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Investigation and Analysis of Levels of Mathematics Class in Middle School

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Nine years after the implementation of the new curriculum, we made inquiry into the use of four levels of a mathematical class system in middle school mathematics classes. The results show that the current mainstream level of mathematics classes is Level 1, which is, teachers guide students step by step. Inquiry level 0 and level 2 also exist and roughly in the same proportion. The survey also revealed a high proportion of students wanted to improve the class inquiry level.

Key words: class, inquiry, investigation

From the late 1990s to the early 21st century, inquiry learning has already been carried out and extended to dozens of countries and regions in the world. In 2001, China launched a new round of reform concerning the elementary school education curriculum, which advocates that students "participate actively and explore happily." (Mathematics Curriculum Standard Research Group, 2002). As a scientific teaching method, Inquiry is winning the hearts and minds of the people. According to 《辞海》, "inquiry" means to "discuss deeply, research repeatedly". Are the teachers or the students going to "discuss deeply, research repeatedly"? Different inquiry subjects require different inquiry levels. It has been 10 years since reform started. This study is about the development of mathematics as the foundation course in the elementary school classroom. This problem was not studied domestically; rather we have developed the Herron four level inquiry systems, building the four level inquiry system for mathematics classes at the middle school. With this help, we conducted the current research to investigate this topic.

Literature Review

The Development of the Inquiry Level

In the 1950s and 1960s, Schwab put forward three inquiry levels which demonstrated improvement one by one in lab exploration. In the simplest level, the student conduct experiments according to the questions and research methods found in the experiment handbook, finding the relationship which they can not find in their books. At the second level, the experiment handbook presents only questions, leaving the students to determine methods and answers. At the third level, the handbook will leave all the questions, methods and answers for the students to determine (Schwab, 1964).

After Schwab in 1971, Herron implemented a level 0 as an addition to the three pre-existing levels in which the problems, the methods to answer questions, and the correct explanation are all given (Herron, 1971). This level has high structure with no openness or exploration.

After the 1990s, researchers have enriched and developed the exploration level system of Schwab and Herron. In 1997, the Science Experiment Research Center of Templeton University divided inquiry into five levels (Mitchell, 2007). However, extensively detailed classification resulted in no significant difference between each level, making them difficult to distinguish.

Current Situation of Inquiry Level Problem Research

In 1971, Herron for the first time used his four-level system to research the new experimental course in 1950s and 1960s and published the inquiry level conclusion. 52 PSSC laboratory activities are classified, 39 of which belong to level 0, 11 belong to level 1, 2 belong to level 2, and none belong to level 3. Using the same four levels system to classify BSCS laboratory materials 62 laboratory activities, Herron found that 45 belonged to level 0, 13 belonged to level 1, 4 belonged to level 2, none belonged to level 3. Obviously, the purpose of science education or exploration principles did not promote the curriculum and teaching affairs at that time. (Herron, 1971).

Ten years later, a group of researchers used Herron's inquiry level classification to investigate whether or not the chemical experiment lab handbook is compatible with inquiry –the intention at the time (Fuhrman, Lunetta, and Novick, 1982). Using the classification in 2005, Park compared the standard curriculum (USA) and traditional high school science textbooks (Park, 2005). Mitchell (2007) explored whether or not the high school biology

course fit the inquiry of science education standard and learned about its inquiry level (Mitchell, 2007). Their conclusions were that these science textbooks (manuals) were mostly at level 1 and did not match the scientific inquiry thought advocated at the time.

Xiang and Liu (2006) analyzed four sets of Sino-Japanese textbooks according to the classification principles of Herron inquiry level. The result was that between the two countries there were marked differences between level 0 and level 2. In terms of level 0, Japan is higher than China while in terms of level 2, China is higher than Japan. In level 1, there are no obvious differences between the two countries.

What is worth mentioning is that Banchi and Bell (2008) tried to gradually implement teaching the four inquiry level in a science (physical) class in an elementary school.

From the above it can be seen that Schwab, Herron and other researchers followed the constructed scientific experiment inquiry level system which made distinctions by **c**lass inquiry. Mathematics classroom exploratory has its unique characteristics. To investigate mathematics classroom exploratory level, we have to build our own inquiry level system. From the above, we can also see that most researchers are doing research on the inquiry level of laboratory manuals (textbooks) without following the research at exploring the class's inquiry level.

