered to not only facilitate students' knowledge acquisition but also to develop students' creative thinking (Yuan & Yue, 2008). Inquiry-based learning is also considered an effective means to cultivate students' innovative spirit (Wen, 2005).

Some researchers have pointed out that question design is both a foundation for learning how to solve problems and a prerequisite for the unfolding of inquiry-based learning (Ma, 2013). There exists difficulty in designing inquiry-based learning (Perrenet, Bouhuijs, & Smiths, 2000). A large number of research studies have pointed out that the forms of teachers' questioning and the ways questions are raised exert huge influences on students' thinking modes, academic performance, learning effectiveness, and attitudes towards the world outside (Jin, 1997). The key points of instruction design of inquiry-based learning, i.e., the openness of questions teachers raise in class, orientation of problems to be solved, as well as how critical and innovative the questions are, are also a key for improving students' learning quality and the cultivation of higher-order thinking ability (Leng, 2013; Liang et al., 2006; Nickerson, 1999; Xu, 2001).

In recent years, with the development of curriculum reform, the attention to teaching issues has increasingly focused on the real classroom. Consequently, the number of studies on classroom questioning has increased dramatically. Classroom questioning has turned into a vital research focus. It is not difficult to see three trends, from a retrospective look at recent years' research and reports on classroom questioning in primary and secondary schools. Firstly, the majority of research on primary and secondary school teachers' classroom questioning is qualitative in nature, and quantitative angles are rarely been addressed. Secondly, case studies constitute a large proportion of studies, while the number of comparative studies on groups of teachers from areas of different education quality are next to zero. Thirdly, findings from preexisting studies reflect major problems in the process of classroom questioning. For example, most questions teachers ask have only one correct answer. That is to say, the questions are not open-ended (Xu, 2001). The content and variety of questions are overly constrained. Meanwhile, what is witnessed is a lack of a complicated context that can be used to solve problems and find out strategies (Leng, 2013). Teachers'

classroom questioning is dominated by questions that only demonstrate knowledge. The lack of participatory questions is also witnessed. This is even more serious when it comes to critical questions. Instead, lower-order cognitive activities predominate in classroom instruction (Shen & Li, 1998).

Being now in the era of big data, we recognize that data is no longer simply a result of processing but now a basic resource (Meng & Ci, 2013). Li and Cheng (2012) point out that big data has now become a strategic resource as vital as natural and human resources. Meanwhile, big data has also become a manifestation of the digital sovereignty of a nation. In the era of big data, competitiveness at the national level will be partially reflected in the size and dynamics of the big data countries have at their disposal to interpret and employ.

Based on the above analysis and discovery, as well as the first author's 15 years' research on classroom teaching behavior in primary and secondary schools using big data, the current study attempts to analyze characteristics of the targeted teachers' classroom questioning patterns. The sampling takes place in City B which is considered a high performing basic education city in the Chinese Mainland. Three districts that vary greatly in terms of educational quality and level, are sampled, including educationally developed District D, less developed District F, and developing District M. The sampling is further stratified to encompass three groups of teachers, namely, novice teachers (teaching experience ≤ 5 years), competent teachers ($5 \text{ years} < \text{teaching experience} \leq 10$ years), and experienced teachers (teaching experience > 10 years). The following quests are pursued: (a) identifying characteristics and tendencies of classroom questioning in light of educational districts and teacher groups; (b) providing empirical evidence for recommendations regarding tailor-made teacher professional development programs on account of the educational maturity of the districts and the professional stages teachers are at.

Literature Review

Research Relating Classroom Teaching Behavior to Behavioral Tendencies

So-called behavior refers to activities conducted concretely to achieve specific intent (Chinese Academy of Social Sciences, 1983). Teacher behavior is a series of concrete actions taken by teachers to achieve pedagogical goals with intent (Li

& Xu, 2006). Teacher behavior is the external manifestation of teachers' practical knowledge, quality, and ability as well as other factors. Of these, teachers' practical knowledge includes teachers' educational aspirations, self-concept, interpersonal knowledge, contextual knowledge, strategic knowledge, and reflective knowledge (Chen, 2003). Classroom behavior includes all actions teachers take to initiate, maintain or facilitate student learning. That is, all activities teachers arrange in order to support, help, and guide student learning, and ultimately facilitate students' completion of learning (Li, 2005). Classroom pedagogy integrates teacher's teaching with students' learning. Nevertheless, for the convenience of theoretical analysis, this study will divide classroom pedagogy into teachers' teaching behavior and students' learning behavior. Only teachers' teaching behavior will be covered in this paper.

Classroom behavior analysis is a research approach aiming at identifying underlying principles between classroom teaching behavior and students' individual development. Researchers adopt theories on behaviorism and educational pedagogy to examine key elements of classroom teaching behaviors and relations between the key elements. Also examined are units that work for the implementation of classroom teaching and internal transition of each and every one of these units (Li, 2005). The purposes of classroom teaching behavior analysis are threefold. First, to examine key elements of classroom teaching behavior, i.e., to identify relations between key elements that constitute classroom teaching behavior (in brief, analysis based on theory of key elements). Second, to examine the process of classroom teaching behavior, i.e., to identify relations of internal conversion between the units that operate to make classroom teaching behavior work effectively (in brief, analysis based on the theory of process). Third, to further explore unique principles of classroom teaching behavior in students' development based on the results of the theories of key elements analysis and process analysis.

There are currently altogether three frequently adopted methods of classroom behavioral analysis: the classroom observation method, classroom language and behavior interaction analysis, and the ethnographic method. The classroom observation method implies that the researcher should have a clear purpose in mind. The researchers use their own sensory organs (such as eyes and ears, etc.) and proper tools (observation table, audio and video equipment, etc.) to collect data from the classroom directly or indirectly (mostly directly). They then use the

data collected to conduct research. Classroom observation method is not only an approach to conducting pedagogical research but also a continuous behavioral system, a type of work flow, and the fruit of teamwork (Flanders, 1970; Wang & Zhang, 2012).

Classroom language and behavior interaction analysis is also known as Flanders's classroom language and behavior interaction analysis. American scholar Flanders proposes the "two-thirds principle" on the basis of abundant classroom observation research, i.e., in class two-thirds of the time should be used for communication. Two-thirds of this time should be used in teacher lecturing, of which two-thirds should be used for teachers' one-way lecturing to students (Shi & Cui, 1999). Flanders's analytic method adopts a coding approach to objectively recording what happens in the classroom and sequencing the occurrences. In this way complex classroom teaching behavior is turned into relatively simple numerical data, and data-based conclusions can be drawn from analysis through matrix and curves analysis. Further, initiatives for improvement are proposed by teachers, thereby adding to this relatively strong diagnostic tool (Wang & Lin, 2004). The coding method that Flanders adopts for his analysis lays a methodological foundation for qualitative research into classroom teaching behavior. This method has led to rather significant initial improvements in the subjective nature of evaluation of traditional classroom teaching and learning.

