Available online at www.elixirpublishers.com (Elixir International Journal)

Psychology

Elixir Psychology 73 (2014) 26380-26385

ISSN: 2229-712X

Investigation of secondary physics teachers' pedagogical content knowledge in China

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ARTICLE INFO

Article history:
Received: 22 June 2014;
Received in revised form:
25 July 2014;
Accepted: 14 August 2014;

Keywords
Pedagogical content knowledge,
Physics teacher,
Questionnaire,
Physics education.

ABSTRACT

Pedagogical content knowledge (PCK) has become a framework for exploring what teachers need to know or to develop for effective teaching. Physics teachers' PCK includes five components. In this study, the self-made "Questionnaire of Physics Teachers' Pedagogical Content Knowledge" was used. The quantitative responses were compiled and analyzed by SPSS. The results indicated that the physics teachers' level of PCK is on the intermediate and many factors help physics teachers to develop their PCK.

Introduction

Teachers often engage in curricular planning by critiquing and adapting existing curriculum materials to contextualize lessons and compensate for their deficiencies [1]. Designing instructional teaching strategies for students is shaped by teachers' teaching ability and professional knowledge. Teachers' professional knowledge is the base of teachers' professional status and professional ability [2]. In 1986, L. Shulman first introduced the notion of pedagogical content knowledge as a fundamental component of the knowledge base for teaching [3]. According to Shulman, teachers' basic knowledge includes subject matter knowledge, curriculum knowledge and pedagogical content knowledge [2-3]. Shulman defined PCK as "the special amalgam of content and pedagogy that is uniquely the providence of teachers, their own special" [4]. Shulman pointed out that PCK includes seven categories: (1) content knowledge, (2) general pedagogical knowledge, (3) curriculum knowledge, (4) PCK, (5) knowledge of learners and their characteristics, (6) knowledge of educational con-texts, (7) knowledge of educational ends, purposes and values, and their philosophical and historical grounds [5]. Shulman thought that PCK represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction [6-8]. Many researchers have defined components of PCK [9]. PCK has become a framework for exploring what teachers need to know or to develop for effective teaching of particular content [10].

Magnusson, Krajcik, and Borko suggested five aspects of PCK that preservice secondary science teachers can begin to develop during their preparation. Those five components are: orientation to teaching, knowledge of curricula, knowledge of student prior understanding and potential difficulties, knowledge of successful instructional strategies, and knowledge of assessment [11]. This model has formed the theoretical basis for much research on science PCK [1]. In physics, PCK can be described as an application of general, subject independent knowledge of how people learn to the learning of physics [12]. 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 [13].

The purpose of this study is to investigate the development of physics teachers' PCK above five components, and establish the base for the practice strategy promoting physics teachers' professional development. This study informs useful information for physics teacher education by providing important insights into physics teachers' knowledge. It also has important implications for higher education workers to reform physics teaching classroom and curricula.

Methods

In this study, the self-made "Questionnaire of Physics Teachers' Pedagogical Content Knowledge" is used. The questionnaire is designed mainly started from the definition of physics teachers' PCK, and consists of 24 items. Thirteen of the items reflect physics teachers' situation or backgrounds, and 11 of items reflect physics teachers' PCK and the sources of PCK.

The survey was implemented in 10 secondary schools in Jinan City, Tai'an City, Qingdao City, and Linyi City in Shandong Province, and the survey objects were physics teachers, and the questionnaire survey didn't note the names of investigated objects. In 215 questionnaires, all of them were returned, and 198 of them are effective, and the efficiency rate is 92.1%. Responses to the survey items were coded; and responses were graded in terms of a Likert five-point (or six-point) scale (for example, 1 = know nothing at all, 2 = not clear, 3 = basically clear, 4 = more clear and 5 = very clear). The quantitative responses were compiled and analyzed using the

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Statistical Package for the Social Science (SPSS 13.0) for Windows computer software.