Research Content

Based on research of materials in all aspects, combining mathematical characteristics and actual middle school classroom observation, we divided math class inquiry elements into question promotion, analysis and assumption, implementation of plans, and evaluation and conclusion. The subject of the implementation was divided into: teachers, teachers/students (cooperation), and students. The four levels of Herron inquiry system have been modified. The middle school math classes 4 level inquiry systems are allotted a bigger degree of distinction and the increasing inquiry levels are indentified as follows:

level 0 - controlled inquiry: Classroom **t**eacher offers the main problem to research, analyzes the problem, comes up with the method (assumption) to solve the problems and the implementation scheme, and then teachers evaluate the problem-solving processes and methods for correction, degree of improvement, ability to form conclusions, etc.

Level 1 - guided inquiry: Classroom teacher offered the main issues, utilizing the method in which teachers guided students step by step (commonly the Q&A between teachers and students). The teachers and students come together to analyze the problem, come up with the methods to solve the problems, implement it together, and together they evaluate the process method of solving the problem.

Level 2 - open inquiry: The task of locating the main problem is carried out by teachers. Students begin to analyze the problem independently or cooperatively, coming up with the method implementing it themselves. Finally, students evaluate their processes and methods of solving the problem.

Level 3 - autonomous inquiry: Teachers create the situation and students create questions according to the situation. Independently or cooperatively, students analyze the problem, proposing assumptions to solve the question. Implementation and evaluation are mainly done by the students.

Level 0 and level 1 are considered to be the lower levels; level 2 and level 3 are higher inquiry levels, as in table 1:

This paper makes use of the mathematics class four level inquiry systems, carrying out the investigation and research of middle school mathematics class inquiry level, examining whether it conforms to our country's class inquiry requirements of the new curriculum standards.

Methods

Participants

In order to have a better understanding of the situation, we conducted one study in Henan province and other provinces. In Henan province we selected the more developed economic city, Pingdingshan, and the agricultural city, Shangqiu. Sample selection is shown in the following list:

We took back 1107 valid questionnaires from Henan students and 482 valid questionnaires from other provinces.

We also investigated the teachers of Henan province and other provinces. Sample selection is shown in the list below:

Table 1

Middle School Mathematics Class Four Level Inquiry System

Element level	Raise questions	analysis and assumptions	implementation scheme	evaluation and conclusion
Level 0 (control inquiry)	teacher	teacher	teacher	teacher
Level 1 (guided inquiry)	teacher	teachers/ students	teachers/students	teachers/students
Level 2 (open inquiry)	teacher	students	students	students
Level 3 (autonomous inquiry)	students	students	students	students

Table 2

City, Schools and Numbers List of Students' Sample

Province and outside	the region	early/ high school	school	students	Number in middle school	total
Henan province	Pingdingshan city	primary school	in junior 43 (urban middle school)	247	546	1118
			51 (urban and rural)	90		
			(township junior high school)	209		
		High school	Henan quality engineering vocational college freshmen	260	260	
	Shangqiu	primary school	junior school kong zu (township junior high school)	105	191	
			junior school kong miao	86		
		High school	High school hui city high school	121	121	
outside Henan	Hubei Xiangning	primary school	spring junior middle school	80	323	485
	Shandong ZaoZhuang	primary school primary school	junior high school XingRen middle school (middle) hi-tech	38		
	Yangzhou	primary school	junior middle school (middle) MeiLing	205		

Guangdong Shunde	High school	north cellar middle school (high school)	162	162	

(Note: the schools extracted students from different levels and from different teachers' classes)

Table 3

Area of Teachers' Sample and Number List

Henan province/outside	city	early/high school	city/township	students	aggregate
Henan province	Zhengzhou city	high school	city	19	95
	Pingdingshan city	junior high school	city	15	
			Township	7	
			Urban and rural	6	
		High school		11	
	Shangqiu city	High school	city	19	
		junior high school	city	10	
			Township	8	
Outside the city of Henan province	Hubei xianning	junior high school	city	18	57
	Shandong ZaoZhuang	junior high school	Urban and rural	6	
	Yangzhou	junior high school	city	18	
	Guangdong shunde	High school	city	15	

We took back 91 valid questionnaires from Henan province and 57 valid questionnaires from other provinces. The majority of schools encouraged almost all of the teachers to take part in the investigation. The teachers' professional title and gender ratio is lined up with the actual situation in the schools.

