Developing an instrument for assessing college students' perceptions of teachers' pedagogical content knowledge

Syh-Jong Jang\textsuperscript{a,}\textsuperscript{*}, Shih-Ying Guan\textsuperscript{b}, Hsing-Fen Hsieh\textsuperscript{a}

\textsuperscript{a}Graduate School of Education, Chung Yuan Christian University, No. 200, Chungpei Rd., Chungli City, Taoyuan County 320, Taiwan

Received October 15, 2008; revised December 10, 2008; January 2, 2009

Abstract

Ongoing professional development for college teachers has been much emphasized. However, previous research has seldom addressed college students’ perceptions of teachers’ knowledge. The purpose of this study was to develop an instrument that could be employed to evaluate college students’ perceptions of teachers’ PCK. According to the pilot test results, the four categories finally constructed were Subject Matter Knowledge (SMK), Instructional Representation and Strategies (IRS), Instructional Objects and Context (IOC), and Knowledge of Students’ Understanding (KSU). In the main study, seven items were generated under each category, making a total of 28 items in the questionnaire, and the instrument was administered to 172 education college students. Results of analysis indicated that the instrument about teachers’ knowledge show satisfactory validity and reliability. The suggestions for application of the instrument in future research are also made.

Keywords: Pedagogical content knowledge; college teachers’ knowledge; professional development; college students’ perceptions; evaluation instrument

1. Introduction

The notion of ongoing professional learning and development for college teachers has been much emphasized (Guskey, 1985; Fullan & Stiegelbauer, 1991; Johnson, 1993; Clarke & Hollingsworth, 2002; Garcia & Roblin, 2008). The central focus of current professional development efforts aligns most closely with the change as growth in learning perspective. Within this perspective, change is identified with learning, and it is regarded as a natural and expected component of the professional activity of teachers and schools (Clarke & Hollingsworth, 1994). Many novice college teachers with doctoral degrees and a certain level of their subject matter knowledge were not able to be effective teachers (Clarke & Hollingsworth, 2002; Major & Palmer, 2006; Jang, 2008a). One of the reasons was that they did not need to get a Teacher’s Certificate to become primary and secondary school teachers (Jang, 2008a). Aside from the subject matter knowledge, they needed more pedagogical knowledge (Leinhardt & Smith, 1985; Hasweh, 1987; Lenze & Dinham, 1994). There are many ways for college teachers’ professional growth, such as researching, instructional observance and reflection, publication of reports and books, joining workshops to share...
experiences with others, seminars, attending professional activities, journal reading, writing, curriculum designing, and peer activities (Lieberman, 1995; Ball, 1996; Cooney & Krainer, 1996; Sykes, 1996; Loucks-Horsely et al., 2003; Dalgarno & Colgan, 2007). Nevertheless, promoting college teachers’ "Pedagogical Content Knowledge (PCK)" is the key point to advancing professional growth of teachers (Lenze & Dinham, 1994).

It has also been reported that the success of college teaching depends not only on the teachers’ subject-matter knowledge but also on their personal understanding of students’ prior knowledge and learning difficulty (Grossman, 1990; Lederman, Gess-Newsome & Latz, 1994). In addition, other factors of success include their own teaching methods and strategies, curriculum knowledge, educational situation, goal and value (Shulman, 1987). In particular, the college teachers’ pedagogical content knowledge is the main issue of the current college education revolution (Shulman, 1986, 1987). Shulman’s notion of PCK has attracted much attention and has been interpreted in different ways (Grossman, 1990; Geddis, Onslow, Beynon & Oesch, 1993). The foundation of science PCK is thought to be the amalgam of a teacher’s pedagogy and understanding of content such that it influences their teaching in ways that will best engender students’ learning for understanding. Initially, college teachers separate subject-matter knowledge from general pedagogical knowledge. These types of knowledge are, however, being integrated as a result of teaching experiences. By getting acquainted with the specific conceptions and ways, teachers may start to restructure their subject-matter knowledge into a form that enables productive communication with their students (Lederman, Gess-Newsome and Latz, 1994). According to Lederman, Gess-Newsome and Latz (1994), the development of PCK among science teachers is promoted by the constant use of subject-matter knowledge in different teaching situations. Many scholars suggest that PCK is developed through an integrative process rooted in classroom practice, and that PCK guides the teachers’ actions when dealing with a specific subject matter in the classroom.

