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"Student-Centered" Teaching Design and Practical Effect Analysis of Big Data Computing and Storage Course

Meiling Wang, Hongmei Ju, Congcong Shen, Fenghua Qi, Jing Wang

School of Statistics and Data Science, Beijing Wuzi University, Beijing, China

ABSTRACT

Based on the requirements of big data computing and storage courses in terms of students' knowledge, abilities, and qualities, this paper proposes a "student-centered" approach to course objectives and teaching design. By designing and developing instructional content that is enlightening, interactive, and practical, this paper focuses on the integration of project-based learning and flipped classrooms, combining theory with practice. At the same time, it emphasizes cultivating students' problem-solving abilities, innovative spirits, and team collaboration skills. Finally, this paper demonstrates the teaching effect through the use of multi-dimensional evaluation indicators and survey questionnaires, and proposes suggestions for the continuous improvement.

KEYWORDS: *student-centered; teaching design; big data; data storage; data computing*

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1. INTRODUCTION

The knowledge system of big data computing and storage courses is complex and challenging, and as an emerging field, the content and design of the curriculum require constant updating and enrichment. As a course that combines theory and practice, how to better cultivate students' practical abilities is also a crucial issue that needs to be addressed. The "student-centered" teaching philosophy has become the mainstream development concept in higher education in recent years, emphasizing a new perspective and model of education that is "student-centered, outcome-oriented, and based on the continuous improvement" [1-2]. Compared with traditional teaching methods, the "student-centered" teaching philosophy emphasizes the initiative of students in learning. In recent years, many courses have implemented "student-centered" teaching reforms and achieved good results [5-6].

This paper aims at reforming traditional teaching methods and propose a "student-centered" teaching design approach for big data computing and storage courses. It designs and develops inspirational, interactive, and practical course content, relying on project-based learning and flipped classrooms. It aims at creating a "student-centered" teaching model for big data computing and storage courses that cultivates students with innovative thinking and practical abilities. By establishing a comprehensive evaluation system that comprehensively considers students' knowledge level, practical abilities, and innovative potential, it further improves the quality of professional talent cultivation in Data Science and Big Data Technology Program.

2. "Student-Centered" Teaching Objectives for Big Data Computing and Storage Course

Based on the "student-centered" teaching philosophy and the comprehensive training requirements for students' knowledge, abilities, and qualities under the new engineering background, we have re-examined the teaching objectives for the big data computing and storage course. Oriented by the certification of big data engineering technology and aligned with professional ideological and political education, this course aims at supporting the knowledge, abilities, and qualities required for graduation. Through the course, students will systematically grasp the basic concepts of big data, the principles of big data storage and computing, and build a knowledge system for big data technology. They will understand and master the theoretical foundations and engineering practices of big data system architectures such as Hadoop, the distributed file system HDFS, the distributed database HBase, the distributed data warehouse Hive, the cluster scheduling framework YARN, the distributed parallel programming model MapReduce, the in-memory big data processing framework Spark, and the real-time processing framework Flink. This lays a foundation for students' future study and work in the field of big data. The specific knowledge, ability, and quality objectives are as follows.

Knowledge Objectives: Through the course, students will systematically grasp the basic concepts of big data, the principles of big data storage and computing, and build a knowledge system for big data technology. They will have a comprehensive understanding of the development history of big data, related knowledge, technical systems, characteristics, and applications of distributed storage and computing. In addition, students need to understand and master the theoretical foundations and engineering practices of big data processing architectures such as Hadoop, the distributed file system HDFS, the distributed database HBase, the distributed data warehouse Hive, the cluster scheduling framework YARN, the distributed parallel programming model MapReduce, the in-memory big data processing framework Spark, and the real-time processing framework Flink.

Ability Objectives: Through the course, students should be proficient in using big data architectures such as Hadoop, HDFS, HBase, Hive, MapReduce, Spark, and Flink for big data storage and processing. They should possess practical abilities in distributed data storage and computing platform setup, basic application development, and operation and maintenance. Students need to be proficient in setting up Hadoop cluster environments, using HDFS Shell commands and HDFS JAVA API for development. Furthermore, they should master the basic operations of HBase distributed databases and Hive distributed data warehouses, understand the basic programming concepts of distributed computing frameworks such as MapReduce, Spark, and Flink, and be able to utilize these frameworks to complete programming practices for engineering cases such as WordCount, deduplication, and secondary data sorting.

