

A Systematic Analysis of the Causes of Physics Learning Difficulties among Chinese Secondary School Students

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Abstract. Current international research on learning difficulties in science has been more comprehensive, with researchers analysing classroom teaching, subject characteristics and individual student factors. Within China, physics in science is taught as a separate subject in junior and senior secondary schools, which is often found difficult for students to master. Researchers in China have examined the causes of physics learning difficulties in a variety of ways, each from a different perspective, but these studies tend to dig deeper from a single perspective and lack a systematic generalisation of the causes of students' learning difficulties in physics. This paper uses a literature analysis approach based on ecosystem theory and systematically summarises the influential studies on the factors affecting physics learning difficulties in China. The study classifies the factors affecting physics learning difficulties into internal factors and external factors in the hope of helping teachers with diagnosing physics learning difficulties among secondary school students. This paper finds that learning difficulties in physics for secondary school students exist at the individual, school, home, subject and socio-cultural levels and that teachers have limited influence. Teachers need to enhance their ability to diagnose physics learning difficulties and improve their subject-teaching ability. It also proved that home-school cooperation needs to be enhanced.

Keywords: Learning difficulties; secondary physics; and science learning.

1. Introduction

According to Piaget's theory of cognitive development, junior high school students are in the developmental stage of formal arithmetic. As an important scientific subject, physics plays an important role in implementing the goals of quality education, cultivating scientific literacy and improving the thinking of junior high school students. At present, more and more students have difficulties in learning physics in junior secondary school and find it "difficult to learn physics". In the long run, this not only poses a great challenge to frontline teachers and affects the teaching of junior secondary physics but also hinders the improvement of science literacy of secondary school students.

In a previous study, Hu Yan summarized the psychological factors that have been revealed in existing studies to cause difficulties in physics learning through literature analysis and found that motivation, self-concept, metacognitive skills and affective factors all have an impact on physics learning [1]. The abstract nature of the subject, the non-routine nature of research problems, the amount of effort required by students to understand concepts scientifically and the difficulty of the process of constructing physical knowledge were identified as subject-specific reasons why science is a difficult subject [2]. Gong Yanxia summarised the reasons for the difficulties in learning physics for secondary school students, arguing that in addition to cognitive factors, teachers' pedagogical factors also have a significant impact and provided suggestions from a practical perspective [3]. In summary, existing review studies have generally looked at the causes from the perspective of the physics discipline or from the individual, but fewer studies have systematically summarised the factors that lead to learning difficulties in physics based on an analytical model. In this paper, the causes of physics learning difficulties are analysed from the inside out based on the ecosystem theory, including personal, school, family and subject factors.

The causes of physics learning difficulties in junior secondary school students are multifaceted and systemic, determined by the family, school, socio-cultural background and the individual student's physiological and psychological conditions. Among them, there may be this complex

mechanism of interaction, which requires us to find out the root cause of learning difficulties from the results in order to provide targeted solutions to guide frontline teachers and thus improve the quality of teaching and learning in small-scale urban schools.

2. Concept definition

2.1 Learning difficulties

There is still no universally agreed definition of a learning disability due to different research perspectives. The definitions that have been accepted and used by a large number of researchers can be divided into two categories: the physical disability and the intellectual-academic achievement gap. Research in China has added observations and considerations of learning processes and learning states to these two categories. As the purpose of this paper is to help teachers diagnose the causes of physics learning difficulties among the average students in their class, physiological factors do not vary much in the target context of this paper, so the academic achievement gap theory is used in this paper.

2.1.1. The physiological theory

The physiological disorder theory focuses on the idea that learning difficulties are caused by inherent physiological, primarily neurological, dysfunctions within the individual, resulting in difficulties in the acquisition and use of a wide range of basic learning skills. The United States Office of Education (USOE, 1997) National Joint Commission on Learning Disabilities (NJCLD, 1981), the Learning Disabilities Association of America (LDA, 1986) and the Interdepartmental Committee on Learning Disabilities (ICLD, 1987) have all defined physiological learning difficulties as difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning and mathematical skills [4]. People with learning difficulties may be accompanied by psychological aspects such as socio-emotional state and self-regulation and be influenced by an adverse environment, but these acquired problems are not the cause of learning difficulties.