1.1. Purpose of the research

Greater emphasis has been paid on the development and research of elementary and secondary teachers’ PCK (Grossman, 1990; Gess-Newsome & Lederman, 1993; Van Driel et al., 1998; Loughran, Mulhall & Berry, 2004; De Jong, Van Driel & Verloop, 2005; Dalgarno & Colgan, 2007). Some studies have even developed an instrument for examining students’ perceptions of secondary teachers’ knowledge (Tuan, Chang, Wang & Treagust, 2000). However, previous research on learning environments has seldom addressed college students’ perceptions of teachers. The purpose of this research was to develop an instrument for evaluating college students’ perceptions of teachers’ PCK in order to help college teachers understand better how they teach.

2. Theoretical framework

2.1. Pedagogical content knowledge

The impact of constructivist epistemology seems to be important in PCK. As constructivism emphasizes the role of previous experience in knowledge construction processes, it is not surprising that teachers’ knowledge is studied in relation to their practice in research from this point of view. Shulman (1987) regarded PCK as the knowledge base for teaching. This knowledge base comprises seven categories, three of which are content-related (content knowledge, PCK, and curriculum knowledge). The other four categories refer to general pedagogy, learners and their characteristics, educational contexts, and educational purposes. PCK is concerned with the representation of concepts, pedagogical techniques, knowledge of what makes concepts difficult or easy to learn, knowledge of students’ prior knowledge, and theories of epistemology. It also involves knowledge of teaching strategies that incorporate appropriate conceptual representations in order to address learners’ difficulties and misconceptions and to foster meaningful understanding (Mishra & Koehler, 2006).

Reynolds (1992) summarizes the literature on PCK in the following aspects: (1) teaching students through different skills and methods; (2) thinking about the content scope and sequence that needs to be covered; (3) understanding students’ previous conceptions, skills, knowledge and interests related to the particular topic; (4) using appropriate representation to introduce subject matter knowledge; (5) using different strategies to help students understand and become interested in a topic; (6) using appropriate evaluation methods to assess students’
understanding of subject matter knowledge. Tuan (1996) further investigated the essence of PCK and suggested that the components of PCK include teachers’ understanding of subject matter knowledge, teachers’ methods, teaching representations, curriculum knowledge, assessment knowledge, knowledge of students’ understanding of the topics, and knowledge of the context of the learning environment (Tuan, Chang, Lee, Wang & Cheng, 2000).

Grossman (1990) has tried to remedy this situation by distinguishing four general areas of teacher knowledge that can be seen as the cornerstones of the emerging work on professional knowledge for teaching: General pedagogical knowledge, knowledge of context, subject matter knowledge, and PCK. Within Grossman’s knowledge base for teaching, the general pedagogical knowledge is defined as knowledge concerning general principles of instructions, learning and learners, knowledge related to classroom management, and knowledge about the aims and purposes of education. Knowledge of context includes knowledge of school setting, for example culture, and knowledge of individual students (Van Dijk & Kattmann, 2007). PCK is a unique domain that is informed by other knowledge areas. There seems to be a reciprocal relationship between PCK and the foundational knowledge domains, subject matter, pedagogy, and context. The foundational knowledge domains inform PCK, which influences the teacher’s knowledge of the subject matter, pedagogy, and the context (Gess-Newsome, 1999).