Instruments

Based on the above middle school mathematics class inquiry four level systems and with the problem put forward, analysis and assumptions, implementation plan, evaluation and conclusions are finished mainly by teachers, students, or a combination of them. Combining the students' preferred mode, we compiled the "mathematical inquiry learning questionnaire (student use)".

Based on the mathematics teachers' realization of inquiry in class on how to operate the above several steps, we compiled the "mathematical inquiry learning questionnaire (teachers use)".

To detect whether the investigation results are of significant difference, we use the χ^2 inspection.

Results

The Results of the Survey of Teachers and Students in Henan Province

Table 4 illustrates the statistics of 1107 questionnaires of high school students and 91 mathematics teachers' of Henan province. The results are shown in table 4:

Table 4 class inquiry situation questionnaire of students and teachers in Henan and statistics numbers on all the options.

Table 3

Questionnaires of High School Students

#	subject	Option	Junior 730	senior 377	middle school students1107	teachers 91
1	What is the main problem in your class when a new	A. after introduction teacher raise questions or look at the book	371（50.8）	186（49.3）	557（50.3）	52（57.1）
		B. students	200	76	276	24

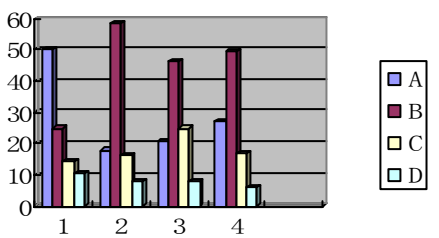
	chapter is taught?	raise questions by themselves according to situation	（27.4）	(20.2)	（24.9）	（26.4）
		C. without questions, teachers provide the notion and formula	105 (14.4)	53 (14.1)	158 （14.3）	3 （3.3）
		D. others	54(7.4)	62(16.4)	116（10.5）	12（13.2）
2	What is the situation after a question come up?	A. teachers analysis and get the method to solve the problem ,stude nt pay attention to listen	128 （17.5）	69 (18.3)	197 (17.8)	27 (29.7)
		B. teachers and students analysis and design the methods to solve the problems. Students sometimes recommendatio n, Instead of only listen to the teacher	451 （61.8）	195 (51.7)	646 (58.4)	48 (52.7)
		C. students analysis problem, design a solution on	88 （12.1）	91 (24.1)	179 (16.2)	16 (17.6)

		their own or cooperation				
		D. teachers give the answer without analysis。	63（8.6）	22(5.8)	85(7.8)	0(0.0)
3	After the solution, you usually	A. teacher solved Problem according to designed good method students look.	165 (22.6)	66 (17.5)	231 (20.9)	2 (2.2)
		B. teachers and students together solve problems with the design, students sometimes put forward Suggestions, etc.	337 (46.2)	175 (46.4)	512 (46.3)	62 (68.1)
		C. students try to solve the problem according to design good Methods. cooperation or independently	169 (23.1)	106 (28.1)	275 (24.8)	24 (26.4)
		D. others	59(8.1)	30(8.0)	89(8.0)	3(3.3)
4	After solving the problem ,the conclution	A. teachers evaluate the steps\ methods to solve the problem and make	184 （25.2）	118（31.3）	302 (27.3)	23 (25.3)

usually is	conclusion				
	B. teachers and students together make conclusion about steps and methods on problem-solving, evaluating various solutions.	396 (54.2)	154 (40.8)	550 (49.6)	46 (50.5)
	C. students make conclusions about the steps, methods ,evaluating various solutions, teacher mainly listen	106 (14.5)	82 (21.8)	188 (17.0)	19 (20.9)
	D. no conclusions	44(6.0)	23(6.1)	67(6.1)	3(3.3)

Note: brackets represent percentages.