2.1.2. Differences in academic achievement theory

In the 1960s, Kirk first used the term student with learning difficulties to describe students with normal intelligence who had difficulty with the curriculum, departing from the previous perspective of learning difficulties that was limited to physical disabilities [5]. Definitions used in this perspective generally support the notion that learning difficulties are not caused by intellectual deficits but are associated with low levels of academic achievement.

In general, learning difficulties are a topic of research that combines the perspectives of several disciplines, including psychology, physiology and education, with different definitions of learning difficulties based on the student's physical condition, course of study and psychological status.

2.2 Learning difficulties in physics

For the subject of physics, most current definitions agree that learning difficulties in physics are caused by multiple external causes and internal student causes. According to Professor Meng Zhaohui of Northeast Normal University, physics learning difficulties refer to "students who are not intellectually backwards or affected by diseases, but students with normal intelligence, who have low efficiency in learning physics and cannot meet the physics learning standards at a certain stage of learning physics" [6]. This reflects the acquired nature of physics learning difficulties, which can be modified through human intervention.

The physics learning difficulties discussed in this paper refer to educational phenomena that occur at stages or over time in the physics learning process, are not caused by a physical impairment, and are steadily below the moderate achievement level of their peers of the same intellectual level, and can be improved by teachers through changes in teaching style, individual lessons and communication with parents.

2.3 Systemic causes

Urie Bronfenbrenner has developed a theory of the ecology of human development, which suggests that social influence can be summarised as a nested system that extends around the individual and includes four circles: micro, meso, outer and macro. The microsystem refers to the activities, roles and styles of interpersonal relationships experienced by individuals in contexts with specific physical and material characteristics; the mesosystem consists of the interrelationships between two or more contexts in which the developing person is actively involved; the outer system consists of the factors which individuals cannot control or participate in yet influence them; macrosystems refer to the coherence in form and content that exists or may exist between microsystems, mesosystems, and outer systems at the level of the culture or subculture as a whole, as well as the ideologies and belief systems underlying this coherence [7].

Ecosystem theory emphasises the importance of the environment and focuses on the interactions between individuals and systems in the environment, as well as the interactions between systems in the environment and the significant influence of the environment on human behaviour. According to ecosystem theory, the poor learning outcomes of physically challenged students are not only caused by the students themselves but are also influenced by external factors such as school, family and society.

3. Analysis of the systematic causes of physics learning difficulties of secondary school students

3.1 Internal causes

As physiological learning difficulties often require the help of professionals in the medical or psychological fields and teachers have limited agency, this study will not analyse the physiological causes of learning difficulties. This section focuses on the impact of individual students' cognitive, thinking and psychological state factors on the physics learning process, and teachers will need to understand individual students through a variety of means, such as questionnaires or interviews, when helping them.

3.1.1. Cognitive and Thinking Disorders

Cognitive and thinking disorders are divided into two components: cognitive disorders and thinking disorders. Cognitive impairment is defined in the clinical field as an impairment in cognitive functioning, including orientation, attention, memory, analysis, synthesis, comprehension, judgement, structural ability, and executive ability [8]. The definition of cognitive impairment in this paper excludes pathology and understands that students have difficulties in these areas. Thought impairment refers to the obstacles students encounter in the thinking process of problem identification and problem-solving.

It was found that cognitive impairment is one of the main causes of secondary school students' learning difficulties in physics, as evidenced by unstable subject knowledge structures, inadequate receptivity to procedural knowledge, and difficulties in knowledge extraction. According to Piaget's theory of cognitive development, an individual's development is divided into 4 stages. Middle school students are in the transition from the concrete to the formal operations stage, and the abstract and empirical nature of the physics subject itself poses a major challenge to students' cognitive processing and understanding. Accordingly, Meng Zhaohui and Yun Yun analysed the cognitive factors of physics learning difficulties and found that junior high school students often experience a "form-concrete" oscillation, resulting in poor physics cognitive structure, poor abstraction, inadequate physics knowledge, low organisation and under-representation [6].

In addition to the cognitive aspects of physics knowledge, poor control of cognitive processes, i.e. metacognition, may also contribute to difficulties in learning physics. Pei Lifang argues that information processing by struggling students is mostly superficial, focusing on descriptive rather

than procedural knowledge and that deficiencies in metacognitive knowledge are also important [9]. In addition, students are unfamiliar with physical phenomena and laws in everyday life due to their lack of background in physics subjects and, thus, are unable to understand and represent abstract concepts [10].

