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The Relationship Between College Students' Epistemological Self-Reflection And Concept Learning

-- Taking College Physics Teaching as An Example

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Abstract

Our results suggest that students' epistemology matters when learning physical concepts. In addition to developing student epistemology to enhance students' conceptual learning, they also promote metacognitive self-reflection skills. We are able to enhance students' content learning by encouraging appropriate epistemology.

Keywords

Epistemology; Concept learning; College physics.

1. Introduction

For 100 years, the Communist Party of China has always regarded higher education as an important revolutionary cause and strategic task, cultivating talents and building the country through education and running schools. Epistemology is a methodological theory about the connotation, essence, process, method and law of human cognition, which guides people to carry out thinking and cognitive activities, transform knowledge into ideological theories, and then into policies to promote social development [1]. The level of epistemology is the concentrated embodiment of ideological depth, action strength and development degree. The profound and lofty understanding and the success and leap of understanding reflect the scientific cognitive method behind it. On the basis of summarizing the practical experience of Chinese revolution, construction and reform, general secretary Xi Jinping inherited and developed Marxist philosophy, and systematically expounded the ontology, epistemology and methodology that run through Xi Jinping thought on socialism with Chinese characteristics for a new era. The thought of characteristic socialism laid the philosophical foundation [2].

Epistemology plays an important role in helping students construct knowledge systems, and epistemological research on student learning has received extensive attention [3-4]. For student learning, "epistemology" can be understood as their beliefs or views on how knowledge is constructed and evaluated. In introductory courses, interactive courses based on research in college physics education are on the rise, as is the use of instructional technology, but little has been done to measure the relationship between students' epistemological beliefs and problem-solving abilities. Students should develop skills of self-reflection, as these skills can take students' understanding of concepts to new levels. Students reflect on how they learn specific physics content to understand the quality of reflection. By studying these relationships, we hope to begin to understand the types of reflections that are most effective for the learning of physics concepts and explore their implications for teaching.

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We first discuss the theoretical basis of this study. Then, the assumptions and characteristics of the survey report and interview are described, including our sample selection method and coding scheme used to analyze the weekly report [5]. We present qualitative and quantitative research methods and discuss the implications of the results for teaching. Ultimately, we found that students with better conceptual understanding had better self-reflection skills than students with poor conceptual understanding.

2. The Theoretical Basis of Epistemology for Physics Education Research

The main point is that the intuition of the mechanism involves many simple elements whose origins are relatively unproblematic, minimal abstractions of common events. The system as a whole is weakly organized and suffers from a number of constraints, including the relative lack of depth in the argumentation structure and the inability to resolve conflicts based on knowledge within the system. Despite its weak organization, the system exhibits some broad features, some of which have been identified. They include causal schemas ("causal syntax") that stand out in terms of agents, patients, and interventions; a tendency to focus on static features of dynamic events, including global forms of trajectories; and a relatively rich phenomenology of equilibrium. Mechanical intuition is a great help in understanding school physics. This development requires a denser organization of knowledge, with increased depth and breadth to allow more confident application of fewer elements of fundamental explanation.

Elements, development, and systemicity compose a comprehensive explanation of a single empirical basis. The Elements includes a relatively long list of mechanistic element descriptions, including a description of the context in which they are used. The development includes some case studies on the development of some concepts in Newtonian mechanics. The systematicity organizes the interpretations made to that point into arguments against hypotheses that compete with those developed here about the level and kind of systematicity one finds in the sense of mechanism.

According to this theory, the application to physical understanding and physical learning should be based on knowledge. It assumes only a few very simple cognitive mechanisms, although the resulting knowledge system is presumed to be large and complex. Methodologically, I think it is important to immediately examine a series of questions that are closely related to the theory-building of any knowledge system: (1) Elements: Describe the size and characteristics of the knowledge structure involved. Related but imprecise categories are ideas, categories, concepts, models, and theories. (2) Cognitive mechanism: Provide an image of the operation of an intuitive knowledge system. First, the point is to have some reason to explain problem solving and reasoning using intuitive knowledge. Beyond that, we hope to eventually have a computationally explicit model showing how development emerges from usage. (3) Development: Understand the origin and development of the system. We want to understand how elements and system properties change. In turn, these changing patterns should explain teaching difficulties, such as the persistence of alternate concepts, and should suggest teaching opportunities to facilitate development. (4) Systematic: Describe the degree and type of association of elements in the system. This includes decomposing descriptions into subsystems that are relatively integrated within themselves and relatively dependent on other subsystems.

3. Design of the Study

3.1. Procedure and Course Description

The subject of this study is college physics, and the students are mainly in the classes taught by teachers, with about 200 students in the lower grades. An attempt can be made to collect

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student reports, once a week for a semester, to prepare material for studying students' epistemological beliefs about different areas of physical knowledge. These reports contain specific questions in which students answer specific questions to reflect on what they learned during the week and how they learned it. By analysing students' reflections on their own learning in weekly reports, measured using measures of conceptual understanding and problem-solving abilities, we hope to answer three questions about epistemological beliefs and self-reflection: (1) What do students like to describe when they reflect on their learning? (Can be called "epistemological preference") (2) The relationship between the quantity and quality of reflection and the effect of concept learning? (3) What is the relationship between epistemological preference and conceptual learning effect? By examining these relationships, we hope to understand the types of reflection that are most effective for the learning of physics concepts, and to explore the impact of types of reflection on teaching.