In order to see the percentage of each topic options more intuitively, we converted it into a graphic below (the left is figure 1,the right is figure 2; four options in each topic are shown from left to right as follows A, B, C, D):



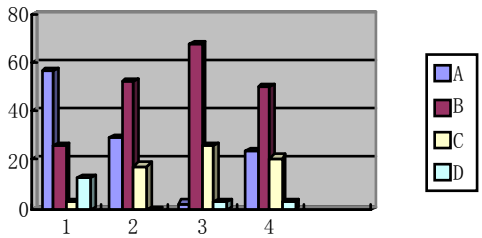


Figure 1. **Henan middle-school student questionnaire options scale map.**
Figure 2.**Teacher questionnaire corresponding subject options scale map.**

It can be seen from Figure 1 and Figure 2, the first question A represents the most responses (50.3 ％-57.1 2%). More than half of students and teachers say the problem is given by a teacher or textbooks. In The 2, 3, 4 questions, B option represents the biggest proportion, analysis and assumptions, implementing scheme, evaluation and conclusion are mostly finished by teachers and students together. This can suggest that at present our country's mathematics class inquiry level mainstream is **at** level 1 – guided inquiry which is based on the middle school math classes 4 level inquiry system: teachers or materials give the problem, which can be analyzed, assumed and implemented, and the final solution is evaluated cooperatively by teachers and students. Although both teachers and students think inquiry level mainstream is at level 1, it can be seen from table 4, the first question A, the 2, 3, 4 questions B options that the proportion of students and teachers are different. It needs to be determined whether these differences are significant.

Table 5

Understanding Differences TAB of Students, Teachers into Inquiry Level Mainstream Polled in Henan

Q1			Q2			Q3			Q4		
A	others	χ^2	B	Others	χ^2	B	Others	χ^2	B	Others	χ^2

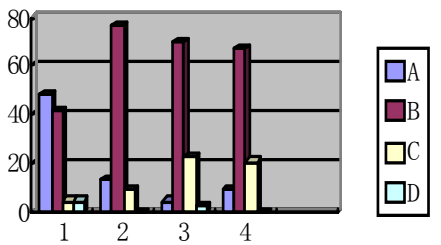
Teachers in Henan	52 (57.1)	39 (42.9)	1.567	48 (52.7)	43 (47.3)	1.088	62 (68.1)	29 (31.9)	16.13	46 (50.5)	45 (49.5)	0.557
Students in Henan	557 (50.3)	550 (49.7)		646 (58.4)	461 (41.6)		512 (46.3)	595 (53.7)		550 (49.6)	557 (50.4)	

Note: brackets represent percentages.

It can be seen from the statistical results of table 5 there are no significant differences in students and teacher understands of Q1- option A and Q2 Q4-option B. For Q3 - option B, where students think "teachers and students together solve problems" in the protocol is of a lower rate than teachers, the significant difference is 21.8%. We can look to table 5 to investigate the reason. 20.9% of students think it is because "teachers solve the problem according to the designed good method ", but only 2.2 % of teachers agree.

From Figure 1 and Figure 2 we can see that besides questions 3 of figure 2, an option still accounts for about 20 % of the last three questions, namely the phenomenon in which teachers manipulate all aspects (level 0) exists, though it is not mainstream. Option C in Q2, Q3, Q4 make up a certain percentage (20 %), and so level 2 can be easily seen in today's math class. Level 3 also exists, for option B in Q1 make up a certain proportion. From table 4 we can see that there are differences between middle school and high school students' individual options which we will not discuss here.

To classify teachers' questionnaires, we found that middle school teachers are different from high school teachers, as can be seen from Figure 3 and Figure 4 (the left is Figure 3, the right is Figure 4; and four options in each topic are shown from left to right as follows A, B, C, D) :



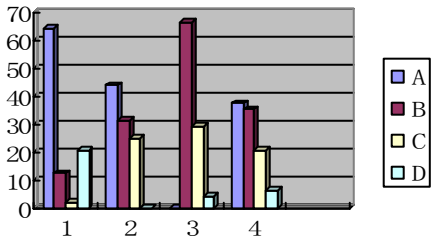


Figure 3. **Junior high school teachers' questionnaire options scale map**.
Figure 4. **High school teachers' questionnaire options scale map.**

From the above Figure 3 and Figure 4 we can see that, in addition to the third question, option A indicated a greater proportion of teachers in junior-middle school than of teachers in senior middle school. When it comes to raising a question analysis as a question and evaluation, high school teachers implement this by themselves. Option B shows a greater proportion of middle school than high school teachers, which indicate a situation that middle school teachers pay more attention to cooperation between teachers and students.