Results

In this section, the data collected using the questionnaire are analyzed. The Cronbach's reliability coefficient for this 24-item scale was found to be 0.971.

Backgrounds of surveyed physics teachers

In the surveyed physics teachers, 60.61% of them are male and 39.39% of them are female, 65.66% are high school teacher and 34.34% are junior middle teacher, teachers from 25to 45 years old are 66.67%% of the total amount. Physics teachers with the undergraduate or graduate degree occupy 97%, and the teachers with the doctor degree occupy 9.09%, and 24.24% of them with senior profession title. 95.88% of them graduated from teacher colleges, which indicates that the teacher colleges play a major role in the cultivation of teachers.

PCK of physics teachers

The total score of physics teachers' PCK is 164.49, and the total score of source of PCK is 228.89, see Table 1. In all five categories, the score of knowledge of physics curricula is highest, and the score of knowledge of physics learning evaluation is lowest. The average score is centered on the "basically clear" option. This indicates that physics teachers can understand physics curricula knowledge well and not good at knowledge of learning evaluation. For the sources of PCK, there are no apparent differences.

In each item of physics teaching beliefs, the average score of physics teachers' own teaching ideas, the ins and outs of physics concepts and laws, nature of physics, influence of physics on the society, ideas about physics curriculum are higher, and the average score of knowledge of physics educational research and history are poor (see Table 2). Reflection on their own teaching, peer/colleague cooperation, participate in open class and teaching master competitions, reading professional and educational books play a major role in obtain knowledge of physics teaching ideas. In-service education, experiences as college students, attending academic conferences are on the contrary (see Table 3).

As far as knowledge of physics curriculum concerned, the average score of understanding of teaching material, specific requirements of each class teaching objectives, longitudinal and cross-sectional knowledge about teaching content are higher, the knowledge of physics education and physics education experience are poor (see Table 4). Reflection on their own teaching, peer/colleague cooperation, participate in open class and teaching master competitions are major sources to obtain knowledge of physics curricula (see Table 5).

As table 6 demonstrated, the knowledge of students' understanding and learning about physics is at the "basically clear" level. Foundations of students' learning ability and features of students' physics learning thinking are slightly higher than basically clear level. Students' basic knowledge of physics and students' pre-concept about physics are lower than basically clear level. Reflection on their own teaching, peer/ colleague cooperation, read professional and educational books, participation in open class and teaching master competitions are major sources to obtain knowledge of students' understanding physics. While, in-service education and attending academic conferences play a little role (see Table 7).

As far as physics teachers' effective instructional strategies for physics topics, instructional strategies for physics concepts and laws, strategies for choose teaching media and teaching methods, strategies for physics experiment are much better than strategies for teaching monitor (see Table 8) . Reflection on their own teaching, peer/colleague cooperation, read professional and educational books are major sources to obtain effective instructional strategies for physics topics. While, in-service education and experiences as primary and secondary students play a little role (see Table 9).

Compared with other PCK categories, physics teachers' knowledge of physics learning evaluation is not good, which is lower than the "basically clear" level, see table 10. Knowledge of physics learning evaluation standards is much better than knowledge of qualitative evaluation. Reflection on their own teaching, peer/colleague cooperation, read professional and educational books, participation in open class and teaching master competitions are major sources to obtain knowledge of physics learning evaluation. While, experiences as primary, secondary and college students play a little role, in-service education play a little role (see Table 11).

Conclusion and discussion

In conclusion, the group of Shandong provincial secondary school physics teachers mainly is young and middle-aged, and the attainment rate of undergraduate education level is high, and the proportion of senior profession tile is normal. Teachers colleges still are the main places to cultivate physics teachers.

In the light of the results of the analysis, the physics teachers' level of PCK is on the intermediate, but not so good. In all five components of PCK, the level of physics teachers' knowledge of physics curriculum, knowledge of effective instructional strategies for physics topics, knowledge of teaching beliefs are on the "Basically clear ". While, the scores of knowledge of, knowledge of students' physics learning evaluation and students' understanding and learning about physics are lower than average level.

