# Research on Data Analysis Literacy of High School Students in China

**Abstract:** Data analysis is an important mathematical technique for studying random phenomena and a major method for mathematical applications in the era of big data. For students, the stage of high school is a critical period to form and develop their data analysis ability, so scholars have paid a lot of attention to the issue of education about data analysis literacy of high school students. The following conclusions are drawn from the summary and analysis of previous studies: 1. Previous studies on data analysis literacy of high school students have focused on five main aspects: basic connotation, cognitive status, influencing factors, cultivation strategies and evaluation methods; 2. Among them, cognitive status and cultivation strategies are the hot issues; 3. In terms of research methods, scholars mostly use pencil-and-paper tests, questionnaires or interviews to investigate cognitive status, and analyze the influencing factors and cultivation strategies just with theoretical thinking; 4. In previous studies, there are shortcomings of single research method and lack of empirical practice, while the previous researches on influencing factors are not systematic or comprehensive. The research conclusions on cultivation strategies lack feasibility or validity, and the researches on evaluation methods are relatively scarce. Therefore, it is necessary for scholars to further improve the research methods on the influencing factors and cultivation strategies in future studies, and to conduct more in-depth and systematic researches on the influencing factors of data analysis literacy from an empirical perspective, in order to find out more comprehensive influencing factors and more operable cultivation strategies.

**Keywords: High school student, Data analysis literacy, Core literacy , Mathematics**



## 1. Introduction

Data analysis refers to the acquisition of data from the research object, the use of mathematical methods to sort, analyze and infer the data, and form the literacy of the knowledge about the research object. With the rapid development of artificial intelligence and big data technology, "using data to infer" has become a widely used and powerful way of thinking in modern society. The education of data analysis literacy has attracted more and more attention from the government and all sectors of society. To this end, the new curriculum standards for senior high school published by the Ministry of Education of the People's Republic of China in 2018 pointed out that data analysis literacy should be fully implemented in senior high school. Scholars have paid attention to the area of data analysis literacy among high school students in recent years, but there is a no collation of relevant research findings. We intend to review and organize the existing related papers and systematically analyze the current status of the researches as well as its shortcomings. We aim to provide corresponding reference

suggestions for improving the data analysis literacy of high school students, and more importantly, to help researchers grasp the characteristics and status to facilitating further researches.

The research question of this paper is what is the current status of research on "data analytic literacy among high school students". The following specific questions are included: 1. What previous researches have been done on data analytic literacy among high school students? 2. Which areas have been studied more by scholars? 3. What research methods have been used by scholars to study data analytic literacy? 4. What are the gaps in current researches on data analytic literacy among high school students?

## 2. Literature Source

### 2.1 Data Source

We adopt the literature analysis method, and the papers are all from the China National Knowledge Infrastructure (CNKI). CNKI is the most authoritative literature search tool for national academic journals in China, which contains all the contents of journals and dissertations in China completely. The choice of this database in this paper can ensure the persuasiveness and reliability of the study.

### 2.2 Data Collection

During the data retrieval, we took "data analysis literacy" and "high school student" as the subject words and "data analysis literacy" as the subject words, and retrieved 38 and 823 articles respectively. Because we would like to discuss the data analysis literacy of senior high school students, considering the research problems and the number of references, 46 references are finally selected.

## 3. Result

Through collation, it was found that previous studies on data analysis literacy mainly focused on five aspects: basic connotation, cognitive status, influencing factors, cultivation strategies and evaluation methods.

### 3.1 The Basic Connotation of Data Analysis Literacy

There have been many studies on the connotation of data analysis literacy and its main components. Wu et al. (2021) put forward that data analysis literacy refers to students' awareness and ability to use data analysis to solve practical problems through learning and applying data analysis knowledge, as well as the character shaped in this process (Wu et al., 2021). Wang (2020) believes that the data analysis literacy of high school students refers to the literacy suitable for problem-solving and the key ability suitable for personal development and social progress formed by students through teachers in the process of learning high school courses (Wang, 2020). Jiang (2021) believes that data analysis is an application process of mathematical knowledge and methods based on problem-solving. It is a process of using mathematical language to express the world and using mathematics as a tool to apply and solve problems. It is a kind of tool literacy (Jiang, 2021). Qiu (2018) proposed that data analysis literacy is to understand the channels and systems for providing data and be able to screen out valuable data, select the best and most convenient system for obtaining data, have a certain ability to store and obtain data, learn some electronic software for processing data (Qiu, 2018). Chang et al. (2017) believe that data analysis is the consciousness of

using data to express practical problems, the ability to deal with and analyze problems, and the habit of using data to think and explain problems, gradually forming in the process of problem-solving (Chang et al., 2017).

