



Development strategies of physics teachers' pedagogical content knowledge

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ABSTRACT

Pedagogical content knowledge exerts significant driving influence in educational research of teachers. PCK is a basic guarantee for teachers to become expert educators. For physics teachers, PCK is a knowledge synthesis which is developed in a specific teaching situation. PCK development of physics teachers needs the accumulation of time and experience. There are many methods to develop physics teachers' PCK, such as self-study, teaching reflection and school-based educational research.

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Introduction

During the study on the professional development process of teachers, the concept of Pedagogical Content Knowledge (PCK) proposed by L. Shulman [1,2] plays an important role in the educational research of teachers. Shulman holds that PCK is a kind of knowledge regarding how teachers could organize, adjust and present subject knowledge and conduct effective education in allusion to different interests and abilities of students when facing specific subject theme. Shulman also proposes different thinking modes to the basic knowledge of teachers [3]. In those modes, Shulman concludes PCK as a category of basic knowledge mastered by teachers, which includes subject knowledge, curriculum knowledge and pedagogical content knowledge. Many scholars have successively conducted study on PCK from the perspective of the connotation and feature of PCK, how to understand the PCK of teachers, the origin and development of teachers' PCK etc. As a result, PCK exerts significant driving influence in educational research of teachers [4-8].

PCK is a kind of knowledge used by teachers in real teaching situations, which is different from pure subject knowledge and general pedagogic knowledge [9]. It is the core of teachers' specialized knowledge. Hence, one of the cores of teacher professional development is the development of PCK. As an important part of teachers' specialized knowledge, PCK is a basic guarantee for teachers to become expert educators.

Conception of PCK of physics teachers

The traditional physics teacher education in China does not well handle the relationship between "educational nature" and "academic nature". Consequently, those qualified physics teachers are far from enough to meet the demand of curriculum reform of basic education. PCK provides an effective method for educational reform of physics teachers.

For physics teachers, PCK is a knowledge synthesis which is developed in a specific teaching situation. Physics teachers' PCK includes knowledge of teaching beliefs, knowledge of physics curricula, knowledge of students' thinking and learning about physics, knowledge of effective instructional strategies for physics topics, knowledge of students' physics learning

evaluation [10]. PCK development of physics teachers needs the accumulation of time and experience; besides, the generation and development of PCK are influenced by key events and figures [11]. Physics teachers have many methods to obtain PCK [12-14], such as reflection on their own teaching, peer/colleague cooperation, read professional and educational books, participation in open class and teaching master competitions, network learning, participation in educational research, experts' influence, pre-service training education, in-service education, attending academic conferences. These sources played different role in obtaining PCK.

Our surveyed results demonstrated that reflection on their own teaching, peer/colleague cooperation, read professional and educational books, participation in open class and teaching master competitions are the most important methods to develop PCK. Network learning, participation in educational research, experts' influence, pre-service training education and in-service education are general sources of PCK. Experiences as primary, secondary and college students are the least important methods to obtain PCK.

The PCK acquisition of physics teachers is a dynamic process. It cannot be naturally acquired through the accumulation of physics expertise and general teaching knowledge. It is distinctly featured by individual, subject and context. With implicitness and indirectness, PCK requires teachers to constantly explore in specific situations, synthesize knowledge and make innovations. Therefore, no optimal method can directly instruct PCK to teachers. The construction of PCK for teachers is a relatively complex process.

Development Strategies of Physics Teachers' Pedagogical Content Knowledge

Active self-study to improve knowledge level of profession and educational theory

Advanced educational idea is the prerequisite for the success of physics curriculum reform as well as the driving force for the profession development of physics teachers. Through initiative study, physics teachers can update and enrich their knowledge of educational theory, improve the quality of educational theory and learn to use educational theory to direct

their own educational behaviors, so as to improve the quality of physics education [16]. The study of physics teachers should be flexible, well planned, optional and critical. Physics teachers could take advantage of various learning methods, such as reading the relevant books, learning through Interest, discussing with partners and colleagues, participating in subject research concerning teaching and academic conferences etc. During the learning process, physics teachers should pay attention to the leading trend of physics development, reform achievement of physics education as well as scientific education and teaching, students' learning status in physics etc.