Major and Palmer (2006) used a qualitative study of faculty members participating in a university campus-wide problem-based learning initiative to examine the process of transforming faculty pedagogical content knowledge. They found that faculty existing knowledge and institutional intervention influenced new knowledge of faculty roles, student roles, disciplinary structures, and pedagogy. Teachers’ PCK is deeply personal, highly contextualized and influenced by teaching interaction and experience (Van Driel, Beijaard & Verloop, 2001; De Jong, Van Driel & Verloop, 2005; Van Dijk & Kattmann, 2007). Mulholland and Wallace (2005) suggested that science teachers’ pedagogical content knowledge requires the longitudinal development of experience as they develop from novices into experienced teachers. Certain studies also showed that a teacher well equipped with the subject-matter knowledge might be able to transfer his/her knowledge in an efficient way, making it easier for students to acquire knowledge (Carter & Doyle, 1987; Tobin & Garnett, 1988). The subject-matter structures of biology teachers were investigated during a year of professional teacher education (Gess-Newsome & Lederman, 1993). Their knowledge structures appeared to be mainly derived from the college science courses. While these structures were often vague and fragmented on entering teacher education, they developed toward more coherent and integrated views of biology during teacher education.

2.2. Students’ perceptions of teachers’ knowledge

Jang (in press) designed a peer coaching-based model for in-service science teachers’ PCK. Four science teachers and 123 secondary students took part in this study on the application of the developed PCK-RIER model (Research, Instruction, Evaluation, and Reflection). Students thought that science teachers had rich subject matter knowledge and often assessed knowledge of their understanding. However, science teachers had difficulty implementing representational repertoire and instructional strategies. Students’ perceptions and teachers’ reflection are the important factors of this model for developing science teachers’ PCK. It is recommended that this model should be adopted in teacher education to offer more opportunities for professional growth among science teachers.

Knight and Waxman (1991) pointed out that although students’ perceptions might not be consistent with the reality generated by outside observers, they could present the range of reality for individual students and their peer in the classroom. Using students’ perceptions can enable researchers and teachers to appreciate the perceived instructional and environmental influences on students’ learning processes. According to Lloyd and Lloyd (1986), students expected teachers to provide a sense of how the constituent parts of a discipline fit together, to have rich and adequate subject matter knowledge, and to be able to teach this subject matter knowledge to their understanding level.

Olson and Moore (1984) revealed that, from the students’ perspective, a good teacher knows the subject matter knowledge well, explains things clearly, makes the subject interesting, gives regular feedback, and gives extra help to students. Similarly, Turley (1994) found that students’ perceptions of effective teaching were a combination of method, context, student effort, and teacher commitment. Students considered those teachers who knew their subject, showed evidence of thoughtful planning, used appropriate teaching strategies, instructional and representational repertoires, and gave adequate structure and direction to effective teachers (Tuan, Chang, Wang & Ttreagust, 2000). In brief, research on students’ perceptions of teachers’ teaching revealed that students expect
teachers to have strong content knowledge, inferring that they were able to perceive whether teachers’ content knowledge was good or bad. Students also expected teachers to use effective instructional methods; in other words, they expected teachers to have good pedagogical content knowledge (Shulman, 1987).

3. Research Methodology

In order to explore college teachers’ understanding of PCK and actualities, we first designed a questionnaire on novice teachers’ PCK. The categories of questionnaire constructed from Shulman’s (1987) PCK. It comprised 15 questions involved in three categories (instructional representation, strategies, and assessments of students’ prior knowledge), and each category had five questions. We conducted a pilot test on 16 novice teachers of PCK workshops at the beginning of the first semester of 2007 in order to examine their understanding of PCK. Moreover, we also selected 182 college students to join the test. After interviewing with some teachers and reviewing the suggestions from the Advancing Teachers’ Teaching Excellence Committee (ATTEC), we found many overlaps between instructional representation and strategies. On the other hand, most college teachers put emphasis on subject matter knowledge, and hence instructional context was neglected in this study.

The four categories finally constructed were Subject Matter Knowledge (SMK), Instructional Representation and Strategies (IRS), Instructional Objects and Context (IOC), and Knowledge of Students’ Understanding (KSU) (See Appendix). Seven items were generated under each of the four categories as agreed by the researchers and team teachers; the instrument was also revised according to the suggestions from five experienced college teachers of the ATTEC. Once the conceptual framework for the instrument was established, the items should be easy for college students in Taiwan to comprehend. Each category of items should be meaningful from the students’ perspective.