To construct physical concepts and laws, students first observe physical phenomena carefully selected by the lecturer and presented in class, then provide qualitative explanations for their observations and test them by predicting the outcomes of new experiments. They then list mathematical publications and design experiments to test and discover the limitations of these explanations, and finally apply concepts and skills to solve experimental problems. In this way, the curriculum structure emphasizes the scientific process and the demonstration of scientific knowledge. From an epistemological perspective, the goal of this design is to help students construct knowledge along the paths that scientists might take, thereby helping them replace their naive epistemology with the epistemology of physics. Each week, students reflect on what and how they learned by writing a weekly report. Students are asked to answer four open-ended questions:

(1) What did you learn in the lab this week? How did you learn it?

(2) What did you learn from the lectures and recitations this week? How did you learn it?

(3) What other issues are still unclear?

(4) If you were a professor, what questions would you ask to determine if your students understood the material?

Students respond online; responses are usually one page long, but may be longer. Each week, half of the reports from each course section are randomly selected for grading and feedback. Comments on questions encourage students to accurately, clearly, and completely describe what and how they learn, and prompt them to refer to classroom observations, experiments, and reasoning designed to help them learn about physics. Weekly reports account for 10% of final grades; as students were told, each report was penalized for lack of clarity or thoroughness, but not for content.

E. Coding scheme for weekly reports

After reading several student reports, it became clear that they described learning in several different ways. Using our knowledge of the epistemological dimensions identified by others and our understanding of the epistemological goals of the course, we were able to create a coding scheme for identifying and categorizing students' thoughts.

3.2. What They Said They Learned

Students usually list what they have learned during the week, making them relatively easy to identify. We consider each mention of something learned to be evidence that the student felt it was important enough, if not really important, to mention it in the report. We use four codes in this class.

(1) Formula: equations or other mathematical statements, or what they think the formula is important to mean, without elaborating on its underlying meaning.

(2) Vocabulary: definitions or other physical language conventions.

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(3) Concepts: qualitatively describe or refer to concepts, ideas, relationships or their limitations.

(4) Skills: lab design skills, measurement skills, or problem-solving methods and skills, or imply that they think skills are important.

3.3. They Say How They Learned

There are many ways students describe how they learn. When reading reports, we look for signs of events that lead students to believe that something is true. As expected, we found references to direct transfer of information from authorities (teachers or textbooks), as well as more independent reasoning processes for acquiring knowledge. Many students also describe practice and simple observation as learning styles. Some also mentioned or implied the role of prediction and testing in building understanding, an explicit focus of this course. We ended up defining eight codes that describe how students say signs of their learning.

(5) Observed phenomena: physical phenomena, demonstrations, or experiments observed that do not mention what was learned in the process.

(6) Building concepts through observation: learning concepts through observation of phenomena, demonstrations, or experiments (confusing reasoning with observation).

(7) Reasoning/derivation in the lecture: follows an inference process where the large class arrives at a concept or formula by using prior knowledge and experience, experimental data, logic, mathematics and/or analogy.

(8) Reasoning/Derivation in the laboratory: the active reasoning of a concept or formula by a person or group using prior knowledge and experience, experimental data, logic, mathematics, and/or analogy.

(9) Learning by doing: learning a concept, definition, or formula by using it, or learning a skill or process by performing or practicing it.

(10) Authority: informed or persuaded by instructor, friend, textbook, or other authority figure.

(11) Predict/test: predict the outcome of an experiment and then conduct or observe the experiment.

(12) Predict/test/explain: conduct or observe an experiment to test an idea and interpret the results of the test.

Many statements by students about the inference of their views imply certain beliefs about the nature of physical knowledge. Some students mentioned the usefulness of physics knowledge in solving real-world problems, and some expressed hope that physics knowledge should be coherently "meaningful" or "joined together". These instructions lead to two other codes.

(13) Applicability of knowledge expresses belief that physical laws or concepts can and should be applied to solve new problems.

(14) The concern with coherence expresses the belief that physical laws and concepts can be combined into a coherent whole, or at least should be consistent with each other and consistent with common sense.

3.4. Inter-rater reliability

After developing the encoding scheme described above, we conducted a reliability check. The two of us independently wrote reports for four different students in the first quarter. In each instance (sentence or group of sentences) in the report, we agreed on which codes were indicated, although not always the exact number indicated by each code. On this number, we agree 90% of the time.