From the perspective of thinking skills, the barriers to learning physics for secondary school students may be caused by the quality of thinking and the way of thinking. According to Wang Jiantao, poor organisation and organisation of students' thinking, poor breadth and depth of thinking, poor flexibility and agility of thinking, and poor logic of thinking are among the major causes of students' learning difficulties [11]. Wan Kaiqiong found that preconceived life experiences, interference from thinking stereotypes and the mathematisation of physics formulas lead to students' thinking difficulties [12].

3.1.2. Motivational and emotional barriers

From the perspective of student motivation and emotion, the psychological trait of tending to take refuge is a key factor in students' difficulties with physics. Amongst the negative perceptions of secondary school students, the most important is the perception that physics is 'difficult', 'irrelevant' and 'boring' [13]. At the same time, parents' and teachers' ideas of meritocracy put enormous pressure on them to progress to higher education, leading to a loss of interest in learning physics [14]. This leads to poor attitudes to learning, low levels of motivation, reluctance to participate in classroom activities, and a lack of affirmation and enjoyment in the learning process and this learned helplessness leads to an aversion to learning [15-17].

In addition to motivation, student interest is a major cause of difficulty in learning physics. The more interested a student is in a subject, the more confident he or she will be in learning it, and the better his or her academic performance will be. Therefore, low interest in physics may lead to a decline in academic performance [18]. Liang Shusen showed that 87.92% of those with high interest in physics were more efficient in physics, while 39.06% of those with low interest were more efficient in physics, a significant difference [19].

Overall, students' cognitive structures, thinking processes, motivational categories and levels, and interest levels may all contribute to intra-individual physics learning difficulties. Cognitive structure and thinking processes reflect the individual's motivation to solve learning difficulties, while motivation and emotion reflect the student's motivation to solve learning difficulties.

3.2 External causes

This paper summarises the external causes of learning difficulties in physics that are not under the control of the student, including the characteristics of the physics subject, the home environment and the school environment.

3.2.1. Physics subject characteristics

Many scholars, such as Li Yajing, have noted that the unique subject characteristics of physics itself contribute to students' learning difficulties. Physics is an experimental science, and the absence of teacher demonstrations and student experiments in the teaching process results in students' inability to develop a concrete perception [14]. Some of the complex issues in science education, including the availability of textbooks and classroom resources, are also debatable [20]. Erinosh, S.Y. explained the difficulties in learning physics mainly from the outside, with the three main sources being: the nature of the subject, teaching factors and curriculum assessment [21]. This revealed that students had difficulty understanding specific topics in the curriculum, which were often characterised by a lack of concrete examples and the need for extensive mathematical operations or visualisation.

3.2.2. The school environment

The school, as a place where subject knowledge is systematically taught, is also the main location where physics learning difficulties occur. Teachers' teaching, feedback, testing and other interactions

with students can lead to difficulties in physics, such as a mismatch between teachers' teaching styles and students' learning strategies, single forms of assessment, lack of respect for students' other intelligence and a lack of motivation and interest.

The school environment is one of the main places where students learn, and is one of the major causes of physics learning difficulties for junior secondary school students. School environment factors include teachers' teaching methods, school workload, interpersonal relationships, and the availability of school hardware and facilities.

3.2.3. Family environment

Parents' literacy, occupation, training, marital status and parenting style provide different levels of family culture and support for their children. In a study conducted by Xiang Rongde comparing junior and senior high school students with learning difficulties in physics with those who excelled, it found that an educational approach that is democratic and harmonious, strict but not scolding and respects the autonomy of their children is conducive to motivating students to learn physics and improving their academic performance [22].

Parents providing emotional support for their children and the characteristics of parent-student emotional interactions can also influence the development of learning difficulties. Lack of emotional warmth in parental interactions, harsh teaching and high expectations of children can all contribute to learning difficulties [23].

4. Conclusion

In current teaching practice, teachers tend to attribute students' academic difficulties to their own motivation, interest and effort. This paper found that the factors that may contribute to secondary school students' learning difficulties in physics are systematic and multiple, so before intervening with students, teachers should gain an in-depth understanding of their students' situation through interviews and scales and then adopt an appropriate approach based on the problems they exhibit.