Quality Objectives: This course aims at cultivating students' engineering practice abilities and their ability to analyze and solve problems using big data thinking. The course also strives to cultivate students' innovative consciousness, information technology research, and proactive learning abilities, enhancing their hands-on skills and team collaboration abilities. Through course teaching and practice, students will further enhance their professional qualities and become high-quality big data application talents who can adapt to social development. Additionally, in the course teaching and practice process, students will be cultivated with a new era spirit of reform, innovation, and technological innovation, enhancing their professional ethics, qualities, and service awareness. Students will possess dialectical thinking and a down-to-earth craftsmanship spirit, enabling them to adapt to job requirements as early as possible.

3. "Student-Centered" Big Data Computing and Storage Course Design

In order to enhance students' learning motivation and interest, cultivate their practical abilities, comprehensive application abilities, and team collaboration abilities, this paper proposes a "student-centered" teaching design plan for big data computing and storage courses based on project-based learning and flipped classrooms. Through project-based learning, students are encouraged to solve practical problems, fostering innovative thinking and creativity. Through challenges and exploration, students develop unique solutions and innovative ideas. Students work together in groups to complete project tasks, and this cooperation and teamwork exercises their team collaboration and communication skills, making them excellent team members and leaders. In the flipped classroom, students give speeches on the knowledge they have understood to other classmates. In this process, students develop and exercise their self-study ability, organizational ability, collaboration ability, expression ability, writing ability, and innovation ability through various links such as team collaboration, information retrieval, courseware production, flipped classroom lectures, discussion organization, and innovative design report writing. By sorting out the content of the big data computing and storage course, the following project-based teaching content and flipped classroom teaching content is designed.

Table 1. Project-Based Instructional Design

No.	Project Name	Knowledge Cultivation	Ability Cultivation	Quality Cultivation
1	Hadoop Environment Setup	Hadoop Installation & Configuration, Pseudo-Distributed Environment Setup, Cluster Environment Setup, Big Data Software Fundamentals	Programming Skills, Autonomous Learning Ability, Technology Application Skills, Problem-solving Skills	Big Data Thinking, Innovation Consciousness, Dialectical Thinking, Down-to-earth Craftsmanship
2	HDFS Shell Programming	HDFS Shell User Commands, HDFS Shell Management Commands	Programming Skills, Problem-solving Skills	Big Data Thinking, Dialectical Thinking, Down-to-earth Craftsmanship
3	HDFS JAVA Development	Using HDFS API to achieve upload, download, create, delete, modify, view file and file status operations	Programming Skills, Autonomous Learning Ability, Technology Application Skills, Problem-solving Skills	Big Data Thinking, Innovation Consciousness, Dialectical Thinking, Down-to-earth Craftsmanship
4	HBase Shell Basic Operations	HBase Installation & Configuration, HBase Shell Startup & Shutdown, HBase Shell General Commands, HBase Shell Table Management Commands, HBase Shell Table Operation Commands	Programming Skills, Autonomous Learning Ability, Technology Application Skills, Problem-solving Skills	Big Data Thinking, Dialectical Thinking, Down-to-earth Craftsmanship
5	MapReduce Principles & Applications	MapReduce Programming Model, Implementing WordCount, De-duplication Sorting, Average Grade Calculation, Annual Highest Temperature Calculation, Secondary Sorting	Programming Skills, Autonomous Learning Ability, Technology Application Skills, Problem-solving Skills	Big Data Thinking, Innovation Consciousness, Dialectical Thinking, Down-to-earth Craftsmanship
6	Hive Installation & Basic Operations	Hive Installation & Configuration, Hive Data Types, Hive Basic Operations, Hive Tables & Advanced Queries	Programming Skills, Autonomous Learning Ability, Technology Application Skills, Problem-solving Skills	Big Data Thinking, Dialectical Thinking, Down-to-earth Craftsmanship
7	Spark Installation, Configuration & Programming	Spark Installation & Configuration, RDD Transformations & Actions, Spark Shell Programming, Spark IDE Setup, WordCount Comprehensive Case, Spark Application Development	Programming Skills, Autonomous Learning Ability, Technology Application Skills, Problem-solving Skills	Big Data Thinking, Innovation Consciousness, Dialectical Thinking, Down-to-earth Craftsmanship
8	Flink Installation, Configuration & Programming	Flink Installation & Configuration, Flink Local Environment Setup & Operation, Implementing WordCount with Flink, Flume + Kafka + Flink Integrated Experiment	Programming Skills, Autonomous Learning Ability, Technology Application Skills, Problem-solving Skills	Big Data Thinking, Innovation Consciousness, Dialectical Thinking, Down-to-earth Craftsmanship