The ethnographic research method has been frequently adopted by anthropologists, linguists, and social psychologists. This method requires researchers to record teachers and students' behavior in the classroom. Based on a variety of documentary evidence, such as lesson preparation notes, meaning is conferred on findings from researchers' studies. This method requires researchers to comply with a basic principle, i.e., to leave aside their own preconceptions, measurement criteria, modes, schemas, typologies etc., and observe classroom teaching and learning behaviors from the common pragmatic perspectives of daily life (Li, 2005).

Teachers' teaching behaviors have different tendencies due to their differing value orientations. The orientations of each specific teaching behavior results from the interaction of a variety of specific value orientations to teaching (Luo & Wang, 2008). Teaching behavior in the classroom reflects activities in teachers' life to pursue values and create values, and thus overflows with values. Teachers' teaching behavior also reflects specific value orientations of individuals and their

professional groups. Some researchers point out that, to date, some noteworthy phenomena have emerged in teachers' teaching behavior in China. These include emphasis on shallow values and neglect of deep values, emphasis on local values and neglect of overall values, and emphasis on instrumental values and rejection of the values of the ultimate goals of education. To be specific, the values of the ultimate goals of education are reflected as teaching objective value orientation that centers on disciplinary knowledge, teaching process value orientation that features indoctrination, and teaching evaluation value orientation that focuses on exams (Luo & Wang, 2008; Zhang & Li, 2015).

In summary, research on classroom teaching behavior has followed three typical research paradigm shifts, namely, "process-results" and "cognition-dialogue" to "context-ecology." The transitory tendency indicates that research into classroom teaching behavior has been going through a change from simple to complex, rational to intellectual, and from the return to the origin to rebirth as an integrated unit. This tendency also implies that research on classroom teaching behavior has been improved in aspects such as ontological assumptions, values, and ethics, as well as methodological guidelines (Gai & Zheng, 2010). However, the body of research that focuses on classroom teaching behavior has been found, from the perspective of research methodology, to be dominated by descriptive case studies. A lack of theoretical analysis has been identified, particularly, a lack of research on the theoretical framework for classroom teaching behavior, the consequences of which are that, most research still stays at a level that stresses the behavior of teachers. In terms of research findings, although most researchers have conducted surveys on classroom teaching behavior, they cannot provide adequate policy recommendations due to a lack of scientific and systematic analysis of the data and information (Gai & Zheng, 2010). With the deepening of curriculum reform and reflection, only through providing more standing points for reflection can teachers see the explicit orientation for teaching and establish new value orientations for teaching.

Research on Classroom Questioning

As an ancient and common teaching approach, classroom questioning is the most often seen and the most important form of classroom teaching behavior. Questioning, as one of the most frequently used forms of classroom interaction,

has also drawn attention from researchers both at home and abroad. A summary of the basic functions of questioning has been made by scholars including Wilen, Ishler, Hutchison, and Kindsvatter (2000) on the basis of other researchers' work on classroom questioning. The functions include, first, fulfilling general objectives of classroom teaching; second, positively influencing students' academic performance; third, enabling students to be more proactively engaged in classroom interaction; fourth, encouraging students to think; fifth, enabling students to ask better questions.

Classroom questioning was first examined scientifically by Stevens, a psychologist. In her four-year empirical research she found that the number of questions teachers raised in class was particularly alarming. On average around 395 questions were raised by a teacher on a daily basis, that is, about two to four questions per minute. The time taken for teacher questioning constituted approximately 80% of the classroom instruction time (Jin, 1997; Stevens, 1912). In China, Shen and Li (1988) find from investigation into 12 Chinese reading sessions that, on average 34 questions were brought up in one session, and the number of questions was as high as 50 in one of the 12 sessions, taking up 23 minutes of the session. While the smallest number of questions also reached a high of 21 times.

In the study of the cognitive level of questioning, Wilen et al. (2000) refer to Bloom's hierarchy of cognitive objectives and classify questioning into four levels, as shown in Table 1.

Table 1 The Four Hierarchical Levels of Questioning

Level	Questioning Type	Student Thinking Characteristics	Student Presentation	Strengthen
1	Low Level extensive questioning	Memory type of thinking	Stimulate students to recognize and recall relevant information	Memory and maintenance
2	High level extensive questioning	Productive thinking	Organize and understand learning material	Beyond memory
3	Low level analytic questioning	Critical thinking	Analyze the corresponding information, and find out reasons and conclude, or find supportive viewpoints	Divergent thinking
4	High level analytic questioning	Original and evaluative thinking	Make predictions and solve problems in life, and make judgment on all sorts of ideas, information, behaviors, and aesthetic expressions based on internal and external standards	Problem-solving

Although the four levels of questioning shown in Table 1 are relatively explicit and feasible, yet any research output based on the evaluation system of this four-level hierarchy has yet to be found.

As elaborated above, teachers differ in terms of their teaching tendencies due to different teaching value orientations. Some researchers have pointed out that teachers have shown clear-cut teaching tendencies as far as their behaviors in questioning and dialogue in class are concerned. Teachers whose value orientations are toward behaviorism will generally adopt closed well-structured questions and bring questions directly to learners. They regard practice in the form of “questioning-answering” as the basic approach to solving problems, thereby tending to approaches such as lecturing, drilling, and indoctrinating in class. Nevertheless, teachers who have a constructive value orientation mostly bring forth centrally constructed open-ended questions, and stress that questions are generated and presented in their specific context. These teachers regard constructivism as the basic approach to solving problems, hence tending to initiate inquiries, discussion, and interactive activities in class (Hu, 2005). Zhang’s (2012) study reveals that currently teachers tend to raise close-ended well-structured questions in class, teachers ask questions too frequently and two-thirds of the questions are about memorization. Further, class questioning in too mechanical a way easily makes students too lazy to think or leads them to respond in a superficial, rough and illogical way. Quick and frequent questioning will stop students from developing the capacities of discretion, deliberation and discrimination, depriving them of the necessary support for this.

The research of Wilen et al. (2000) proposes strategies to improve classroom questioning from the expression of questions and cognitive levels. The statement of questioning includes six dimensions, namely, proper level of questions, time allowed to think, collective-individual equilibrium, voluntary and involuntary participation, questioning, and appropriate language level. Cognition of questions reflects a four level hierarchy, i.e., cognitive-memory level, convergent thinking level, divergent thinking level, and evaluation of the level of thinking. The strategic improvement plan that Wilen et al. put forward is shown in Fig. 1.

In summary, researchers to date have paid increasingly more attention to classroom questioning. Research on classroom questioning has emerged from theoretical studies, and the change trajectory has been headed by practical and empirical research which has examined how to improve classroom questioning.

Research on the effectiveness of questioning and “inter-subjectivity” arising from dialogue and resulting from classroom questioning have become new focuses of research. However, research on classroom questioning tendencies using big data from classroom teaching behavior has yet to be spotted, let alone research that address characteristics and tendencies of classroom questioning from different education areas or teacher groups. These types of research are able to provide empirical evidence and research findings to distinguish teacher groups thus suggesting professional development programs that cater for the needs of individual teachers.