In 2017, the Ministry of Education of the People's Republic of China comprehensively summarized the above statements and gave the most formal statement in the latest version of curriculum standards. The new standard states that data analysis refers to the literacy of obtaining data for the research object, using mathematical methods to organize, analyze and infer the data, and forming knowledge about the research object. The main manifestations are: collecting and organizing data, understanding and processing data, obtaining and interpreting conclusions, as well as generalizing and forming knowledge. Among them, the process of data analysis consists of six main modules: collecting data, organizing data, extracting information, constructing models, making inferences and obtaining conclusions. The benefits of data analysis literacy for students' knowledge, ability, thinking, and quality are also clarified.

### 3.2 The Cognitive Status of Data Analysis Literacy

He (2018) studied the second-year students of a high school in Jiangsu Province from three dimensions of obtaining data, processing data, and interpreting data. He found that most students' score levels in these three dimensions correspond to high, average, and low respectively. At the same time, he found that most students still have some problems interpreting the data (He, 2018). Cai (2020) divided the data analysis literacy into four dimensions, and he investigated the third-year students of a high school in Hubei Province. It was found that 46% of the students reached Level 0, 39% of the students reached Level 1, only 15% of the students reached Level 2, and no one reached Level 3 (Cai, 2020). Liu (2020) concluded through questionnaire survey and conversation survey that senior high school students have a strong ability to collect and use data, and a weak ability to sort and analyze data (Liu, 2020). By analyzing the questionnaire and test paper, Hu (2018) found that the data analysis literacy of senior high school students is generally not high, only reaching the level of multiple structures and being able to do the mechanical calculation, but they didn't realize the importance of data analysis and didn't know what content to include (Hu, 2018). In the survey of data analysis literacy of senior high school students in Qingdao, Sun (2018) found that their average level is about Level 2, that is, students can make relevant questions, but they can't apply them to real-life (Sun, 2018). Zhao (2017) interviewed 196 high school students in Henan Province. The overall level of data analysis literacy of the interviewed high school students was low, only 30.6% (Zhao, 2017). By testing the explicit data ability, Zhang (2017) found that high school students' ability to obtain, process, and interpret data is not high (Zhang, 2017).

### 3.3 The Influencing Factors of Data Analysis Literacy

Data analysis literacy plays an important role in the current mathematics learning in high school, and it is especially important to explore its influencing factors to better implement this literacy. After generalization, it was found that previous researches on the factors influencing data analysis literacy were conducted mainly from two perspectives: teachers and students.

### 3.3.1 From the Teacher's Perspective

Shen et al. (2019) analyzed and summarized that teachers' professional literacy has a significant impact on cultivating students' data awareness. To improve students' data literacy, teachers must have high data professional literacy, so the key is to improve teachers' data literacy (Shen et al., 2019). Jiang (2021) found that some teachers lack professional knowledge related to data analysis and ignore the mining and training of students' data analysis ability, resulting in students' fear of data analysis (Jiang, 2021). Wu et al. (2021) analyzed that there are problems in the development of students' data analysis literacy due to teachers' lack of understanding in probability and statistics teaching (Wu et al., 2021). Zhang, et al. (2016) found that students' performance in collecting and searching data is not satisfactory. One of the important reasons is that teachers do not pay enough attention to how to collect and find data in a problem and how to extract useful information (Zhang, et al., 2016). Zhang (2019) explored the impact of 47 teachers' behaviors on all aspects and levels of students' data analysis literacy and found that there are both positive and negative effects (Zhang, 2019).

### 3.3.2 From the Student's Perspective

#### 3.3.2.1 About Students' Non-intellectual Factors

Liu (2020) suggested that students' learning attitude will affect students' data analysis literacy. Some students think that this part of knowledge is relatively simple, or occupies fewer points in the exam, so that the learning process is not taken seriously (Liu, 2020). Wu (2019) believed that teachers should focus on stimulating students' interest in learning, and only by making students enjoy learning can they produce good learning results (Wu, 2019). Zhu, et al. (2020) investigated the factors influencing the mathematical core literacy of high school students in Hubei Province and found that the correlation coefficient between students' drive and motivation to learn mathematics and their mathematical core literacy was 0.565 (Zhu, et al., 2020). Zhou (2020) says that subjective initiative will also have an important impact, the lack of subjective initiative of students is not conducive to the learning process of exploration for knowledge (Zhou, 2020).