In order to seriously and systematically study educational and teaching theory regarding new curriculum, physics teachers should systematically read books related to education and natural science such as physics teaching theory, physics pedagogy, pedagogy, psychology, learning psychology etc. Via Internet, physics teachers could skim various scientific websites, education websites, education blogs and electronic journal to timely acquire information concerning physics education and teaching. For example, the remote studies of primary and middle school teachers which are held every year provides a favorable platform of learning and communication for physics teachers. Physics teachers who participate in training can discuss with each other under the guidance of specialists in terms of concrete physics teaching issues. In such a process, physics teachers can be directed to integrate modern education technology with subject teaching.

Through initiative self-study, physics teachers can further their comprehension in specialized knowledge of physics such as the essence, concepts and rules of physics, know about the reasons of knowledge, display the formation process of knowledge through proper ways, reveal the connotation and essence, and adeptly conduct knowledge application and extension. Through study, physics teachers can deeply understand the knowledge of physics curriculum, grasp modern education concepts and develop their own capacity of lifelong learning.

Active teaching reflection to promote the integration among all factors of PCK

Teaching reflection is an important method to promote the mutual integration, adjustment and reconstitution of PCK factors for physics teachers. Teaching reflection of physics teachers refers to the positive, constant, thorough, deep and self-regulatory reflections of teachers on education and teaching activities which have already happened or are happening as well as culture, theory and assumption behind those activities. During the reflection process, physics teachers could find and clearly represent teaching and education issues encountered by them, and actively look for various methods to solve those issues. As a result, physics teachers could improve their teaching practice, and give more rationality to teaching practice. The quality of students can be promoted; meanwhile, the expertise of teachers can also be developed [17]. The formation process of teachers' PCK is simultaneous with the reflection process of teaching, and the relevant methods are also consistent. To some degree, PCK is formed in such a simultaneity and consistency [18].

The teaching reflection content of physics teachers may have different directions [19], which mainly include classroom teaching, development of students, development of teachers, teaching practice and teaching reform.

Reflection on classroom teaching. After class, physics teachers should analyze and evaluate their own teaching activities, including the effect of lesson preparation, analysis and treatment of key points and difficulties in teaching, application of teaching

methods and strategies, comprehensive control of various teaching links, emergency treatment, quality of classroom teaching etc. Through reflection, teachers could find their own merit and demerit in physics teaching, improve their recognition in classroom teaching, gradually condense their education concepts in physics and improve their physics teaching strategy.

Reflection on the development of students. The reflection of physics teachers should not be restricted to themselves, and the development status of students in physics learning needs reflecting as well, so as to implement teaching purposefully. During the reflection process, teachers should put students in the dominant position, reflect their own teaching behaviors as well as the background education concepts based on how to make students learn to study, and reflect whether their teaching methods are successful and effective based on whether the learning behaviors of students are improved [20]. Reflections on physics learning of students mainly include: the effect of learning evaluation, the achievement made by students in physics study as well as the development of various abilities, the cultivation of students' interest and learning method in physics, and the healthy mentality and personality development of students.

Reflection on teaching practice. Physics teachers also need to reflect all teaching practice related to physics education and teaching. Physics teachers reflect their practice experience, summarize their practice experience of physics education as well as progress degree, in order to improve their own teaching behavior and make the practice and recognition more reasonable. The reflection on teaching practice specifically include three aspects. Firstly, the reflection concerns the specialized knowledge in physics and teaching capacity owned by teachers. Secondly, the reflection concerns personality charm and self-image of teachers. Thirdly, the reflection concerns issues regarding salary of teachers.

Reflection on reform of physics curriculum. Physics teachers should pay attention to not only the reform of physics curriculum, education and examination system, but also the reform of macroscopic education system. Physics teachers need to reflect the effect of curriculum reform with the combination of their own physics education experience, and the factors that have an effect on curriculum reform, such as the knowledge and capacity basis of students, the attitude held by parents of students, the atmosphere of schools, the support degree of society on curriculum reform etc.