Fig. 1 Analytic Approach to Big Data on Classroom Teaching Behavior

Big Data on Classroom Teaching Behavior and Related Research

Big data refers specifically to unstructured or semi-structured data in particular areas of expertise, characterized by large volume, large variety, velocity, and diversified values, or the four Vs. Big data is huge and a special type of data collection, differing conceptually from “mass data” and “very large-scale data” (Li, Wang, & Ma, 2015; Meng & Ci, 2013).

Currently there is yet to be a generally accepted definition of big data. Likewise, currently there is yet to be a universally accepted definition of big data regarding classroom teaching behavior. Authors of the present study believe that big data for classroom teaching behavior refers to special collections of diversified large volumes of unstructured or semi-structured data in which rich connotations of teaching and learning are embedded. This data is generated in the classroom context and in the process of teaching and learning. This is integrated with research on big data for classroom teaching behavior that the first author of this study and his research team have been working on for 15 years. Four types of big data regarding classroom teaching behavior have been identified to date.

These four types are typically model data, relational data, structural data, and behavioral data. Details are presented in Table 2.

Table 2 Big Data for Four Typical Types of Classroom Teaching Behavior

Data Type	Data Significance
Model data	Reflect relations between key elements of teaching mode
Relational data	Reflect relational structure between actors in the classroom
Structural data	Reflect, from the perspective of time and space, relatively stable tendencies and procedures displayed by all elements that constitute teaching and aim at completing certain teaching objectives
Behavioral data	Reflect behavioral characteristics of actors of teaching and learning

To summarize research and analysis of big data on classroom teaching behavior that the author and his research team have been working on over the past 15 years, the author proposes a five stage analytic approach to manage big data on classroom teaching behavior, comprising data collection, data storage, data analysis, data presentation, and application services. The processes and principles are schematically shown in Fig. 2.

Fig. 2 Strategic Plans to Improve Classroom Questioning

The analytic approach to big data on classroom teaching behavior, as shown in Fig. 2, is not a linear process, but a typical complex multi-branched and multi-iterated process of data manipulation.

Currently, the easiest way to collect big data on classroom teaching behavior is to use the three seats automatic recording and broadcasting system. This system can automatically record three-way video signals separately, i.e., teacher

behavior, student behavior, and content written on the blackboard. Therefore, it is an ideal tool for collecting big data on classroom teaching behavior.

Coding system analysis and token system analysis methods are often used for data collection and analysis when the purpose is to analyze big data collected from a single lesson. The so-called coding system analysis is a type of classroom observation analytic method. This method is based on cognitive theory, pedagogical theory, and specific disciplinary knowledge to encode information from public dialogue between and among teachers and students in the process of classroom teaching and learning, as recorded on video. The purpose is to externalize tacit knowledge, and generate new knowledge that can be used to analyze the teaching process.

Generally, the information coding system has two basic objectives: First, to describe and build teaching quality, which is usually directly related to curriculum standards; second, to effectively reflect the real situation of classroom teaching. Therefore, information coding that corresponds to dialogue includes both the teaching structure and events taking place in the teaching process that will be encoded. Token system analysis method and content analysis method are very similar. This method requires behaviors that need to be observed and that might happen to be listed in advance in a pre-designed token system observation table. Observers make a record when each type of event or behavior that has been anticipated takes place, and count after the observation how many records have been made and how many times the events and behavior have happened. In-depth analysis will be conducted in this observation and analysis method. Both coding system analysis and token system analysis may use charts and tables for rich data presentation. Both can provide analysis and diagnosis of teaching behavior in a single session, premised by the norm for big data being available (Wang, 2012a).

When it comes to multiple sessions and multiple groups of teachers, analysis for big data on classroom teaching behavior must go further for more complex and in-depth exploration, on the basis of sampling, data storage, and analysis that coding and token system analysis follow. That being said, data analysis methods and techniques such as correlation analysis, regression analysis, cluster analysis, and evolutionary analysis will be adopted. Correlation analysis, also known as association mining, is a simple and practical analytic technique. The purpose of correlation analysis is to identify relations from large volumes of associated data.

Therefore, regularity and patterns of some properties of an object that might appear simultaneously can be described. For example, Wang (2012b) identified from correlation analysis with big data on one year's teaching behavior of 120 reliable teachers who had joined a Online Communities of Practice (COP) and received training where, in terms of high level reflection on teaching, correlation on the level of reflection on teaching between novice teachers and key teachers was 0.996 at the 0.01 significance level. In brief, in this regard these two groups of teachers are positively and significantly correlated. Meanwhile, correlation between novice teachers and experienced teachers is 0.993 at the 0.01 level. These two groups of teachers are also positively and significantly correlated in terms of their level of reflection on teaching. Likewise, correlation between key teachers and experienced teachers is 0.999 at the 0.01 level, again positive and significant.

Regression analysis is a statistical analytic approach that aims to determine quantitative relationships, i.e., dependency, between two or more variables. It is based on observed data and establishes dependent relationships between variables in order to explore inherent laws reflected in the data. The results can be used for prediction and control. For example, Wang, Zhang, and Yang's (2011) study finds that the dependency between high reflection levels of novice teachers (Y) and competent teachers can be expressed as a univariate linear regression equation, $Y = 0.362 + 0.801X_1$.

Cluster analysis refers to the analysis process that classifies objects into groups according to certain abstract characteristics. The analysis will end up with multiple groups, and objects in each group have similar characteristics. For example, when doing cluster analysis with the above mentioned big data, Wang et al. (2011) find that, in terms of high level reflection on teaching, key teachers and experienced teachers can be clustered into a group due to similarity of characteristics in their reflection, while novice teachers make up another group.

Evolution analysis takes fluctuations of variables as its research objects, traces directions of fluctuations and spatial changes in dynamic follow-up analysis and visualizes the whole process. The purpose is to examine the patterns of changes and tendencies of those changes. For example, Wang et al. (2011) find that, through revolution analysis of big data collected from Shandong province and Beijing municipality, which included 45 competent teachers who received COP professional training, the key teacher group displayed an upward trend in terms

of teaching monitoring strategy in the teacher practice community. The uplifting rate in the later stage is even faster than in the early stage. At the third stage, the monitoring strategy of the key teacher group was higher than for the experienced teacher group. Further, the teaching monitoring strategy of the novice teacher group shows a relatively stable upward trend, but the rise is small and at the lowest level of the three groups. The teaching monitoring strategy of the experienced teacher group demonstrates a rapid upward trend at the first and second stages, but a declining trend is revealed after the second stage.

In summary, although big data analysis of classroom teaching behavior is only in its infancy compared with big data analysis in other areas, preliminary research frameworks have been established, and basic practice has been conducted. Some initial achievement has been identified as well. However, currently when it comes to big data of classroom teaching behavior that can be collected and used for analysis, there are many gaps to be filled, such as the lack of comprehensive analysis of certain classroom teaching behaviors.