Table 2. Flipped Classroom Instructional Design

No.	Chapter	Teaching Content	Flipped Classroom Design
1	Overview of Big Data	Eastern Data to Western Computing, Data Centers, Definition and Characteristics of Big Data, Big Data Computing Models, Big Data Applications	Teachers provide learning materials, students self-study, group discussion, create presentations, classroom lectures, and teacher summaries.
2	Hadoop Distributed File System (HDFS)	HDFS Architecture, Storage Principles, Key Technologies (Master-Standby Switchover, Triple Replication), Read/Write Operations	Students self-study through group discussion, retrieve materials, create presentations, classroom lectures, collaborative discussion, and form reports. Teachers answer questions, summarize, and evaluate.
3	NoSQL Databases	Comparison between NoSQL and Relational Databases, Three Pillars of NoSQL Theory, Four Types of NoSQL Databases	Teachers provide learning materials, students self-study, group discussion, create presentations, classroom lectures, and form reports. Teachers answer questions, summarize, and evaluate.
4	HBase Distributed Database	HBase Data Model, HBase Architecture, HBase Internal Principles, HBase's Connection with Hadoop Ecosystem	Teachers provide learning materials, students self-study through group discussion, retrieve materials, create presentations, classroom lectures, and form reports. Teachers answer questions, summarize, and evaluate.
5	Batch Processing Framework MapReduce	MapReduce Computing Model, Mapper and Reducer Processes, Shuffle Principles and Applications, MapReduce Operating Mechanism, MapReduce Design Philosophy (Divide and Conquer, Data Locality, Space for Time)	Students self-study through group discussion, retrieve materials, create presentations, classroom lectures, collaborative discussion, and form reports. Teachers answer questions, summarize, and evaluate.
6	Hadoop 2.x Cluster Scheduling Framework YARN	MapReduce 1.0 Architecture, YARN Design Philosophy, YARN Architecture Design and Workflow, Comparative Analysis of MapReduce 1.0 and YARN (Differences and Relationships between Slot and Container)	Teachers provide learning materials, students self-study through group discussion, retrieve materials, create presentations, classroom lectures, and form reports. Teachers answer questions, summarize, and evaluate.
7	Distributed Data Warehouse Hive	Hive System Architecture, Hive Working Principles, Differences and Relationships between Hive, HDFS, and HBase	Teachers provide learning materials, students self-study through group discussion, retrieve materials, create presentations, classroom lectures, and form reports. Teachers answer questions, summarize, and evaluate.
8	Distributed Memory Processing Framework Spark	Spark Ecosystem, Spark System Architecture, RDD Concepts and Operations, Spark Principles	Students self-study through group discussion, retrieve materials, create presentations, classroom lectures, collaborative discussion, and form reports. Teachers answer questions, summarize, and evaluate.
9	Real-time Processing Framework Flink	Stream Data, Stream Processing, Flink Application Scenarios, Flink Architecture, Comparative Analysis of Storm, Spark Streaming, and Flink	Teachers provide learning materials, students self-study through group discussion, retrieve materials, create presentations, classroom lectures, and form reports. Teachers answer questions, summarize, and evaluate.

4. Analysis of the Practical Effects of a "Student-Centered" Big Data Computing and Storage Course

The author implemented the project-based and flipped classroom teaching methods outlined in Table 1 and Table 2 in the fall semester of the 2023-2024 academic year, and designed a questionnaire to evaluate the teaching effectificy from the perspective of students. The specific content and results of the questionnaire are summarized in the following table.