Survey's Results of Students, Teachers from Other Provinces

We use the same question to investigate students and teachers from other provinces and the outcomes are as follows:

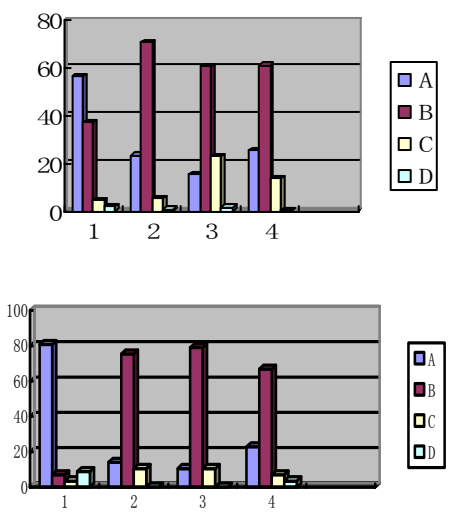


Figure 5. **Other provinces' junior high school students' questionnaire options scale map.**

Figure 6. **Other provinces' junior high school teachers' questionnaire options scale map.**

We can see that the situation in Figure 5 and 6 is similar to that in Henan. In the two Figures, option A makes up most of Q1. More than half of the students (80% of teachers) agree that the question is given by teachers and the textbooks. However, option B takes up the most of Q2, Q3, Q4, saying that considering the analysis and assumption, plan implementation, evaluation and conclusion, most can be finished by teachers and students alike. Namely teachers and students in other provinces also think the mainstream is level 1. The proportion that chooses B for Q1 is higher in Figure 5 than in Figure 6. 37.1 % of students think the "problem is put forward by the students themselves according to the situation," but there only 7% of the teachers who agree with that. Since these teachers and students come from the same school, why is the knowledge gap so big? Do these students misunderstand? This requires further investigation. Besides, the percent of option A in Q 2Q3Q4 is higher in students (23.4%, 15.4%, 25.3%) than teachers (14%, 10.5%, 22.8 2 %), which explains that students think a higher than 0 level of implementation is used, unlike the teachers.

Whether students from other provinces have similar knowledge as students of Henan is also a matter of investigation.

Table 6

The Differences Statistics Tab of Students Surveyed for Mainstream Level Understanding from Henan and Other Provinces

	Q1			Q2			Q3			Q4		
	A	others	χ^2	B	others	χ^2	B	others	χ^2	B	others	χ^2
1	557 (50.3)	550 (49.7)		646 (58.4)	461 (41.6)		512 (46.3)	595 (53.7)		550 (49.6)	557 (50.4)	
2	272 (56.4)	210 (43.6)	5.03	340 (70.5)	142 (29.5)	21.17	292 (60.6)	190 (39.4)	27.58	293 (60.8)	189 (39.2)	$p<0.05$

Note: brackets represent percentages, 1=Students in he nan ; 2=Students from other provinces

From table 6 we can see that with the exception of Q1 option A, there exists significant difference in option B in the rest of the questions between students from Henan and other provinces. Students from others provinces indicate a higher proportion than many students in Henan province. This indicates that students from others provinces think exploration level 1 is the higher proportion.

In Figure 5,the proportion of option C in Q2Q3Q4 are respectively 5.4%, 22.6%, 1.35%, which is lower than 17.6%, 26.4%, 20.9% In figure 1, the proportion of students from others provinces think inquiry level 2 is lower than in Henan. Figure 6 shows that option C of Q2Q3Q4 teachers from others provinces are respectively, 10.5% 10.5%, 7% which is greatly lower than Henan's 17.6%, 26.4%, 20.9%. Answers from teachers from others provinces are also lower than Henan teachers concerning level 2 classes. Figure 6 first topic's B is only 7% (the ratio that students raise questions is only 7%), answers from teachers from others provinces' level 3 class is also lower.