The subject characteristics that lead to learning difficulties in physics provide some guidance on teaching approaches and curriculum design and can be improved when teaching the subject to address the factors that lead to learning difficulties; the internal factors of students provide guidance for classrooms to analyse individual students' learning difficulties and can provide teachers with ideas for analysing individual differences in students' performance in physics; and the socio-cultural context emphasises the importance of home-school cooperation and teacher involvement in school management respectively. The socio-cultural context emphasises the importance of home-school cooperation and the importance of teacher involvement in school management, respectively. The socio-cultural context and the intra-student factors that contribute to learning difficulties are somewhat interdisciplinary in nature and may also be relevant when analysing the causes of learning difficulties in other subjects.

References

- [1] Hu Y, Tang R X, Xu D Miao. A review of research on the psychological causes of physics learning difficulties of secondary school students. *Modern Educational Science*, 2007(02): 75-77.
- [2] Millar, R. Why is science hard to learn? *Journal of Computer Assisted Learning*, 1993(2), 66-74.
- [3] Gong, Yanxia. Causes and countermeasures of physics learning difficulties of secondary school students, 2011(03): 45-47.
- [4] Cai Dan. Cognitive processing characteristics of junior high school students' learning difficulties in mathematics. East China Normal University, 2010.
- [5] Ke Ke. Psychological education of special children. Translation by Tang Shengling. Tianjin: Tianjin Publishing House, 1989.
- [6] Meng Zhaohui. Physics Curriculum and Pedagogy. Changchun. Northeast Normal University Press, 2005.6

- [7] Liu Honggang. Research on foreign language teacher development based on Brofenbrenner's ecosystem theory: a review and outlook. *Theory and Practice of Foreign Language Teaching*, 2021(02): 56-63.
- [8] Li Sun-Wei. Diagnosis and treatment of cognitive dysfunction. *Chinese Journal of Neuropsychiatric Disorders*, 2006(02): 189-191.
- [9] Pei Lifang. Analysis of the cognitive factors of students with learning difficulties. *Psychological Dynamics*, 1995(04).
- [10] Karakuyu, Y. Problems of Physics Teachers in Physics Education: Afyonkarahisar Sample, Mustafa Kemal University Journal of Social Sciences Institute, 2008,10
- [11] Wang, J.T., Zheng, F.C., Wang, H.Y. Barriers to learning physics concepts and teaching strategies. *Teaching and Management*, 2010(30)
- [12] Wan Kaiqiong. A brief discussion on the barriers to secondary school students' learning in physics. *Physics Teacher*, 2013, 34(05): 21-22.
- [13] Williams, C., Stanisstreet, M., Spall, K. & Boyes, E. (2003). Why aren't secondary students interested in physics? *Physics Education*, 2003, 38(4): 324.
- [14] Li, Y. J. Causes and solutions of physics learning difficulties among junior high school students [J]. *Middle School Physics (Middle School Edition)*, 2019, 37(3)
- [15] Mu Xiaowen, Zhang Dingqing. Analysis of the causes and countermeasures of "struggling students" in junior high school physics. *The study of physics in junior high school (middle school version)*, 2016, 34(2).
- [16] Bai Jingxi, Lu Feilin. Self-concept reconstruction and exploration of transformation strategies for students with learning difficulties in physics. *Higher Science Education*, 2003(S1).
- [17] Chen Xiantang. Exploration and reflection on the strategy of "feeling success" for students with learning difficulties in junior high school physics. *The study of physics in junior high school (middle school version)*, 2016, 34(5).
- [18] Hu Yan, Tang Rixin, Xu Demiao. A review of research on the psychological causes of physics learning difficulties among secondary school students. *Modern Education Science*, 2007(02): 75-77.
- [19] Liang Shusen. *Theory of physics learning*. Guangxi: Guangxi Education Publishing House, 1996: 160-161.
- [20] Anderman, E.M., Sinatra, G.M., & Gray, D.L. The challenges of teaching and learning about science in the twenty-first century: exploring the abilities and constraints of adolescent learners. *Studies in Science Education*, 2012, 48(1): 89.
- [21] Erinosho S Y. How Do Students Perceive the Difficulty of Physics in Secondary School? An Exploratory Study in Nigeria. 2013.
- [22] Xiang Rongde. A Psychobehavioral Study of Secondary School Students' Learning Difficulties in Physics. *Physics Teacher*, 2017, 38(06): 72-73.
- [23] He Peng. Exploring family influences on children's learning difficulties. *China School Health*, 1999(04): 270-271.