Table 3: Questionnaire Content and Survey Results

No.	Questionnaire Content	Very Agree	Agree	Neutral	Disagree	Strongly Disagree
1	I have a strong interest and curiosity in the "Big Data Computing and Storage" course, and invest time and effort in it.	54.29%	31.43%	11.43%	2.86%	0.00%
2	I can actively learn before, during, and after class for the "Big Data Computing and Storage" course.	48.57%	24.29%	25.71%	1.43%	0.00%
3	I can identify my learning needs and development aspirations for the "Big Data Computing and Storage" course and communicate them to the teacher.	48.57%	27.14%	24.29%	0.00%	0.00%
4	I can adapt well to the pace of classroom teaching.	54.29%	35.71%	7.14%	2.86%	0.00%
5	I can identify and solve key and difficult points in learning.	48.57%	37.14%	11.43%	2.86%	0.00%
6	I actively share my opinions and ideas with teachers and classmates.	44.29%	27.14%	24.29%	4.29%	0.00%
7	After learning, I can master the knowledge, skills, and learning methods required by the course.	48.57%	32.86%	17.14%	1.43%	0.00%
8	After learning, I can apply the knowledge and skills learned to solve practical problems in new situations.	45.71%	28.57%	21.43%	1.43%	2.86%
9	I believe that the knowledge and skills learned are helpful to my life and future career development.	52.86%	31.43%	11.43%	2.86%	1.43%
10	I am more interested in this course and related fields, and am confident about future learning.	51.43%	28.57%	12.86%	4.29%	2.86%
11	Teacher has provided me with rich learning resources and learning method guidance.	71.43%	24.29%	4.29%	0.00%	0.00%
12	When I encounter learning difficulties, the teacher can provide me with timely help.	71.43%	22.86%	5.71%	0.00%	0.00%
13	Teacher's content is challenging and motivating.	70.00%	25.71%	4.29%	0.00%	0.00%
14	Teacher's teaching style is easy to understand and attractive.	74.29%	22.86%	2.86%	0.00%	0.00%
15	I think the teacher is proficient in teaching and has a high level of teaching.	74.29%	20.00%	5.71%	0.00%	0.00%
16	In class, I feel a good and harmonious teacher-student relationship.	80.00%	18.57%	1.43%	0.00%	0.00%
17	The examination and evaluation of the course can reflect my actual learning situation.	71.43%	24.29%	4.29%	0.00%	0.00%
18	Overall, what I have learned in class is conducive to my growth and development, and the whole learning process is meaningful and rewarding.	75.71%	21.43%	2.86%	0.00%	0.00%

Based on the questionnaire survey results in Table 3, the following conclusions can be drawn: Over 95% of students have shown strong interest and curiosity in the "Big Data Computing and Storage" course, and they are willing to invest time and effort in learning. Whether before, during, or after class, students can actively engage in learning. They can well adapt to the pace of classroom teaching and identify and solve key and difficult points in learning. In addition, students are also willing to share their opinions and ideas with teachers and classmates. After learning, they can master the knowledge, skills, and learning methods required by the course, and apply the knowledge and skills learned to solve practical problems.

Students generally believe that the knowledge and skills learned are helpful for their lives and future career development, and they are more interested in the course and related fields, with confidence in future learning. All students can clearly recognize their learning needs and development aspirations and express these needs to the teacher. They believe that teachers have provided rich learning resources and learning method guidance, and that the content taught by teachers is challenging and motivating, with an easy-to-understand and attractive teaching style. Teachers also have a high level of teaching, and the examination and evaluation of the course can accurately reflect the actual learning situation of students. In class, students feel a good and harmonious teacher-student relationship, and receive timely help when they encounter learning difficulties. All students believe that the course is meaningful and rewarding for their growth and development.

Overall, students have a very positive evaluation of the "Big Data Computing and Storage" course, showing a high level of learning motivation and satisfaction. However, there are a few students who lack interest in learning and have low learning initiative. Based on the results of the questionnaire survey, teachers should conduct in-depth interviews with key students to understand the problems they encounter during the learning process. Combining the results of the questionnaire survey and issues encountered in class, teachers should continuously adjust the teaching plan during the teaching process and continue to improve in the subsequent teaching process. First, provide students with more teaching materials, including videos, electronic documents, cases, blogs, etc., and place them on the Chaoxing teaching platform in advance for students to consult and learn at any time. Second, during the flipped classroom teaching process, provide sufficient PPT production tutorials and template materials, more design report templates and writing requirements, as well as common issues and solutions to help students solve problems in PPT production and report writing. Finally, in the project-based teaching link, especially in the computer experiment link, conduct more detailed teaching design, grasp the pace, help students overcome fear of difficulties, and make learning more relaxed and enjoyable.

5. Conclusion

Through the construction of a "student-centered" big data computing and storage course, we have designed a teaching mode combining project-based learning and flipped classrooms, integrating theory with practice. Students have improved their comprehensive qualities such as problem-solving ability, innovative spirit, and team collaboration ability through various practical activities such as independent learning, mutual assistance, discussion, and exchange. After analyzing the results of the questionnaire survey on students, we found that the "student-centered" big data computing and storage course has achieved very good practical effects. Students have given very positive evaluations of the course, demonstrating a high level of learning motivation and satisfaction. All students believe that the course is meaningful and rewarding for their growth and development. In the future teaching process, we will continue to improve teaching methods, optimize teaching plans, and further enhance teaching organization and guidance capabilities to continuously enhance students' learning interest and effectiveness.

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Corresponding author: Meiling Wang (1991-), born in Heilongjiang Province, Ph. D., Associate Professor at the School of Statistics and Data Science, Beijing WUZI University.

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