Subject Matter Knowledge (SMK) refers to students’ perceptions of the extent to which the teacher demonstrates a comprehension of the subject matter and ideas within the discipline. The construction process of content knowledge and entire structure and direction of subject knowledge are also included. Examples of items in this category are:

- a1. My teacher knows the content he/she is teaching.
- a7. My teacher knows the whole structure and direction of this subject matter knowledge.

Instructional Representation and Strategies (IRS) refers to students’ perceptions of the extent which the teacher uses a representational repertoire including analogies, metaphors, examples, and explanations, and the teacher selects teaching strategies if benefit the content learning, including informational technology. Examples of items in this category are:

- b1. My teacher uses familiar examples to explain concepts related to the subject matter.
- b7. My teacher uses multimedia or technology (e.g. PowerPoint) to express the concept of subject.

Instructional Objects and Context (IOC) comprises knowledge about the aims and process of education. IOC also includes the interactive atmosphere in the curriculum, teachers’ attitudes, knowledge related to classroom management, knowledge of school setting, and instructional values.

- c1. My teacher makes me understand clearly the objectives of this course.
- c6. My teacher copes with our classroom context appropriately.
- c7. My teacher’s teaching belief or value is active and aggressive.

Knowledge of Students’ Understanding (KSU) refers to college students’ perceptions of the extent to which the teacher evaluates student understanding before and during interactive teaching, and at the end of lessons and units. Examples of items in this category are:

- d1. My teacher realizes students’ prior knowledge before the class.
- d7. My teacher’s tests help me realize the learning situation.

3.1. Analysis of data

The pilot study indicated that the survey yielded high reliability and validity results (Jang, 2008b) and some items from the original instrument were revised. The revised instrument representing college students’ opinions about their teacher’s PCK were divided into four main categories, namely SMK, IRS, IOC and KSU, consisting of seven items per category for a total of 28 items. The questionnaire survey employed in this research included one open-ended question for students to comment on the course. Finally, participants of this study were students in the
College of Humanities and Education at the University. They took courses from the novice college teachers of participating in PCK workshops at the beginning of this semester. A total of 172 valid responses were collected.

This research used the quantitative research method. Statistical analyses on the survey data were carried out. The survey adopted the Likert scales, with five points designed for students to express their opinions as follows: “Never”, “Seldom”, “Sometimes”, “Often”, and “Always” correspond respectively to 1 - 5 points according to students’ responses. Moreover, we also tested reliabilities and validities in connection with the questionnaire. For reliabilities, Cronbach’s alpha would be adopted to evaluate the internal consistency. On the other hand, factor analysis would be adopted to evaluate the constructed validities.

4. Results and Discussion

Table 1 shows the descriptive statistics of students’ responses to the four categories in the questionnaire including mean scores and standard deviation. Results obtained by ANOVA show significant differences (p = .000 < .05, F = 46.757) among the four categories. The highest mean score is the SMK (M = 4.35, SD = 0.542), followed by the IRS (M = 4.28, SD = 0.573) and the IOC (M = 4.23, SD = 0.634) with the score of the KSU (M = 3.99, SD = 0.828) being the lowest. All of them indicate that these items were investigating occur between ‘often’ and ‘always’. As seen in the table 1 results, students considered their teachers’ subject matter knowledge (SMK) rich and positive, but indicated that knowledge of students’ understanding (KSU) could be improved.

| Category | Items | N  | Mean | SD    |
|----------|-------|----|------|-------|
| SMK      | 7     | 172| 4.35 | 0.542 |
| IRS      | 7     | 172| 4.28 | 0.573 |
| IOC      | 7     | 172| 4.23 | 0.634 |
| KSU      | 7     | 172| 4.00 | 0.664 |