Research Design and Research Methods

Research Design

Big data has led the scientific community to re-examine methodologies of scientific research, and has triggered a revolution in scientific research thinking and methodology. After the Turing Award winner, the renowned database expert Dr. Jim Gray, observed and summed up the three paradigms for experiments, theory, and computation that human beings have gone through in scientific research, he proposed that the three traditional paradigms have stopped functioning properly in scientific research. This is particularly true in some new research areas. Therefore, a totally new fourth paradigm is needed to direct scientific research under the new circumstances (Li & Cheng, 2012). The fourth paradigm (Hey, Tansley, & Tolle, 2009) that Jim Grey had proposed for scientific research in essence is a transition from the computer-centered thinking mode for statistical analysis to a research method and thinking mode for big data analysis that centers on the manipulation of big data. The thinking mode for statistical analysis and for big data analysis comply with thoroughly different paradigms and routes with respects to research design (Li, 2014). The differences are

detailed in Table. 3.

Table 3 Comparison on Research Design of the Thinking Modes for Statistical Analysis and Big Data Analysis

	Research Design of Statistical Analysis Thinking	Research Design for Big Data Thinking
Analysis thinking route	Hypothesis–verification	Discovery–Summary
Analysis process	Qualitative–quantitative–qualitative again	Quantitative–qualitative
Logical relations	Distribution theory–probability guarantee–general inference	Actual distribution–general characteristics–probability judgment

As shown in Table 3, research design for big data thinking has undergone significant changes. First, in research the thinking pattern for routes of data analysis has changed in that restrictions on research hypotheses no longer exist. Relations and principles can be identified directly through analysis of big data, after which research conclusions can be drawn. Considering the data analysis process for the research, since those real and fundamental quantitative characteristics and relations can be identified from all types of “qualitative responses” that correspond to big data, probabilities for the acquisition of new qualitative conclusions have increased dramatically. Considering the logical relations in research, probability is no longer preset but obtained from judgments made on the basis of actual distribution (Li, 2014).

Data and Sample

In the book *Big Data*, Viktor Mayer-Schönberger and Kenneth Cukier pointed out that the traditional thinking mode for data analysis should have undergone three major ideological shifts. Among them the first is to shift the sampling ideology. They first proposed the new idea that the sample is the population. However, this proposition does not mean that sampling is not necessary when big data analysis is to be conducted. On the contrary, when doing big data analysis, sampling and surveying have become vital clues and tools, with which researchers are to identify rules and relations from complex and chaotic data after data mining and quick exploratory analysis (Zhu, Zhang, & Liu, 2014).

In this study, a multiple stratified sampling method is first adopted to select from City B three educational districts, namely, educationally developed District

D, less developed District F, and educationally developing District F. City B itself is among the most developed cities in basic education on the Chinese Mainland, and the three selected districts differ distinctively from each other. Next, a fixed-ratio stratified sampling method is used to select 36 teachers from the three districts, respectively. The targeted teachers are from three predefined groups based on their levels of teaching experience, i.e., novice teachers (teaching experience ≤ 5 years), competent teachers (5 years < teaching experience ≤ 10 years), and experienced teachers (teaching experience > 10 years). The ratio of sample from the three teacher groups are 1:1:1, that is, case studies comprising classroom teaching video recorded data are collected for this study from a total of 108 teachers. Among the 108 cases, 56 are humanities and liberal arts classes and 52 are science classes, while 59 are from primary schools and 49 from secondary schools. The purpose is to ensure that the sample is sufficiently representative.

Research Methods

This study uses three basic research methods: video recorded case studies, Item Response Theory (IRT) modeling, and induction and deduction.

As described above, video recorded case studies are an analytic method which transforms big data on classroom teaching behavior into structural data, including coding system analysis and token system analysis. This study mainly adopts token system analysis, which is also known as project checklist analysis. Observers list in advance some behaviors that need to be observed and might appear during observation, marking it down once a type of these is observed and its behaviors appear. The purpose of so doing is to verify whether behaviors to be observed have appeared during the observation (Chen, 2002). This study uses token system analysis to sample and record types of questions the teachers ask in the 108 sessions. The frequency of eight types of question are recorded respectively, namely, “what questions,” “why questions,” “how questions,” “if what questions,” “memory questions,” “inference questions,” “creative questions,” and “critical questions.”

The second research method used in this study is the IRT modeling method. This method adopts advanced educational and psychological measurement theories and regards all measurement as based on items, and latent traits of the

measured objects can be predicted through responses of the objects to a few items. The so-called items are the general elements and subdomains in researchers' analysis (Schönbrodt & Gerstenberg, 2012). In the current study, the above mentioned eight types of questions that teachers ask are set as items. IRT modeling method is adopted to predict tendencies of teacher questioning in the process of classroom teaching (Dai, 2006).

IRT modeling method has its own theoretical assumptions (van der Linden & Hambleton, 1997). First, unidimensionality, i.e., all the items are used to measure the same teaching tendency; second, local independence, i.e., the items are not interrelated; third, items used for measurement can correctly reflect probabilities of right answers to appear and predict relations in the form of statistical functions between different tendencies. The items also meet requirements of characteristics of S curves, hence termed as item-characteristic curves (ICCs). IRT modeling has strict requirements on data structure. It generally takes a dichotomous 0–1 scoring system to recording responses. To be exact, when a respondent gives a correct answer to an item, the response is denoted as 1 and will be 0 if the answer is wrong.

In this study, the authors record how many times the teachers have asked the eight types of questions respectively, and then compare the number of times with the average that is the norm out of the measurement data that the author and his team have accumulated over 15 years. When the number of the teachers' questions of each type is above the average of the norm, the response is denoted as 1. Conversely, it is recorded as 0. In this way the big data on teaching behavior is transformed into dichotomous data expressed as 0 and 1 for subsequent analysis. Further, a mathematical model estimates the relationship between a teacher's teaching tendency and their probability of asking certain types of questions. IRT modeling method is a method based on a mathematics model to quantitatively predict objects' teaching tendencies. Generally speaking, because the logistical model shown in Formula 1 is extremely close to a normal oval model, and rationality for a normal oval model for psychological research has been verified, the logistic model is often adopted in IRT modeling (Yu, 1992).

$$p_i(\theta) = \frac{e^{1.7x}}{1 + e^{1.7x}} = \frac{1}{1 + e^{-1.7x}} \quad (1)$$

In Formula 1 i indicates a teacher, θ indicates certain teaching tendency of this teacher, e is the base of the natural logarithm, x represents different parameters of

the algebraic expression, and P is the probability value. Logistic models can be divided into a variety of models according to parameters included in individual models. According to the number of parameters in a model, there are a single parameter model, a two-parameter model, and a three-parameter model. This study follows optimally-reduced principles of the Akaike Information Criterion (AIC; Liu, 1980) and the Bayesian Information Criterion (BIC; Xia & Zhang, 2007) to select models against the principle of minimum value. In doing so, individual teachers' teaching behavior tendencies can be predicted by the types of questions they raise in class.