3.5. Favorable and Unfavorable Codes

Because the curriculum emphasizes specific learning styles, some code instructions are considered more appropriate than others. In this study, we identify epistemically favorable

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codes as those that indicate students' reflection on constructing their own knowledge: reasoning using observational data or prior knowledge, experimental testing of ideas, and a focus on coherence. We call these epistemologically unfavorable codes that indicate that students report observations without reference to making inferences, rely excessively on authority as a source of knowledge, or describe test experiments without reasoning or interpretation. As mentioned earlier, this course emphasizes a learning style characterized by favorable codes and is therefore considered an appropriate subject for reflection. Unfavorable codes represent learning styles that run counter to the objectives of the course. While it is sometimes appropriate to learn something through authority, this is rarely the case in this course.

4. Results and Discussions

The results of our analysis of weekly reports using our coding scheme show that, in fact, different students respond differently to knowledge structures in the same instructional setting. For example, even though the curriculum is structured in an epistemologically favorable manner, students do not acquire new concepts from an authority, yet some of them still believe that they learn from an authority.

Based on the improvement of students' conceptual knowledge, we selected a sample for research. All 12 students in the study started studying mechanics and electromagnetism in college with lower pre-test scores compared to their classmates. Each quarter, six students had lower post-test scores and six had higher post-test scores. This separation suggests that the first group of students was less successful in the coursework. We found that different students from two sample groups (low earners and high earners) showed preferences for different learning styles.

(1) What students prefer to describe when reflecting on their learning, i.e. what are their “epistemological preferences”.

By analyzing students' responses to the question "How did you learn?" we found that students focused almost exclusively on experimental evidence, logical reasoning, practice, and authority. They also pointed to common sense, applicability of knowledge and its coherence as factors affecting their learning. This focus allowed us to develop 14 codes to describe three aspects of student reflection (what they learned, how they learned it, and inferences about beliefs). This encoding scheme represents our findings. The fact that students' reflections on knowledge construction can be coded with limited codes suggests a general consistency between different students and different physical content. This finding suggests that the same coding scheme can be used to analyze student interviews and classroom interactions to compare the results of different studies.

(2) How does the amount of reflection they exhibit relate to their conceptual learning gains?

Our results suggest a correlation between students' conceptual acquisition and their ability to reflect on learning. Most of us low earners don't write much about how they learn compared to high earners. At the same time, we found exceptions to this rule: in our small sample, one low earner reflected on his own learning in great detail, while two high earners did not write much. Nonetheless, these high gainers were able to reflect on the construction of knowledge by following the reasoning process in the classroom or by making the knowledge relevant to their personal experience. They also try to understand the material by asking deep questions. These exceptions may mean that it may not be the quantity of reflections that matters, but the quality of reflections, and that students' questions may provide valuable insights into their epistemological preferences.

(3) How do their epistemological preferences relate to their conceptual learning gains?

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Analysis of specific codes suggests that there may be a correlation between conceptual gain and epistemological perspectives. Low-concept acquirers are more likely than others to refer to epistemologically less desirable learning activities: learning formulas without paying attention to their conceptual implications, learning from authority, and predicting and testing without explanation. However, high gainers referred more frequently to reasoning and interpretation of experimental results and were more concerned with knowledge coherence than their counterparts.

More extensive research is needed to verify these temporal relationships. However, the possibility of this connection means that "good" students have knowledge that is epistemologically and conceptually appropriate, and that they are better at reflecting on what and how they learn.

Our results suggest that students' epistemology matters when learning physical concepts. This is just the beginning of our investigation into this link, but this study of 12 students over 20 weeks of college physics teaching suggests that we may be able to improve students' content learning by encouraging appropriate epistemology. If in fact this is the case, then this has big implications for teaching. While the effects of the methods listed below have not been carefully measured, we have used them in this course and recognize that they may help develop complex epistemological thinking: students can be encouraged to regularly reflect on how they build content knowledge and acquire skills. While weekly reporting is a time-consuming approach, the same goal can be achieved by asking similar questions in homework or lab reports. The latter approach also encourages students to see reflection as an integral part of doing science. Another way to encourage content-based thinking might be to ask content questions that require justification of knowledge, such as "How do you convince a friend that two objects always interact with forces of equal magnitude?" We can also design questions that indirectly encourage students to think about how they know what they know by asking them to make a decision, for example, "You have a motorized toy car". How do you know if it is moving at constant velocity, constant acceleration or varying acceleration?

These are examples of open-ended problems that do not have a single solution. In addition to developing student epistemology to enhance students' conceptual learning, they also promote metacognitive (self-reflection and monitoring) skills. Students cannot develop these higher-order thinking skills if they solve problems with only known answers. More research is needed to link these three aspects of learning: content acquisition, epistemology, and self-reflection. Do we want to develop epistemology and self-reflection to enhance content learning, or should we view content learning as a tool for developing students' epistemological and higher-order thinking skills? The demand for investigative and problem-solving skills in the current workplace shows that second choices are also very important for college graduates.

5. Conclusion

Our results suggest that students' epistemology matters when learning physical concepts. In addition to developing student epistemology to enhance students' conceptual learning, they also promote metacognitive self-reflection skills. We are able to enhance students' content learning by encouraging appropriate epistemology.

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