Furthermore, we also analyzed each item. Items with mean below 4 points included Q-b3 (My teacher’s teaching methods keep me interested in this subject), Q-d1 (My teacher realizes students’ prior knowledge before the class.), Q-d2 (My teacher knows student’s learning difficulties of this subject before the class.), and Q-d4 (My teacher’s tests evaluate my understanding of the subject.). The study showed that college students expressed that most of the teachers could not fully understand students’ difficulties and prior knowledge (KSU). The critical way to promote KSU was to make students become aware of their teachers’ understanding and pay attention to their learning difficulties. From students’ comments, it may be caused by teachers’ subjectivities, faster progress of the program, and too many assignments so that it affected teachers’ teaching results. Many students in a normal class were also a problem. We advised to adopt an e-learning method to make up for the insufficient interaction among students and college teachers.

4.1. Reliabilities of the instrument

In reliability of this instrument, we used Cronbach alpha values to evaluate its internal consistency. After statistic analyzing, the Cronbach’s alpha value of 28 items was 0.965, indicating that the questionnaire had a good internal consistency. Moreover, in “Item-Total Statistics” (Table 2), the section of “Corrected Item-Total Correlation” revealed each corrected item not only presented a higher correlation (all correlation values were greater than 0.400) but also had a higher psychological homogeneity. Furthermore, from the section of “Cronbach’s alpha if item Deleted”, it meant: if we deleted one of the items, the Cronbach’s alpha values were almost the same, even smaller than items deleted. It followed from what had been said that the instrument had a higher consistency and reliability so that it was unnecessary to delete any item from the scale.
Table 2. Item-Total Statistics

| Item | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|------|---------------------------|-------------------------------|-------------------------------|---------------------------------|---------------------------|-------------------------------|-------------------------------|---------------------------------|
| a1   | 113.39                    | 226.508                       | .543                          | .965                            | c1                        | 113.69                        | 219.641                       | .737                            | .964                            |
| a2   | 113.51                    | 223.000                       | .674                          | .964                            | c2                        | 113.70                        | 218.865                       | .770                            | .963                            |
| a3   | 113.58                    | 222.982                       | .673                          | .964                            | c3                        | 113.74                        | 216.756                       | .803                            | .963                            |
| a4   | 113.81                    | 217.875                       | .772                          | .963                            | c4                        | 113.90                        | 214.492                       | .826                            | .963                            |
| a5   | 113.72                    | 220.205                       | .736                          | .964                            | c5                        | 113.83                        | 217.502                       | .663                            | .964                            |
| a6   | 113.83                    | 218.983                       | .649                          | .964                            | c6                        | 113.88                        | 216.669                       | .797                            | .963                            |
| a7   | 113.56                    | 221.253                       | .721                          | .964                            | c7                        | 113.56                        | 222.750                       | .652                            | .964                            |
| b1   | 113.64                    | 221.518                       | .649                          | .964                            | d1                        | 113.99                        | 218.403                       | .674                            | .964                            |
| b2   | 113.83                    | 218.948                       | .726                          | .964                            | d2                        | 114.15                        | 217.353                       | .726                            | .964                            |
| b3   | 114.06                    | 214.184                       | .745                          | .964                            | d3                        | 113.94                        | 218.242                       | .725                            | .964                            |
| b4   | 113.76                    | 218.197                       | .647                          | .964                            | d4                        | 113.99                        | 217.357                       | .741                            | .963                            |
| b5   | 113.59                    | 222.208                       | .607                          | .964                            | d5                        | 113.90                        | 219.891                       | .651                            | .964                            |
| b6   | 113.80                    | 218.795                       | .767                          | .963                            | d6                        | 113.96                        | 217.852                       | .667                            | .964                            |
| b7   | 113.26                    | 227.747                       | .484                          | .965                            | d7                        | 113.97                        | 218.543                       | .639                            | .964                            |

* Item a1-a7 means question 1 – 7 of SMK, Item b1-b7 means question 1 – 7 of IRS, Item c1-c7 means question 1 – 7 of IOC, Item d1-d7 means question 1 – 7 of KSU.