A third research method used in this study is induction and deduction. The inductive inference method is a basic method that allows researchers to generalize overall characteristics from a sufficient number of individual pieces of information and find new knowledge (Li, 2009). During the analysis of big data, it is not enough to value only induction and characteristics generalization. Analysis on subclass information and individual information, as well as special or unusual information, should also be conducted. It is necessary to infer and analyze other more affluent and specific principles through distribution features and relevant knowledge and experience that have been mastered. It is also necessary to identify relationships at deep levels and make judgments on some conclusions. For these reasons, deductive method is needed. Deductive method can help researchers make full use of existing knowledge to learn more specific and finer features, and form more useful conclusions. As long as induction and deduction can be well integrated, we can not only find contingency from the inevitability in big data, but can also make use of the inevitability of comprehensive data to observe, understand, and even use contingency, thereby improving our ability to manage contingency capacity (Kong & Li, 2007).

Data Preprocessing

To ensure the robustness of IRT modeling method at model selection, this study adopts the AIC and BIC criteria to validate model parameters and to complete data preprocessing.

In Step 1, this study takes the records of “what questions” and “memory questions” as the data source, which is imported into the SPSS software program. The AIC and BIC values of three models are generated. The results are shown in

Table 4.

Table 4 Model Estimation of Open Tendency in Teacher Questioning

Model	AIC	BIC
One-parameter model	304.2841	309.6484
Two-parameter model	302.3116	307.0401
Three-parameter model	308.3116	321.7222

Based on the estimation results of AIC and BIC values as reported in Table 4 and also in order to reduce analytic errors, this study selects the model with the smallest AIC and BIC values, i.e., the two-parameter model, as the model to evaluate the openness of teacher’s questioning tendencies. As observed from the item-characteristic curve (ICC) shown in Fig. 3(a), the ICC out of the two-parameter model matches the characteristics of S curves. Therefore, openness of teacher questioning can be estimated through the two-parameter model.

Fig. 3 Item-Characteristic Curves of Questioning Tendencies

In Step 2, this study takes records of “how questions,” “why questions,” and “inference questions” as the data source, which were imported into the SPSS

software program. The AIC and BIC values of three models are generated. The results are shown in Table 5.

Table 5 Model Estimation of Problem-Solving Tendencies in Teacher Questioning

Model	AIC	BIC
One-parameter model	456.2515	464.2979
Two-parameter model	449.1148	465.2076
Three-parameter model	460.25	479.0249

As shown in Table 5, the two-parameter model has the smallest AIC value, while the one-parameter model has the smallest BIC value. The differences between the AIC and BIC values of the two models suggest that, the difference between the AIC values of the two-parameter model and the one-parameter is bigger than that between the BIC values of both models. Further, the ICC in Fig. 3(b) shows that, the ICC out of the two-parameter model matches the characteristics of S curves. Therefore, the problem-solving tendency of teacher questioning can be estimated through the two-parameter model.

In Step 3, this study takes the records of “if what questions,” “creative questions,” and “critical questions” as the data source, which is imported into the SPSS software program. The AIC and BIC values of the three models are generated. The results are shown in Table 6.

Table 6 Model Estimation of Critical and Creative Tendencies in Teacher Questioning

Model	AIC	BIC
One-parameter model	421.5044	429.5508
Two-parameter model	420.6224	426.7152
Three-parameter model	422.8959	441.6709

As shown in Table 6, the two-parameter model fits the best for estimating critical and creative tendencies in teacher questioning. Further, the ICC in Fig. 3(c) shows that, the ICC out of the two-parameter model matches the characteristics of S curves. Therefore, critical and creative tendency of teacher questioning can be estimated through the two-parameter model.

The results of data preprocessing manifests that, two-parameter models can be used to estimate open, problem-solving, and critical and creative tendencies of

teacher questioning.

Results of Analysis on Classroom Questioning Tendencies

The eight types of questions, i.e., the eight items that this study focuses on, represent three tendencies in teacher questioning. These are, “what questions,” “why questions,” “how questions,” “if what questions,” “memory questions,” “inference questions,” “creative questions,” and “critical questions.” Among the eight, “what questions” and “memory questions” reflect openness of teacher questioning. The more frequent these “what questions” and “memory questions” appear, the lower the openness tendency level of the teacher’s questioning. “How questions,” “why questions,” and “inference questions” reflect problem-solving tendency of teacher questioning. The more frequent “how questions,” “why questions,” and “inference questions” appear, the higher the level of the problem-solving tendency of the teacher’s questioning. “If what questions,” “creative questions,” and “critical questions” reflect critical and creative tendency of teacher questioning. The more frequent “if what questions,” “creative questions,” and “critical questions” appear, the more clear the critical and creative tendency of the teacher’s questioning.

Overall Tendency of Teacher Classroom Questioning

Results of Open Tendency of Teacher Questioning

In questions teachers raise during classroom instruction, “what questions” and “memory questions” are close-ended questions. Close-ended questions can generally be classified into two types (Wang, 2014). One type aims to find out unknown information through a question, and this unknown information often has only one fixed answer; the other type is used to obtain known information. This type of question also only has one answer. The more likely questions teachers raise in class are to be closed-ended, the smaller the scope teachers leave to students for divergent thinking. If teachers often bring up this type of strongly closed questions in class, teaching activities will be dominated by memory knowledge, which is not conducive to development of students’ creative thinking ability. In predicting the openness tendency in teacher questioning, the lower a

teacher’s score is, the higher their level of open classroom questioning will be.

Fig. 4 demonstrates mean scores and standard deviations of openness tendencies in teacher classroom questioning in the three districts selected from City B. Among them, District D is educationally developed, District F is educationally developed to the medium level, and District M is educationally developing. The lower the mean scores, the more open the teacher’s questioning tendency.

Fig. 4 Comparison of Openness Tendency in Teacher Questioning in the Three Districts

Fig. 4 shows that, in this questioning tendency estimation, on average teachers in educationally developed District D score lowest, indicating that their questions in class are most open. Teachers in educationally developing District M however score the highest on average, indicating that teachers in District M are most likely to use closed-ended questions in class. The openness level of questioning for teachers in less educationally developed District F is between the averages of their counterparts in District D and M. It is evidenced from the standard deviations and trend that the three districts do not differ much. In this way, the openness tendency of questioning in class in these three districts is reflected in the mean scores.

Results of Problem-Solving Tendency of Teacher Questioning

Problem-solving refers to the process by which people use certain methods and strategies to reach their target state from their initial state. Problem-solving has three basic characteristics: purpose, operation sequence, and cognitive operations. Typically a problem is solved through a series of four interrelated stages:

identifying problems, analyzing problems, proposing hypothesis, and testing hypotheses.