Physics teachers have many methods to obtain PCK, 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. The data indicated that reflection on their own teaching, peer/colleague cooperation, read professional and educational books, participation in open class and teaching master competitions helped physics teachers to develop their PCK. These factors could better promote physics teachers' PCK. Experiences as primary, secondary and college students are the least important sources of PCK.

The findings of this research indicated that PCK could be a useful tool in diagnosing or monitoring the development of physics teachers. It is the PCK that enables teachers to support students' physics learning. In order to develop PCK, physics teachers should understand the nature of physics, general pedagogy knowledge, and the context knowledge (students, schools and societies) in which they are teaching.

Acknowledgment

The research is supported by the Education Science "Twelfth Five-year" Plan of Shandong Province (No. 2011GG082).

References

[1] Carrie J. Beyer, Elizabeth A. Davis. Learning to critique and adapt science curriculum materials: Examining the development of preservice elementary teachers pedagogical content knowledge. *Science Education*, 2012,96(1):130-157.

[2] SHAO Guanghua, CHEN Xuemei. Perspectives of the development of the teaching expertise. *Journal of Hebei Normal University (Educational Science Edition)*, 2009(2):65-67.

Table 1. Score of physics teacher' PCK and sources

	Score	Average	Score of sources	Average score of sources
Knowledge of teaching beliefs	30.85	3.09	45.66	3.81
Knowledge of physics curricula	34.78	3.16	45.75	3.81
Knowledge of students' understanding and learning about physics	23.41	2.93	45.90	3.83
Knowledge of effective instructional strategies for physics topics	55.83	3.10	45.96	3.87
Knowledge of physics learning evaluation	20.12	2.87	45.62	3.80
Total	164.99	15.15	228.89	19.12

Table 2. Percent and scores of knowledge of teaching beliefs

	Know nothing at all (%)	Not clear (%)	Basically clear (%)	More clear (%)	Very clear (%)	Average
Own physics teaching ideas	1.01	14.14	41.42	43.43	0	3.27
The ins and outs of physics concepts and laws	0	23.23	36.36	40.41	0	3.17
Nature of physics	1.01	23.23	34.34	41.42	0	3.16
Influence of physics on the society	0	21.21	44.45	34.35	0	3.13
Knowledge about physics curriculum reform	1.01	25.25	37.38	35.35	1.01	3.10
Ideas about physics curriculum	22.23	47.47	29.29	1.01	0	3.09
Physics pedagogical knowledge	1.01	25.25	41.42	32.32	0	3.05
Methods of inquiry new physics knowledge	0	26.53	43.88	29.59	0	3.03
History of physics	4.04	28.28	36.37	31.31	0	2.95
Knowledge of physics educational research	4.04	33.34	31.31	31.31	0	2.90
Total						30.85

Table 3. Percent and scores of sources of knowledge of teaching beliefs

	Very large role (%)	Relatively large role (%)	General role (%)	Little role (%)	No effect (%)	No such experience (%)	Average
Reflection on their own teaching	49.5	45.45	5.05	0	0	0	4.44
Peer/colleague cooperation	36.36	51.52	11.11	1.01	0	0	4.23
Participation in open class, teaching master competitions	35.35	42.43	18.18	1.01	0	3.03	4.03
Read professional and educational books	30.31	45.45	20.20	3.03	1.01	0	4.00
Network learning	21.22	49.49	25.25	4.04	0	0	3.88
Pre-service training education	24.24	37.37	26.26	10.11	1.01	1.01	3.71
Participation in educational research	21.21	45.46	21.21	8.08	1.01	3.03	3.69
Experts' influence	16.17	46.46	27.27	7.07	2.02	1.01	3.65
Experiences as primary and secondary students	14.15	45.45	26.26	12.12	2.02	0	3.58
Attending academic conferences	13.13	50.51	24.24	5.05	3.03	4.04	3.54
Experiences as college students	18.18	34.34	31.32	13.13	3.03	0	3.52
In-service education	11.12	41.41	34.34	6.06	3.03	4.04	3.39
Total							45.66