After exploring the item-total statistics, the factor analysis of 28 items would be the next in order to test the constructed validity. By factor analyzing, we tried to examine whether construction of this questionnaire were consistent to four perspectives of PCK we defined or not. Besides, we also checked the definitions and concepts of items which were involved in four categories were accurate or not. Finally, the questionnaire was formed so that we could use it to do the research and explore further.

4.2. Validity

The validity of the new instrument was confirmed in terms of its content and constructed validity. Content validity refers to the extent that the content of the items measure what is claimed to be measured (Anastasi, 1988; Zeller, 1994); in this case content validity was ascertained by responses during the process of developing the instrument, from college students and experienced college teachers. Additionally, the researchers in teachers’ pedagogical content knowledge areas provided comment and critical feedback. According to Zeller (1994), constructed validity focus on the assessment of whether a particular measure relates to the measures consistent with a theoretically anticipated way and this is usually done by factor analysis (Anastasi, 1988). Based on the factor loadings, the items in each category were deleted that had low item-scale correlations from the reliability section and had factor loadings less than 0.40. This study also corresponded with factor analysis: 1. Pilot questionnaire had cited some theories and references associated; 2. Items were clearly divided into few categories (perspectives); 3. All of the items were also defined clearly; and 4. All of the items were checked and revised by some experts (Wu, 2007).

4.3. The factor analysis of four categories: SMK, IRS, IOC, and KSU

In table 3, factor loadings of seven items in SMK were over 0.600 (ranging from 0.762 to 0.860), and the percentage of its total variance explained was 64.514%. For IRS, the factor loadings of its seven items were over 0.600 (ranging from 0.625 to 0.819), and the percentage of its total variance explained was 57.031%. For IOC, the factor loadings of its seven items were over 0.600 (ranging from 0.745 to 0.885), and the percentage of its total variance explained was 67.659%. Finally, the factor loadings of seven items in KSU were over 0.600 (ranging from 0.749 to 0.834), and the percentage of its total variance explained was 64.159%. It revealed that each category could explain the variance of items up to 36% at least, and all of items were retained. After factor analysis with four categories, the items of each category were confirmed approximately. If numbers of distributed items is appropriate, we had better to proceed testing internal consistency of four categories further. After re-testing that, we found the
Cronbach’s alpha value of four categories were still higher (ranging from .871 to .918). In other words, items of each category had a higher internal consistency.

Table 3. Factor analysis of the 28-item instrument in four categories

| Items | SMK  | Items | IRS  | Items | IOC  | Items | KSU  |
|-------|------|-------|------|-------|------|-------|------|
| a3    | .860 | b2    | .819 | c3    | .885 | d3    | .834 |
| a2    | .847 | b1    | .785 | c4    | .881 | d2    | .818 |
| a7    | .823 | b4    | .777 | c2    | .860 | d1    | .804 |
| a5    | .809 | b6    | .775 | c6    | .857 | d6    | .804 |
| a4    | .808 | b3    | .772 | c1    | .769 | d7    | .803 |
| a6    | .739 | b5    | .719 | c7    | .747 | d4    | .792 |
| a1    | .726 | b7    | .625 | c5    | .745 | d5    | .749 |
5. Conclusions

The major contribution of this study was to develop an instrument that could be used to evaluate college students’ perceptions of teachers’ PCK. The findings differ from Major and Palmer (2006) where they used qualitative methods, such as interviews and course portfolios, to describe the process of existing and transforming faculty’s PCK. In our study, we adopted the quantitative way (survey) to analyze and realize the PCK that college faculty members (especially novice teachers) would have. The data analysis indicated that the questionnaire of this study had satisfactory validity and reliability. The uniqueness of the survey was that it was specifically related to college teachers’ knowledge within the particular teaching and learning context. This was important because research had shown college teachers’ knowledge influenced students’ perceptions of the learning environment. Tobin (1996) showed that teachers’ metaphors and beliefs influenced how they taught and implemented the curriculum and their level of content knowledge influenced whether or not students were taught for factual retention or for understanding. Tobin and Fraser (1990) also investigated the teaching characteristics of exemplary science teachers. These effective teachers used not only management strategies to sustain students’ engagement but also teaching strategies such as problem solving activities. Besides, they also provided concrete examples for abstract concepts, asked questions to increase students’ understanding, helped students to engage in both large or small group activities, and maintained favorable classroom learning environments.