In the classroom, the three types of questions, i.e., “how questions,” “why questions,” and “inference questions” have the three basic characteristics of problem-solving, learners have to go through the four stages to answer these three types of questions. Therefore, the three types of questions, i.e., “how questions,” “why questions,” and “inference questions” correspond to problem-solving tendencies in teacher questioning. When asking these three types of questions, teachers leave learners some room to think, and sometimes there is not only a sole answer to a question. Additionally, as opposed to closed questions, these types of questions function better at cultivating students’ thinking ability. However, they still cannot provide students with more space to think and have an ill-structured problem space domain. In the estimation of problem-solving tendency in teacher questioning, the higher the mean score, the higher the average problem-solving tendency in teachers’ questioning in a particular district. The converse applies to low scores regarding the problem-solving tendency in teachers’ questioning.

Fig. 5 showcases the mean scores and standard deviations of problem-solving tendencies of teacher classroom questioning in the three districts selected from City B. The higher the mean score, the stronger the problem-solving tendency in teachers’ questioning.

Fig. 5 Comparison of the Problem-Solving Tendency in Teacher Questioning in the Three Districts

Fig. 5 shows that, in City B, apart from District D, which is educationally developed and has a mean score for problem-solving of over 0, the mean scores

for less developed District F and educationally developing District M are both below 0. The results indicate that teachers in all the three districts show low levels of problem-solving tendencies in terms of classroom questioning. It is necessary to strengthen professional learning and teaching practices in the domain of problem-solving. Teachers in District D, the educationally developed district, show certain level of problem-solving in terms of teacher questioning. However, in this district, teachers' professional competence still needs to be further enhanced.

Prediction of Critical and Creative Tendency of Teacher Questioning

In class, critical questions refer to questions that need students to change their perspective for in-depth thinking or reflection in order to find the answers. The core elements of critical questions are interpretation, analysis, evaluation, inference, explanation, and self-regulation. The critical behavior of teacher questioning often points to and challenges clarity, accuracy, precision, relevance, depth, breadth, and logic of the answers that students provide. Therefore, critical questions often appear in extended questions, i.e., follow-up questions from teachers (Sternberg, 1987). Critical questions require students to think about the content concerned critically. The critical thinking process is shown as students analyzing relevant information, identifying reasons, drawing conclusions, or seeking supportive viewpoints, etc.

The tendency for creative questioning will affect learners' creativity (Sternberg, 1987). Creative questioning refers to behaviors creating new questions out of an existing situation or learners' experience and stating newly discovered questions via language (Fei, 2003). Such questions require students to be committed to originality and evaluative thinking. To be specific, students are mainly required to make predictions and solve problems in life, and based on internal and external standards to make judgments on all sorts of ideas, information, behavior, and aesthetic expressions. When students think about and answer creative questions, they not only have to have the ability to generate new ideas, but also to balance their creative, analytic and practical intelligence in order to find good solutions (Sternberg & Spear-Swerling, 2001).

In classroom questioning "how questions," "creative questions," and "critical questions" are also known as high-order open-ended question. Fig. 6 displays mean scores and standard deviations for the critical and creative tendencies in teacher classroom questioning in the three districts. Among them, the higher the

mean score, the stronger the critical and creative tendencies in teacher questioning.

Fig. 6 Comparison of Critical and Creative Tendency of Teacher Questioning in the Three Districts

Fig. 6 shows that, on average teachers in the educationally developed District D score the highest, indicating that teacher questioning in this district is most critical and creative. While, teachers in less developed District F score the lowest on average, indicating that teacher questioning in this district is least critical and creative. Teachers in educationally developing District M score somewhere between their counterparts in the other two districts, but their score values are still below 0. The results displayed in Fig. 6 also indicate that mean scores of these three districts on critical and creative tendencies in teacher questioning are all relatively low, and relatively big differences are spotted between them all. Of all of them, teachers in District F show a negative tendency.

In summary, it can be clearly seen that educationally developed District D is strongest in terms of the openness tendency and problem-solving tendency in teacher questioning, and scores highest in critical and creative tendencies as well. Whereas educationally developing District M falls behind in all three tendencies in teacher questioning.

Analysis on Differences in Classroom Questioning Tendency

Analysis on Differences in Classroom Questioning Tendency of Primary School Teachers across the Three Districts

Based on the aforementioned two-parameter models, the authors estimate

separately the scores of teacher questioning in primary schools in the three districts for the three types of tendencies respectively, i.e., open tendency, problem-solving tendency, and critical and creative tendency. Means scores and standard deviations for each of the three teacher groups and each of the three districts are estimated as well. Eventually a scatter plot is created showing differences in the three tendencies across the three districts, as shown in Fig. 7, Fig. 8, and Fig. 9 respectively.

Fig. 7 Scatter Plot Showing Differences in the Openness Tendency in Teacher Classroom Questioning in Primary Schools in the Three Districts

Fig. 8 Scatter Plot Showing Differences in Problem-Solving Tendency of Teacher Classroom Questioning in Primary Schools in the Three Districts

Fig. 9 Scatter Plot Showing Differences in Critical and Creative Tendency of Teacher Classroom Questioning in Primary Schools in the Three Districts

As shown by the estimates of mean scores plotted in Fig. 7 for the three teachers groups (i.e., novice teachers, competent teachers, and experienced teachers), four groups of teachers show lower levels of openness in questioning. These four groups are: experienced teachers in District D, novice teachers in District F, experienced teachers in District M, and competent teachers in District M. Conversely, five groups show higher levels of openness in questioning. These five groups are: novice teachers in District D, experienced teachers in District F, competent teachers in District F, novice teachers in District M, and competent teachers in District D. Among the five groups, novice teachers in District D have the highest level of openness in classroom questioning.

As evidenced from differences between the standard deviations, the dispersion is highest for competent teachers in District D and experienced teachers in District D. In other words, there are relatively larger differences within the two groups respectively on account of open tendency in teacher questioning. Comprehensive analysis on information from Fig. 7 reveals that, in the three educational districts, as far as the three groups of teachers in primary schools (i.e., novice teachers, competent teachers, and experienced teachers) are concerned, the levels of classroom questioning apparently decrease with an increase of teaching years.

As shown by the estimates of mean scores visualized in Fig. 8 for the three teacher groups (i.e., novice teachers, competent teachers, and experienced teachers), six groups of teachers show higher levels of problem-solving

tendencies in classroom questioning. The six groups are: competent teachers in District M, competent teachers in District D, experienced teachers in District F, novice teachers in District M, competent teachers in District F, and novice teachers in District D. Meanwhile, novice teachers in District D have the highest level of problem-solving tendency. By contrast, three groups show relatively lower levels of problem-solving tendency. These three groups are: experienced teachers in District D, novice teachers in District F, and experienced teachers in District M.

As evidenced from differences between the standard deviations in Fig. 8, the dispersion is higher for seven groups of teachers, i.e., competent teachers in District D, experienced teachers in District D, competent teachers in District M, novice teachers in District M, experienced teachers in District M, novice teachers in District F, and competent teachers in District D. That is to say, there are relatively large differences within the seven groups respectively on account of problem-solving tendency in classroom questioning. Comprehensive analysis of information from Fig. 8 reveals that, competent teachers have higher levels of problem-solving tendency in classroom questioning. Novice teachers in District D, novice teachers in District M, and competent teachers in District F have stable and high levels of problem-solving tendency in classroom questioning. In addition, competent teachers in District D, competent teachers in District F, and experienced teachers in District D show relatively large variation within groups on account of problem-solving tendency in classroom questioning, respectively.