Reflection on interpersonal relationship. In the process of teaching activities, physics teachers need to interact with students; besides, they might have various relationships with others, including colleagues, leaders, parents, specialists etc. Hence, physics teachers should reflect the influence on them brought by various interpersonal relationships which are relevant to physics education. For example, physics teachers should reflect teaching methods of colleagues or famous teachers which are worthy of reference, gains obtained from the cooperation with colleagues, evaluation made by students and their parents etc. Reflection on interpersonal relationship can help physics teachers not only form harmonious interpersonal relationship, but also improve physics education and promote the development of PCK.

During the reflection process, physics teachers should make timely record and summary, and combine reflection, record and summary together [21]. Physics teachers can also record their reflection on physics education and teaching in the form of teaching diary, teaching case report or monographic study papers, in order to better accumulate PCK [22].

Active school-based educational research activity to improve the quality of PCK roundly

Through teaching reflection, physics teachers will have a comprehensive understanding on their own physics teaching activities, including the merits and demerits of teaching as well as the existing problems. Consequently, physics teachers can consider how to solve those problems. School-based education research is an effective way to solve those problems. Through school-based education research, physics teachers could integrate their daily teaching with education research. If physics teachers can implement physics teaching with the consciousness of research, inspect various elements, links and even the whole process in physics teaching and education from a research perspective and reflect, criticize and analyze teaching and education activities, their attainment of educational theory and teaching capacity can be roundly improved; meanwhile, the development of PCK can also be promoted [23].

School-based educational research is a kind of activity which takes the problems and phenomenon in teaching and education as the research object, the teachers as the subject, the subject group and the teaching research group as the basis, and the action research and the narrative research as the major methods [24]. School-based physics research and teaching conducted by physics teachers can effectively combine various education resources in school. In this way, the passive position of physics teachers in obedience and execution under the context of new curriculum reform can be changed, and the dominant role of physics teachers can thus be fulfilled. Besides, school-based educational research is beneficial to structure a teaching mode which can embody the concept of new physics curriculum, and helps physics teachers to form education experience and talent which can control physics education.

The forms of school-based educational research on physics are quite flexible. The major activities include activities of teaching research group, training on specialized knowledge, research on lesson case, research on subject, research on educational narration, research on education behaviors, development of school-based curriculum, theme forum etc [16].

Physics teachers should take an active part in various teaching and researching activities organized by teaching researching group, such as collective preparation for lessons, demonstration class, public class, study for theory, special lectures, subject research, special discussion, extracurricular activities, forums for teaching and researching. As a result, the class teaching skills of teachers can be exercised, meanwhile, their education concepts, teaching ideas and art can thus be promoted and perfected, so does their teaching skills. The education research of physics teachers can use the problems found in their reflection as the "task", follow the procedures and steps of scientific research, carry out action research and narrative research and improve their conceptual knowledge on education practice.

In teaching and researching activities, physics teachers have more opportunities to communicate with colleagues and specialists. During the communication process, through consultation and cooperation, discussion and debate, physics teachers could subtly transfer their comprehension, inspiration, intuition and knacks on physics education and teaching to their partners, at the same time, they also absorb knowledge shared by others. Through school-based educational research, teachers could clarify their confusion and doubt in their physics education practice, solve practical problems, and transform the teaching behaviors of teachers to knowledge system with

explicit content and clear logic. In this way, the quality of PCK can be improved roundly.

Conclusion

The PCK of physics is distinctly featured by individual, subject and context. PCK is beneficial for physics teachers and physics education to link up "educational nature" and "academic nature", so as to improve the overall quality of physics teacher team. The acquisition of physics teachers' PCK is a dynamic process, which runs through the life-long learning process of teachers. The development of PCK can effectively promote the professional development of teachers. Through initiative self-study, regular reflection on teaching and active participation in teaching and researching activities, the PCK of physics teachers can be effectively developed.