#### 3.3.2.2 About Students' Mindset

Guo (2020) believed that students' lack of creative thinking leads to fewer problem-solving ideas, which in turn affects core mathematical literacy (Guo, 2020). Zhang (2021) found that students' divergent thinking is important, and the lack of divergent thinking leads to rigidity in students' thinking, which is a difficulty faced in teaching mathematics in the context of core literacy (Zhang, 2021).

#### 3.3.2.3 About Students' Learning in Mathematics

Zhu, et al. (2020) surveyed 16 cities and states in Hubei Province and studied the current development level of students' core literacy in mathematics and the influencing factors through questionnaires. From the students' perspective, they proposed the following influencing factors, which are: subjective attitudes towards learning mathematics, the degree of participation in mathematical activities, mathematical anxiety, mathematical learning habits, mathematical self-efficacy, persistence in mathematical learning, and attribution of failure and achievement in mathematical

learning (Zhu, et al., 2020). With the help of the questionnaire to investigate high school students' statistical knowledge and data processing skills, Ke (2018) found that the average amount of time students spend studying mathematics each day also has an impact (Ke, 2018). Yu (2018) proposed that students' academic performance in mathematics and students' data analysis literacy level are significantly correlated through example investigation (Yu, 2018). According to Dong (2018), students' learning of mathematics outside the classroom also has a great impact, such as students reading relevant books outside the classroom, participating in competitions, and attending lectures, all of which will have an impact on students' data analysis literacy (Dong, 2018).

**3.3.2.4 About Students' Classroom Performance**

By investigating high school students' knowledge of statistical probability and teachers' teaching, Liu (2020) found that students' emotions toward math classes and their perceptions of probability and statistics courses affect the implementation of data analysis literacy (Liu, 2020). Liu (2020) analyzed the factors affecting data analysis literacy, and believed that it mainly comes from two aspects: teachers and students, among which from the students' perspective, students' classroom listening efficiency, post-class summary and the number of exercises they do are all factors that affect the implementation effect (Liu, 2020). Through interviews with secondary school students and her own teaching experience, Guo (2021) believed that students' participation in math class and practice after class affect the development of data analysis literacy (Guo, 2021). Zhai (2018) said that it is important to summarize after class, students should summarize the knowledge and ideas learned on time, so that they can internalize the data analysis literacy and better apply it to practical problems (Zhai, 2018). Wu (2019) suggested that students' sense of cooperation is an influential factor and that using good group cooperation in the classroom can improve learning efficiency, expand problem-solving ideas, and facilitate the implementation of literacy (Wu, 2019).

**3.3.2.5 About Students' Knowledge of Probability Statistics**

Hu, et al. (2021) found that there is a correlation between students' familiarity with statistical probability knowledge and their development of data analysis literacy (Hu, et al., 2021). Ke (2018) suggested that the number and seriousness of students practicing statistical knowledge-related topics and the methods and strategies students use to solve statistical knowledge affect students' data analysis literacy (Ke, 2018). He (2020) believed that students' organization of relevant questions will also affect the development of data analysis literacy work. Due to the hard knowledge points and emphasizing the strategy fluency, timely summary reflection on relevant questions is particularly important in high school (He, 2020). Zhang (2019) conducted a questionnaire survey on senior students in Xinxiang City, Henan Province, and found that students' interest in knowledge about statistics is positively correlated with data analysis literacy (Zhang, 2019). Yang (2019) suggested that the method of learning statistical probability knowledge also needs attention. Some students follow the learning method of geometry and function to learn statistical probability knowledge, which leads to the low learning efficiency (Yang, 2019).