Results of Attend Lectures

In order to validate survey results, we attended more than 30 random lectures in Pingdingshan city, Zhengzhou city, and Luoyang city. Lectures basically conform to the questionnaire surveys' results. At present, most middle school mathematics class inquiry level is level 1. It is mainly Q&A between teachers and students. The teachers guide students to analyze and solve problems step by step. Evaluation and summary are taught by the teachers to the students. Level 0 (teaching method) exists in some old teachers. There are also Level 2 classes whose quantity are small but have diverse forms. Unfortunately inquiry level 3 classes have not been found. We found that not one class was the main problem raised by students after teachers created the situation with students finishing the solving method, implementation and evaluation on their own. Therefore, we will interview those teachers and students who choose level 3.

Investigation Results of Middle School Students' Preference

Which kind of inquiry level class do middle school students prefer? To determine this we made an investigation regarding question formation, analysis and assumptions, implementing scheme, evaluation and conclusion in

the first 5, 6, 7, 8 respectively problems of our questionnaire. This is in comparison with the first 1, 2, 3 problems method which about making changes (such as after designing the methods to solve the problems, which is your preferred implementation pattern?) with the option to leave the content unchanged. Statistical results are shown in figure 7 (four options in each topic are shown from left to right as follows A, B, C, D):

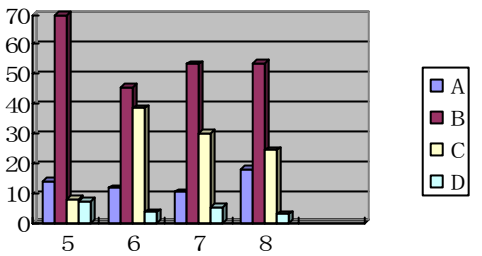


Figure 7. **Options of middle school students' questionnaire scale map.**

From Figure 7 we can see the proportion of options B of Q 5 was improved significantly, indicating that the students like to put forward questions according to the situation by themselves, rather than being asked by the teacher or the textbook. In the last three topics option B is still higher. Many students like to analyze and solve and explain evaluation problems together with teachers, indicating the method of long-term scenario of teachers' guidance lead them depend on teachers. C option of Article 6, 7, 8 problems shows much improvement indicating that many students are not satisfied with being led step by step way by the teachers while demanding independence or student collaboration to solve problems or evaluation quality (i.e. more students tend to prefer level 3). Accordingly, the percentage of each question A in figure 7 decreased significantly. This implies fewer students prefer the simple lecturing method.

Conclusions and Recommendations

The above investigation results show that today's nine years later after the new curriculum's implementation; China's middle school mathematics class inquiry mainstream levels are no longer level 0. Namely, under the pressures to enter college, the viewpoint that the lecturing method takes predominance is wrong. At present the middle school mathematics class

mainstream level is at level 1 (guided inquiry), specifically indicating Q&A between teachers and students, with the teacher leading step by step. Analysis and creating the solution and the implementation schemes are done by teachers and students together, as are evaluation and making conclusions about the situation. Inquiry level 0 and inquiry level 2 classes exist simultaneously. In Henan, inquiry level 2 classes exist more than in other provinces, according to diverse lectures. In other provinces, level 0 inquiry students indicate a higher incidence of lectures than their teachers. The reason may be that some teachers use their traditional teaching practice habitually and don't realize it. Although survey results contain level 3 classes, the author has not found them. The survey also showed that concerning raising questions, analyzing and evaluating, and summarizing, high school teachers are in control more often than junior high school teachers.

Although inquiry level 1 is higher than level 0, it still belongs to a lower level. It also is a disparity when compared to China's new basic education curriculum reform goal. From the results of the survey we also see that many students wish for higher exploration levels, hoping to have more exploration opportunities. Therefore, large numbers of mathematics teachers should further emancipate the mind to establish a correct view of their students and switch from distrust to release. As for which kind of teaching method allows students to exert better intelligence when raising questions, analyze and assume, implementing plan, evaluating and making conclusions, modes such as found in high schools Du Lang Kou and Yangsi are worth using for as a reference.

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