In this study, college students expressed that most teachers were insensible to students’ learning difficulties and their prior knowledge, which became the weak point of college teachers’ teaching. Concerning the teaching strategy, college teachers adopted inefficient teaching approach, which couldn’t stimulate students’ interests of learning for certain subject matter. The causes form students’ comments were teachers’ subjective attitude, their explanatory lecture in class, and the speedy procession of curriculum, which couldn’t match up with students’ learning status. The current questionnaire functioned as an instrument to help college teachers understand actively students’ reaction toward the procession of courses, improve the comprehension on students’ learning difficulties, further adopt proper and efficient teaching strategies and achieve a better performance in teaching. Through the reflective research and participation to the PCK workshops, college teachers would amend their teaching approaches and strategies, and further improve their ability in course design (Sykes, 1996; Loucks-Horsely et al., 2003; Dalgarno & Colgan, 2007).

New perspective in further research was concerned about the implementation of the questionnaire as an instrument to investigate college teachers’ teaching results based on PCK. Participants were college teachers from different departments in the campus, not only from the College of Humanities and Education previously. Upon the analysis of the survey collected from university students’ feedback in class as well as the follow-up testing of reliability and validity of the collected questionnaire, college teachers’ auto-examination mechanism was established on the teaching performance and the efficiency related to PCK. The investigation of the questionnaire was planning to be implemented in the middle and the end of semester. Other data sources were collected from personal interviews with teachers, as well as from students’ feedback information, and further examined individual teacher’s improvement of PCK. Furthermore, it also could be designed a teaching or research model for college science teachers to develop their PCK (Jang, in press). The above mention helped to comprehend the interactive condition between college teachers and students in class, which constituted the substantial reference for the college curriculum design and instruction in the future.

References

Anastasi, A. (1988). *Psychological testing* (6th ed.). New York: Macmillan.
Ball, D. L. (1996). Teacher learning and the mathematics reforms: What we think we know and what we need to learn. *Phi Delta Kappan*, 77(7), 500-508.
Carter, K., & Doyle, W. (1987). Teachers’ knowledge structure and comprehension process. In J. Calder-head (Ed.), *Exploring teachers’ thinking* (pp. 147-160). London: Cassel.
Clarke, D. J., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, 18(8), 947-967.
Clarke, D. J., & Hollingsworth, H. (1994). Reconceptualising teacher change. In G. Bell, B. Wright, N. Leeson, & J. Geake (Eds.), *Challenges in mathematics education: Constraints on construction*, Vol. 1. Proceedings of the 17th annual conference of the Mathematics Education Research Group of Australasia (pp. 153-164). Lismore, NSW: Southern Cross University.
Cooney, T. J., & Krainer, K. (1996). Inservice mathematics teacher education: The importance of listening. *International Handbook of Mathematics Education* (pp. 1155-1185). Netherlands: Kluwer Academic Publishers.
Dalgarno, N., & Colgan, L. (2007). Supporting novice elementary mathematics teachers’ induction in professional communities and providing innovative forms of pedagogical content knowledge development through information and communication technology. *Teaching and Teacher Education, 23*(7), 1051-1065.

De Jong, O., Van Driel, J.H., & Verloop, N. (2005). Preservice teachers’ pedagogical content knowledge of using particle models in teaching chemistry. *Journal of Research in Science Teaching, 42*(8), 947-964.

Fullan, M., & Stiegelbauer, S. (1991). *The new meaning of educational change* (2nd ed.). New York: Teachers College Press.

Garcia, L. M. & Roblin, N. P. (2008). Innovation, research and professional development in higher education: Learning from our own experience. *Teaching and Teacher Education, 24*(1), 104-116.