**3.3.2.6 About Students' Data Analysis Level**

Zhang (2021) suggested that teachers should focus on developing students' sensitivity to data so that they can capture the information behind the data (Zhang, 2021). Wang (2020) suggested that it is difficult for students to discover the data embedded in practical problems, and the lack of data analysis awareness is not conducive to the cultivation of data analysis literacy (Wang, 2020). Shu, et al. (2019) believed that students are not capable of extracting data information enough and should develop the habit of reading information so that they can quickly extract the main information (Shu, et al., 2019). Liu (2020) said that due to the relatively small proportion of data analysis related topics in the college entrance examination, students believe that even if they subtract these scores and do well in other aspects, they still get high scores, which directly leads to students weakening their attention to data analysis and causes difficulties for teachers' teaching (Liu, 2020). Wang (2019) believed that students should personally experience the whole processes of data analysis after learning the theoretical knowledge, and the current students lack the application experience of statistical knowledge (Wang, 2019). He (2018) conducted a quantitative research on students' data analysis literacy through a questionnaire survey. He found that there was a significant positive correlation between data analysis literacy and whether students had statistical survey practice activities. Generally speaking, students who has participated in statistical survey practice activities also has a relatively high level of data analysis literacy, and students who have not participated in a statistical survey practice activity, their data analysis literacy level is at a medium or low level (He, 2018). Wu (2020) believed that students' experience in statistical analysis of data is also important, and accumulation of experience can enhance the ability to handle data and to express real-world problems through data (Wu, 2020). Li (2021) said that students lack the ability to reasonably question and reason based on data, which in turn affects high school students' data analysis literacy (Li, 2021). Li (2019) mentioned in the cultivation strategy of data analysis literacy that students should focus on improving their ability to read and interpret data information (Li, 2019). Liu (2020) pointed out that students lack multiple perspectives and methods to deal with data, and whether they master the data analysis methods or not will affect the data analysis literacy (Liu, 2020). According to Jiang (2021), students' model awareness and mathematical thinking in modeling can also have an impact on the data analysis process (Jiang, 2021).

**3.3.2.7 About Students' Learning Ability**

Zhou (2020) suggested that students' independent learning ability and comprehension will affect the effect of classroom lectures, and students who are active learners or accept new knowledge better will learn more easily (Zhou, 2020). Through the interview and investigation of front-line teachers, Wang (2019) found that students' computing ability is poor, which affects the implementation of data analysis literacy (Wang, 2019). Lin (2021) analyzed the current situation of data analysis training from both teachers' and students' perspectives, and he found that students' ability to grasp key information when dealing with more contextual problems was insufficient (Lin, 2021). Jiang (2021) proposed that in the classroom, teachers should cultivate students' ability to read pictures, read tables and combine numbers and shapes. For data, drawing analysis, list analysis and calculation analysis are conventional analysis methods (Jiang,

2021). Zhang (2021) said that whether students can think independently or not is also one of the influencing factors. Students are the main body of learning, and teachers should guide students to think actively through the appropriate context (Zhang, 2021). Wu (2019) believed that to better implement the core literacy in mathematics, teachers need to develop students' creativity and the ability to summarize and reflect (Wu, 2019).

### 3.4 The Cultivation Strategies of Data Analysis Literacy

Yu (2018) studied the cultivation of mathematics core literacy from the perspective of knowledge classification. He believed that to implement data analysis literacy, students need to develop their ability to read, summarize and analyze problems. Therefore, he put forward that students should strengthen reading training, improve quantitative thinking and provide exploration situations for them in the teaching process (Yu, 2018). Wu et al. (2017) proposed that teachers should first grasp the teaching objectives of statistics as a whole, and the teaching method is mainly case teaching. Secondly, teachers should teach students different data analysis methods and let students experience complete statistical investigation activities (Wu et al., 2017). Zhang, et al. (2018) proposed that to develop students' core mathematical literacy and realize the modernization, internationalization and big data of probability and statistics teaching, teachers must change their educational concepts, practice their basic teaching skills, and unremittingly carry out the reform and innovation in mathematics education and teaching (Zhang, et al., 2018). Cheng et al. (2021) proposed that in the process of problem-solving, teachers should cultivate students' data analysis literacy and teach students to look at local statistical methods from the whole of statistics; In the process of teaching, teachers should pay attention to the connection between junior and senior high school contents and make rational use of information technology (Cheng et al., 2021). Wu et al. (2021) give experience enlightenment from four dimensions: pay attention to situation setting in problem introduction, case teaching in the process of new knowledge learning, solve real-life problems in application, and pay attention to a diversified evaluation in the evaluation system (Wu et al., 2021). Ji (2020) believes that teachers should cultivate students' core literacy of data analysis through diversified paths, such as mathematics problem-solving teaching, data situational teaching, case teaching, inquiry teaching and open teaching, mathematics thought and method teaching (Ji, 2020). Qiu (2018) believes that first of all, teachers should create a good learning atmosphere for students and stimulate students' thirst for knowledge and interest in learning in teaching methods. Secondly, teachers should improve students' practical ability and strengthen their sensitivity to data (Qiu, 2018).