Table 4. Percent and scores of knowledge of physics curricula

	Know nothing at all (%)	Not clear (%)	Basically clear (%)	More clear (%)	Very clear (%)	Average
Understanding of teaching material	1.01	10.10	37.37	50.51	1.01	3.40
Specific requirements of each class teaching objectives	1.01	15.15	32.32	50.51	1.01	3.35
Cross-sectional knowledge about teaching content	1.01	16.16	38.39	43.43	1.01	3.27
Longitudinal knowledge about teaching content	2.02	16.16	42.42	38.39	1.01	3.20
Sub-knowledge of physics concepts and laws	2.02	17.17	43.44	36.36	1.01	3.17
Knowledge of physics experiment	1.01	17.17	47.48	33.33	1.01	3.17
Broader concept of physics concepts and laws	2.02	17.17	44.45	35.35	1.01	3.16
Nature of physics curriculum	1.01	26.26	38.39	34.34	0	3.06
Knowledge of scientific inquiry	2.02	21.21	46.47	29.29	1.01	3.06
Theory of physics education experience	1.01	26.26	45.46	27.27	0	2.99
Theory of physics education	3.03	26.26	44.45	25.25	1.01	2.95
Total						34.78

Table 5. Percent and scores of sources of knowledge of physics curricula

	Very large role (%)	Relatively large role (%)	General role (%)	Little role (%)	No effect (%)	No such experience (%)	Average
Reflection on their own teaching	44.44	45.46	9.09	1.01	0	0	4.33
Peer/colleague cooperation	32.32	55.56	11.11	1.01	0	0	4.19
Participation in open class, teaching master competitions	34.35	44.44	18.18	0	0	3.03	4.04
Read professional and educational books	28.28	45.45	22.23	3.03	1.01	0	3.97
Network learning	24.25	43.43	29.29	3.03	0	0	3.89
Participation in educational research	20.21	45.45	27.27	5.05	1.01	1.01	3.76
Experts' influence	19.19	47.47	24.25	6.06	2.02	1.01	3.73
Experiences as college students	23.24	37.37	32.32	4.04	3.03	0	3.72
Pre-service training education	16.16	37.37	41.42	2.02	2.02	1.01	3.61
Experiences as primary and secondary students	16.17	35.35	37.37	9.09	2.02	0	3.55
Attending academic conferences	16.17	37.37	38.38	4.04	1.01	3.03	3.55
In-service education	10.10	44.44	32.33	6.06	4.04	3.03	3.41
Total							45.75

Table 6. Percent and scores of knowledge of students' understanding and learning about physics

	Know nothing at all (%)	Not clear (%)	Basically clear (%)	More clear (%)	Very clear (%)	Average
Foundations of students' learning ability	3.03	23.23	42.43	31.31	0	3.02
Features of students' physics learning thinking	2.02	23.23	46.47	28.28	0	3.01
Methods of students' physics learning	2.02	22.22	50.51	25.25	0	2.99
Learning difficulty and learning disability of physics	3.03	23.23	50.51	23.23	0	2.94
Knowledge of physics learning psychology	5.05	21.21	54.55	19.19	0	2.88
Strategies for physics learning	4.04	25.25	49.50	21.21	0	2.88
Students' basic knowledge of physics	2.02	30.30	48.49	19.19	0	2.85
Students' pre-concept about physics	4.04	30.30	43.44	22.22	0	2.84
Total						23.41

Table 7. Percent and scores of sources of knowledge of students' understanding and learning about physics