As shown by the estimates of mean scores visualized in Fig. 9 for the three teachers groups (i.e., novice teachers, competent teachers, and experienced teachers), four groups of teachers show higher levels of critical and creative tendency in classroom questioning. The four groups are: experienced teachers in District F, competent teachers in District F, novice teachers in District M, and experienced teachers in District D. Meanwhile, experienced teachers in District D have the highest level of critical and creative tendency in classroom questioning. On the contrary, five groups show relatively lower levels of critical and creative tendency. These five groups are: novice teachers in District D, novice teachers in District F, competent teachers in District M, competent teachers in District D, and experienced teachers in District M.

As evidenced from differences between the standard deviations in Fig. 9, only novice teachers in District M have relatively large dispersion. That is, there are

relatively large differences within this group on account of their critical and creative tendency in teacher questioning. Comprehensive analysis on information from Fig. 9 reveals that, in the less developed District F, experienced and competent primary school teachers are prominent and show higher levels of critical and creative tendency in classroom questioning. By contrast, in the educationally developed District D and less developed District F, novice teachers in primary schools fall behind, showing lower levels of critical and creative tendencies in classroom questioning.

Analysis on Differences in the Classroom Questioning Tendency of Secondary School Teachers across the Three Districts

Based on the aforementioned two-parameter models, the authors estimate separately the scores for teacher questioning in secondary schools in the three districts for the three types of tendencies respectively, i.e., open tendency, problem-solving tendency, and critical and creative tendency. Means scores and standard deviations for each of the three teacher groups and each of the three districts are estimated as well. Eventually scatter plots are created showing differences in the three tendencies, as shown in Fig. 10, Fig. 11, and Fig. 12.

Fig. 10 Scatter Plot Showing Differences in Open Tendency of Teacher Classroom Questioning in Secondary Schools in the Three Districts

As shown by the estimates of mean scores plotted in Fig. 10 for the three teacher groups (i.e., novice teachers, competent teachers, and experienced teachers), six groups of teachers show lower levels of openness in classroom

Fig. 11 Scatter Plot Showing Differences in Problem-Solving Tendency of Teacher Classroom Questioning in Secondary Schools in the Three Districts

Fig. 12 Scatter Plot Showing Differences in Critical and Creative Tendency of Teacher Classroom Questioning in Secondary Schools in the Three Districts

questioning. The six groups are: competent teachers in District D, novice teachers in District D, experienced teachers in District M, competent teachers in District F, novice teachers in District M, and novice teachers in District F. Conversely, three groups show higher levels of open tendency in teacher questioning. The three groups are: experienced teachers in District F, competent teachers in District M, and experienced teachers in District D. Among these three groups, on average it is the experienced teachers in District F who have the highest level of openness to classroom questioning.

As evidenced from differences between the standard deviations, the dispersion

is relatively high for all groups except competent teachers in District D. In other words, apart from competent teachers in District D there are relatively large differences within the eight other groups respectively on account of openness tendency to classroom questioning. Comprehensive analysis on information from Fig. 10 reveals that, as far as the openness tendency in questioning is concerned, eight of the nine teacher groups show relatively high variations, implying that they are all in the process of adjusting to greater openness. Set against competent teachers and experienced teachers, novice teachers have the lowest openness in teacher questioning.

As shown by the estimates of mean scores plotted in Fig. 11 for the three teachers groups (i.e., novice teachers, competent teachers, and experienced teachers), five groups of teachers show lower levels of problem-solving in teacher questioning. The five groups are: competent teachers in District D, experienced teachers in District M, novice teachers in District F, experienced teachers in District F, and novice teachers in District M. Meanwhile, four groups of teachers show higher levels of problem-solving in teacher questioning. The four groups are: competent teachers in District F, competent teachers in District M, experienced teachers in District D, and novice teachers in District D. Among the four groups, novice teachers in District D have the highest levels of problem-solving in classroom questioning.

As evidenced from differences between the standard deviations in Fig. 11, the dispersion is higher for three groups of teachers, i.e., competent teachers in District F, novice teachers in District F, and novice teachers in District D. That is to say, there are relatively large differences within the three groups respectively on account of problem-solving in classroom questioning. Comprehensive analysis on information from Fig. 11 reveals that, experienced teachers in District D and competent teachers in District M not only have relatively high problem-solving tendencies in classroom questioning, but also have lower levels of within-group variations. This suggests that the problem-solving tendency in teacher questioning is generally stable for these two groups of teachers. Competent teachers in District F and novice teachers in District D have relatively high levels of problem-solving tendency in classroom questioning, but in-group variations for these two groups are relatively high, suggesting that some teachers in these two groups differ obviously on problem-solving tendency in classroom questioning.

As shown by the estimates of mean scores plotted in Fig. 12 for the three teachers groups (i.e., novice teachers, competent teachers, and experienced teachers) in secondary schools, six groups of teachers show lower levels of critical and creative tendency in classroom questioning. The six groups are: competent teachers in District F, novice teachers in District M, novice teachers in District F, experienced teachers in District D, novice teachers in District D, and experienced teachers in District M. Meanwhile, competent teachers in District D, competent teachers in District M, and experienced teachers in District F have the higher level of critical and creative tendency in classroom questioning. Among the three groups, experienced teachers in District F have the highest level of critical and creative tendency in classroom questioning.

As evidenced from differences between the standard deviations in Fig. 12, novice teachers in District D, experienced teachers in District D, and competent teachers in District D show larger dispersion levels. This indicates that, there are relatively large differences within all the three teacher groups in District D in terms of critical and creative tendency in teacher questioning. Integrated with information shown in Fig. 12, all three teacher groups in District D have higher levels of critical and creative tendencies in classroom questioning but also larger within-group differences. By contrast, all the three teacher groups in District F have lower levels of critical and creative tendencies in classroom questioning but smaller within-group differences. Regarding group characteristics, experienced teachers and competent teachers in District M are closer to each other, but differ noticeably to novice teachers in the same district.

Conclusions and Recommendations for Improvement of Classroom Questioning

Data has become raw material just as much as minerals and chemical elements are. A strategic new industry may emerge in future, providing a range of data manipulation services. The rise of big data processing has changed the direction of cloud computing, leading it into the Cloud 2.0 era, the landmark of which is that data analysis has become a service (AaaS, i.e., Analytics as a Service; Li & Cheng, 2012). In the book *Big Data*, Viktor Mayer-Schönberger and Kenneth Cukier (2013) point out that there should be an ideological shift from the traditional way of doing data analysis. For example, they suggest that the idea of

data measurement should be changed. People should be more willing to accept chaotic and disordered data, no longer expect accurate and concise data, and no longer seek after elusive causality. Instead, they should focus on correlations between objects.