### 3.5 The Evaluation Methods of Data Analysis Literacy

Yu (2017) believes that the evaluation of students' mathematics core literacy should be based on three forms of knowledge learning, namely knowledge understanding, knowledge transfer and knowledge innovation. Based on this, he constructs an evaluation framework with three forms corresponding to three levels (Yu, 2017). Li (2019) analyzed the current situation of data analysis literacy. Based on the curriculum standard and PISA evaluation theory, she took the content, process, situation and emotional attitude values as the four dimensions of data analysis literacy

evaluation. Based on SOLO classification theory, she formulated the content dimension level division standard. Therefore, a data analysis literacy evaluation system for senior high school students is established. (Li, 2019).

## 4. Discussion

From the above studies, it can be seen that the previous studies on data analysis literacy mainly focus on five aspects: basic connotation, cognitive status, influencing factors, cultivation strategies and evaluation methods. Some of the studies are richer, such as the study of influencing factors and cultivation strategies that a variety of options are currently given. But, there are also aspects of this which are less involved, such as the study of evaluation methods.

Specifically, in terms of the basic connotation, researchers mostly define data analytic literacy as the ability to use data to solve real-world problems, while some others define it as the awareness formed, character shaped, or habits developed, which makes the concept of data analytic literacy ill-defined. Wu et al. (2021) pointed out that it is necessary to further clarify the connotation of data analysis literacy according to the developmental lineage of data analysis and the formulation of the new curriculum (Wu et al., 2021).

In terms of the cognitive status, researchers are basically in agreement that present high school students' data analysis literacy is not high. However, the researchers generally used questionnaires, test questions and interviews to conduct example studies on high school students, which the survey method is slightly single and the quality of the questionnaires and test questions also needs to be verified.

In terms of influencing factors, researchers have mainly explored the factors that influence students' implementation of data analysis literacy from two perspectives: teachers and students. From the perspective of inquiry, the current study is not comprehensive and systematic enough; from the perspective of inquiry methods, scholars mostly use theoretical thinking to analyze the influencing factors, which leads to a strong subjectivity of the research results. Therefore, in the future, it is necessary for scholars to increase the research perspectives and innovate research methods to conduct a comprehensive and objective analysis of the factors influencing high school students' data analysis literacy.

In terms of cultivation strategies, the researchers mainly put forward their views based on their own teaching experiences and previous teaching suggestions, including "how to implement them in school" and "how to implement them in the classroom". However, the feedback on whether the development strategies are comprehensive or reasonable needs to be obtained through actual teaching. Therefore, in future research, scholars should study the feasibility and effectiveness of the cultivation strategies and find more targeted teaching suggestions.

In terms of evaluation methods, there are relatively few relevant studies by scholars, and the evaluation methods they propose are based on different perspectives. Therefore, scholars must strengthen their researches on this aspect in the future and find out a scientific and reasonable evaluation system.

## 5. Conclusion

The following conclusions are drawn from the summary and analysis of previous

studies: 1. Previous studies on data analysis literacy of high school students have focused on five main aspects: basic connotation, cognitive status, influencing factors, cultivation strategies and evaluation methods; 2. Among them, cognitive status and cultivation strategies are the hot issues; 3. In terms of research methods, scholars mostly use pencil-and-paper tests, questionnaires or interviews to investigate cognitive status, and analyze the influencing factors and cultivation strategies just with theoretical thinking; 4. In previous studies, there are shortcomings of single research method and lack of empirical practice, while the previous researches on influencing factors are not systematic or comprehensive. The research conclusions on cultivation strategies lack feasibility or validity, and the researches on evaluation methods are relatively scarce.

Therefore, it is necessary for scholars to further improve the research methods on the influencing factors and cultivation strategies in future studies, and to conduct more in-depth and systematic researches on the influencing factors of data analysis literacy from an empirical perspective, in order to find out more comprehensive influencing factors and more operable cultivation strategies.



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