	Very large role (%)	Relatively large role (%)	General role (%)	Little role (%)	No effect (%)	No such experience (%)	Average
	40.40	50.51	7.07	2.02	0	0	4.29
Reflection on their own teaching	36.36	50.51	13.13	0	0	0	4.23
Peer/ colleague cooperation	27.27	49.50	21.21	2.02	0	0	4.02
Read professional and educational books	34.34	43.43	16.17	3.03	0	3.03	4.00
Participation in open class, teaching master competitions	21.21	49.50	23.23	6.06	0	0	3.86
Experts' influence	21.21	48.48	20.21	7.07	2.02	1.01	3.78
Pre-service training education	19.19	46.47	28.28	4.04	1.01	1.01	3.76
Participation in educational research	17.17	48.48	24.25	7.07	2.02	1.01	3.69
Experiences as college students	19.19	43.43	24.25	9.09	4.04	0	3.64
Experiences as primary and secondary students	10.10	52.53	29.29	5.05	3.03	0	3.62
Attending academic conferences	13.13	48.49	26.26	7.07	2.02	3.03	3.55
In-service education	12.12	44.44	29.30	8.08	3.03	3.03	3.46
Total							45.9

Table 8. Percent and scores of knowledge of effective instructional strategies for physics topics

	Know nothing at all (%)	Not clear (%)	Basically clear (%)	More clear (%)	Very clear (%)	Average
Instructional strategies for physics concepts	1.01	20.20	37.37	41.42	0	3.19
Instructional strategies for physics laws	3.03	16.16	39.39	41.42	0	3.19
Strategies for choose teaching media	2.02	14.14	47.48	36.36	0	3.18
Strategies for choose teaching methods	0	20.20	42.43	37.37	0	3.17
Strategies for physics experiment	3.03	18.18	38.38	40.41	0	3.16
Strategies for achieve teaching objects	1.01	21.21	39.40	38.38	0	3.15
Interactive classroom Strategies	2.02	17.17	45.46	35.35	0	3.14
Strategies for teaching design	1.01	20.20	43.44	35.35	0	3.13
Teaching feedback strategy	2.04	21.43	39.80	36.73	0	3.11

Presentation strategies for teaching behavior	4.04	19.19	40.41	36.36	0	3.09
Strategies for analyze students	1.01	22.22	44.44	32.33	0	3.08
Strategies for establishing teaching objects	0	25.25	42.43	32.32	0	3.07
Strategies for difference of students' ability	0	23.23	47.48	29.29	0	3.06
Strategies for students' cognitive style	1.01	20.20	50.51	28.28	0	3.06
Strategies for solving physics problems	2.02	23.23	42.43	32.32	0	3.05
Strategies for designing teaching environments	4.04	21.21	42.43	32.32	0	3.03
Strategies for difference of students' age	3.03	24.24	42.43	30.30	0	3.00
Strategies for teaching monitor	5.10	18.37	50.00	26.53	0	2.97
Total						55.83

Table 9. Percent and scores of sources of knowledge of effective instructional strategies for physics topics

	Very large role (%)	**Relatively large role (%)**	**General role (%)**	**Little role (%)**	**No effect (%)**	**No such experience (%)**	**Average**
Reflection on their own teaching	49.50	38.38	9.09	3.03	0	0	4.34
Peer/colleague cooperation	38.38	45.46	11.11	2.02	3.03	0	4.14
Read professional and educational books	31.31	45.46	19.19	3.03	1.01	0	4.03
Participation in open class, teaching master competitions	37.38	38.38	17.17	2.02	1.01	4.04	3.97
Network learning	27.27	38.39	27.27	6.06	1.01	0	3.85
Participation in educational research	23.23	47.48	20.20	4.04	4.04	1.01	3.79
Experts' influence	23.23	46.47	16.16	9.09	5.05	0	3.74
Pre-service training education	21.21	41.42	29.29	6.06	1.01	1.01	3.73
Experiences as college students	23.23	29.29	39.40	6.06	2.02	0	3.65
Attending academic conferences	17.17	44.45	25.25	7.07	4.04	2.02	3.58
Experiences as primary and secondary students	15.15	42.43	28.28	12.12	2.02	0	3.57
In-service education	21.21	41.42	20.20	10.10	4.04	3.03	3.57
Total							45.96