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References

- [1] Lee S. Shulman. Those who understand: Knowledge Growth in Teaching. *Educational Researcher*, 1986, 15(2):4-14.
- [2] Lee S. Shulman. Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review*, 1987, 57(1):1-22.
- [3] Cochran K F, DeRuiter J A, King R A. Pedagogical content knowledge: An integrative model for teacher preparation. *Journal of Teacher Education*, 1993, 44(4):263-272.
- [4] Deborah Loewenberg Ball. Bridging practices: Intertwining content and pedagogy in learning to teach. *Journal of Teacher Education*, 2000, 51(3):241-247.
- [5] Lorenzo Blanco. Problem Solving and the Initial Practical and Theoretical Education of Teachers in Spain. *Mathematics Teacher Education and Development*, 2004(4):31-42.
- [6] Sibel Yeşildere İmre, Hatice Akkoç. Investigating the development of prospective mathematics teachers' pedagogical content knowledge of generalising number patterns through school practicum. *Journal of Mathematics Teacher Education*, 2012, 15(3):207-226.
- [7] Sandra K. Abell, Meredith A. Park Rogers, Deborah L. Hanuscin. Preparing the Next Generation of Science Teacher Educators: A Model for Developing PCK for Teaching Science Teachers. *J Sci Teacher Educ*, 2009(20):77-93.
- [8] Sun Zihui, Gao Xiaofu, Zhu Haiying. Pedagogical content knowledge of teacher educator. *Chinese Teacher*, 2009(3):39-41.
- [9] Sun Haibin, Liu Tingting. Framework of physics teachers' pedagogical content knowledge. *Theory and Practice of Contemporary Education*, 2013, 5(11):46-48.
- [10] Zhu Lianyun. Case study of novice and expert teachers' PCK in elementary school mathematics. *Shang Hai Education Research*, 2007(10):55-58.
- [11] Xu Yinghua, Li Xiaolin. Development approach of experts' knowledge of chemistry teaching. *Chemistry Education*, 2011(6):33-35.
- [12] Liao Dongfa, Zhou Hong, Chen Suping. Investigation and analysis of sources of pedagogical content knowledge of primary and secondary teachers. *Education Exploration*, 2009(12):92-94.
- [13] Liu Qinghua. Source of development of pedagogical content knowledge. *Tianzhong Journal*, 2005(1):131-133.
- [14] Li Lihua. Structure and construction of language teachers' pedagogical content knowledge. *Journal of Ningxia University (Humanities & Social Sciences Edition)*, 2010(4):189-192.

- [15] Sun Haibin, Liu Tingting. Strategies of high school physics teachers' professional development. *Theory and Practice of Contemporary Education*, 2010(8):15-18.
- [16] Shen Jiliang, Liu Jiaxia. Studies of teachers' teaching reflection. *Journal of East China Normal University (educational sciences)*, 2004(3):44-49.
- [17] Wang Zheng, Ren Jingmin. Teachers' pedagogical content knowledge and its development. *Elementary & Secondary Schooling Abroad*, 2010(3):29-32.
- [18] AN Fu-hai. Teaching reflection: connotation, influencing factors and problems. *Journal of Hebei Normal University (Educational Science Edition)*, 2010(10):80-84.
- [19] Wang Enhui. Teaching Reflection distortion and return to the real path. *Journal of The Chinese Society of Education*, 2009(3):67-69.
- [20] Chen Zhenhua. Development of teaching practice and teaching of knowledge. *Global Education*, 2009(9):26-32.
- [21] Zhang Tiedao. Leading teachers to construct teaching knowledge and develop practical ability. *People's Education*, 2011(6):59-62.
- [22] Wu Yinying, Chen Zhiwei. Promotion of science teachers' PCK in the school-based research. *Modern Education Science*, 2009(2):30-32.
- [23] Wang Jian, Xu Libo. Connotation and ways of teacher professional development. *Journal of Huazhong Normal University (Humanities and Social Sciences)*, 2008(3):125-129.