To date, three research paradigm shifts have emerged in research on classroom teaching behavior, i.e., the process-results paradigm, the cognition-dialogue paradigm, and the context-ecology paradigm (Gai & Zheng, 2010). Research based on big data for classroom teaching behavior provides quantitative evidence to answer key questions arising from the first paradigm regarding the relationship between teacher instructional behavior and teaching effectiveness. Such research also provides more cognitive mediators for the development of reflexive practice, which contributes to the goal of enhancing the effectiveness of teaching behavior. The goal is supposed to be achieved through research on the effects of teachers' cognitive teaching behavior and improvements in their knowledge structure and cognitive approaches. These are the focuses of the second paradigm. Such research further provide standing points based on visualizable analytic results out of big data, which meet the needs of the third paradigm that proposes capture of the whole picture for characteristics of integration and evolution of classroom teaching behavior through description and observation of such classroom teaching behavior.

Conclusions of this study focus on the three questioning tendencies of teacher classroom questioning (i.e., open tendency, problem-solving tendency, and critical and creative tendency) in three districts which have developed to different level with respects to basic education.

Conclusions and Recommendations Regarding Openness in Teacher Classroom Questioning

From the perspective of open tendency in teacher classroom questioning, all the districts need to enhance and improve the level of open tendency of experienced teacher classroom questioning in primary schools. Among the three districts, those educationally developed can promote peer coaching activities on the basis of classroom practice in the form of the same structure for the same lesson, different structure for same lesson, etc. These initiatives correspond to larger variations that experienced teachers in primary schools show on account of open

tendency in classroom questioning. The larger variations characterize this group of teachers in primary schools in this district. Experienced teachers can also be invited to observe, in groups, the classroom questioning behavior of novice teachers in the educationally developed district in order to influence and improve their own open questioning tendency.

When it comes to the open questioning tendency of secondary school teacher groups, the level of openness in novice teachers' questioning is significantly lower than that of experienced and competent teacher groups. Therefore, initiatives such as teacher training can be arranged to dramatically enhance the openness of teacher questioning. In this regard, the three teacher groups in the educationally developed district are at the similar level, thus overall improvement can be considered for holistic improvement. While competent teachers in the less developed district need to further raise the level of open tendency in classroom questioning. The suggestion is to integrate the education idea of new curricula and competent teachers' reflection and critique into classroom phenomena for improvement of their questioning open tendency. This can be achieved through implementation of research projects focusing on classroom questioning.

Conclusions and Recommendations Regarding the Problem-Solving Tendency in Classroom Questioning

As found from the quantitative study of the three types of tendencies of teacher questioning, the problem-solving tendency is at the lowest level. The low level remains even in the educationally developed area.

From the perspective of the problem-solving questioning tendency, competent primary school teachers in all the three districts have higher levels of problem-solving orientation in questioning. In both educationally developed and less developed districts, experienced teachers and novice teachers in primary schools show very large differences in the problem-solving questioning tendency. No matter whether in the educationally developed district or the less developed one, novice primary school teachers show significant group advantages as opposed to their experienced peers. For this reason, in primary schools there is the need for an intensification of efforts to vastly improve experienced teachers' practical knowledge such as disciplinary knowledge and strategic knowledge in

order to facilitate their professional development. To be concrete, three types of questions, i.e., “how questions,” “why questions,” and “inference questions” can be used frequently in their classes.

In secondary schools from the perspective of problem-solving questioning tendency, novice teacher groups in all the three districts show higher levels in this regard. Among them, novice and experienced teachers in the educationally developed district are at the top level. While competent teachers in both the less developed and developing districts also have a relatively high level of problem-solving questioning tendency, and this group in both districts show higher levels than their peers of the other two groups in the same district. The recommendation is that, in both educationally developed and developing districts, enhancement of levels of problem-solving questioning tendency of both competent and experienced teachers should be stressed. Competent teachers’ practical knowledge can be developed through the dimensions of education aspirations, interpersonal knowledge, strategic knowledge, contextual knowledge, and reflexive knowledge.

Conclusions and Recommendations Regarding the Critical and Creative Tendency in Teacher Classroom Questioning

With respect to the critical and creative questioning tendency, teachers in all three districts are at low levels. In the three districts, experienced and competent primary teachers of the less developed district have more prominent advantages in the critical and creative questioning tendency; while novice primary teachers in educationally developed district and less developed district are in a worse situation. To make changes happen, it is recommended that in all the three Districts research projects be arranged purposefully to examine classroom questioning. The examination can start from designing of questions to be raised in class, in the hope that in the preset questions quantity and quality of critical and creative questions can be stressed.

In secondary schools, on average novice teachers generally have lower levels of critical and creative questioning tendency than competent and experienced teachers. The three groups (i.e., novice teachers, competent teachers, and experienced teachers) in educationally developed district all have higher levels tendency for critical and creative questioning. In contrast, it is the key issue for

less developed district to help competent and experienced teachers to increase the tendency for critical and creative questioning. While less developed district should endeavor to improve the critical and creative questioning tendency of novice teachers.

Classroom Value Orientation Reflected from Classroom Questioning Tendency from the Perspective of Big Data

Differences in teachers' instructional behavior ultimately result from differences in teachers' value orientation. While teachers' instructional behavior reflects different value orientation, there are two types of very common phenomena resulting from the teaching behavior and classroom questioning (Luo & Wang, 2008). The first type of phenomena is that, teacher questioning is often obviously random. During classroom instruction, teachers often convey warning messages by the means of random questioning when they find there are students playing tricks but not listening to them or there are student dozing off. As a consequence, the number of questions brought up in class is amazing. While most are simple memory questions or mechanical judgmental questions like "What did I say just now?" "Yes or no?" and "Right or wrong?" The second type of phenomena happen because teachers often rely on whether questions they ask can be correctly answered by most students in class to decide whether the teaching activities should be brought to an end. Consequently, most questions that teachers ask are well-structured problems which have only one correct answer and the answer of which can hardly be explored creatively and critically. These two types of phenomena happen particularly often in the educationally developing district.

The results of big data analysis in this study can reflect the value orientation that teachers have in classroom questioning. The value orientation is expressed as: emphasis on the local value of classroom questions and a lack of awareness of the overall value that classroom questioning can inspire in students, enabling them to be engaged in classroom interaction more actively; also emphasis on instrumental value and lack of awareness of the value and the ultimate goal of education as encouraging students to think deeply; emphasis on superficial values and lack of awareness of deep values and that the function of classroom questioning is to encourage students to raise better questions. Considering

classroom questioning, the current value orientation deserves more attention from teacher training institutions and education administrative departments, which should lead teachers to recognize again the educational value and purposes of questioning, what might be seen as the oldest teaching behavior. Based on this, they can provide more concrete evaluation to classroom teaching activities in real life, propose new pedagogical principles, designs, approaches for the questioning process.

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