Table 10. Percent and scores of knowledge of physics learning evaluation

	Know nothing at all (%)	Not clear (%)	Basically clear (%)	More clear (%)	Very clear (%)	Average
Knowledge of physics learning evaluation standards	3.03	24.24	47.48	25.25	0	2.95
Knowledge of process evaluation	7.07	21.21	46.47	25.25	0	2.90
Knowledge of summative evaluation	6.06	23.23	45.46	25.25	0	2.90
Content of learning evaluation	3.03	29.29	43.44	24.24	0	2.89
Function of learning evaluation	4.04	29.29	40.41	26.26	0	2.89
Knowledge of quantitative evaluation	5.05	28.28	42.43	24.24	0	2.86
Knowledge of qualitative evaluation	7.07	34.34	37.38	21.21	0	2.73
Total						20.12

Table 11. Percent and scores of sources of knowledge of physics learning evaluation

	Very large role (%)	Relatively large role (%)	General role (%)	Little role (%)	No effect (%)	No such experience (%)	Average
Reflection on their own teaching	36.36	50.51	12.12	1.01	0	0	4.22
Peer/colleague cooperation	35.35	50.51	10.10	3.03	1.01	0	4.16
Read professional and educational books	32.32	38.39	26.26	3.03	0	0	4.00
Participation in open class and teaching master competitions	32.32	45.46	13.13	6.06	0	3.03	3.95
Participation in educational research	22.22	48.49	21.21	5.05	2.02	1.01	3.81
Experts' influence	20.20	51.52	19.19	6.06	3.03	0	3.80
Network learning	25.25	37.38	29.29	5.05	2.02	1.01	3.76
Pre-service training education	20.20	35.35	37.38	5.05	1.01	1.01	3.66
In-service education	16.16	48.49	26.26	3.03	3.03	3.03	3.63
Attending academic conferences	17.17	45.46	23.23	9.09	4.04	1.01	3.60
Experiences as college students	20.21	35.35	31.31	8.08	3.03	2.02	3.56
Experiences as primary and secondary students	12.12	39.40	34.34	12.12	2.02	0	3.47
Total							45.62

[3] Deborah L. Hanuscin, Michele H. Lee, Valarie L. Akerson. Elementary Teachers Pedagogical Content Knowledge for Teaching the Nature of Science. *Science Education*, 2011,95(1):145-167.
[4] Lee S. Shulman. Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review*, 1987,57(1):1-22.
[5] Esther M. van Dijka,Ulrich Kattmannb. A research model for the study of science teachers' PCK and improving teacher education. *Teaching and Teacher Education*,2007,23(6):885-897.
[6] YANG Wei, GUO Yuying. The influence and implication of PCK on American scientific teacher education. *Contemporary Teacher Education*, 2008, 1(3):6-10.
[7] Lee S. Shulman. Those who understand: Knowledge Growth in Teaching. *Educational Researcher*, 1986, 15(2):4-14.
[8] SUN Keping. New perspectives to cultivating science teachers: pedagogical content knowledge. *Global Education*, 2008(5):67-71.
[9] Fien Depaepe,Lieven Verschaffel,Geert Kelchtermans. Pedagogical Content Knowledge: a Systematic Review of the Way in Which the Concept Has Pervaded Mathematics Educational Research. *Teaching and Teacher Education*, 2013(34):12-25.
[10] Sibel Yesildere Imre, 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.
[11] Eugenia Etkina. Pedagogical content knowledge and preparation of high school physics teachers . *Phys. Rev. ST Phys. Educ. Res.*, 2010(6):20110.
[12] Eugenia Etkina. Physics teacher preparation: dreams and reality. *Journal of Physics Teacher Education online*, 2005, 3(2).
[13] SUN Haibin, LIU Tingting. Framework of physics teachers' pedagogical content knowledge. *Theory and Practice of Contemporary Education*, 2013, 5(11):46-48.