Geddis, A. N., Onslow, B., Beynon, C., & Oesch, J. (1993). Transforming content knowledge: Learning to teach about isotopes. *Science Education, 77*(6), 575-591.

Gess-Newsome, J., & Lederman, N.G. (1993). Preservice biological teachers’ knowledge structures as a function of professional teacher education: A year-long assessment. *Science Teacher Education, 77*(1), 25-43.

Gess-Newsome, J. (1999). Pedagogical Content Knowledge: An introduction and orientation. In J. Gess-Newsome & N. G. Nederman (Eds.). *Examining pedagogical content knowledge* (pp. 3-17). Dordrecht: The Netherlands: Kluwer.

Guskey, T. R. (1985). Staff development and teacher change. *Educational Leadership, 42*(7), 57-60.

Grossman, P.L. (1990). *Mathematics, Science, and Technology Education*. New York: Teachers College Press.

Hasweh, M. (1987). Effects of subject matter knowledge in the teaching of biology and physics. *Teaching and Teacher Education, 3*(1), 109-120.

Jang, S. J. (2008a). The effects of integrating technology, observation and writing into a teacher education method course. *Computers & Education, 50*(3), 853-865.

Jang, S. J. (2008b). *The reports of pilot study for enhancing college teachers' PCK research project*. Chung-Li, Taiwan: Chung-Yuan Christian University.

Jang, S. J. (in press). Developing in-service science teachers’ PCK through a peer coaching-based model. *Journal of Education Research.

Johnson, N. (1993). A celebration of teachers as learners. Paper presented at The Australian College of Education 1993 National Conference: Global Economy, Global Curriculum. Melbourne.

Kyle, W. C. (1994). Editorial. Public language and vision. *Journal of Research in Science Teaching, 31*(10), 1075-1076.

Knight, S. L., & Waxman, H. C. (1991). Analyzing effective teaching of Hispanic students’ problem-solving strategies in Spanish. *NAEY Annual Conference Journal, 1988-1989*. Washington, D.C.: National Association for Bilingual Education.

Lederman, N.G., Gess-Newsome, J., & Latz, M. S. (1994). The nature and development of preservice science teachers’ conceptions of subject matter and pedagogy. *Journal of Research in Science Teaching, 31*(2), 129-146.

Leinhardt, G. & Smith, D. (1985). Expertise in mathematics instruction: Subject matter knowledge. *Journal of Educational Psychology, 77*(3), 247-271.

Lenze, L.F. & Dinham, S. M. (1994). Examining pedagogical content knowledge of college faculty new to teaching. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, Louisiana.

Lieberman, A. (1995). Practices that support teacher development. *Phi Delta Kappan*, 76(8), 591-596.

Lloyd, B. C. and Lloyd, R. C. (1986). Teaching/learning: The student viewpoint. *Reading Horizons, 26*, 266-269.

Loucks-Horsley, S., Love, N., Stiles, K., Mundry, S., & Hewson, P. W. (2003). *Designing professional development for teacher of science and mathematics* (2nd ed.). Thousand Oaks, CA: Corwin Press, Inc.

Loughran, J. J., Mulhall, P. & Berry, A. (2004). In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching, 41*, 370-391.

Major, C. & Palmer, B. (2006). Reshaping teaching and learning: The transformation of faculty pedagogical content knowledge. *Higher Education, 51*(4), 619-647.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A new framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.

Muldolland, J., & Wallace, J. (2005). Growing the tree of teacher knowledge: Ten years of learning to teach elementary science. *Journal of Research in Science Teaching, 42*(7), 767-790.

Olson, L., & Moore, M. (1984). *Voices form the classroom: Students and teachers speaking out on the quality of teaching in our schools*. (ERIC Document Reproduction Service No. ED 252497.)

Reynolds, A. (1992). What is competent beginning teaching? A review of the literature. *Review of Educational Research, 62*(1), 1-35.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*, 4-14.

Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Sykes, G. (1996). Reform of and as professional development. *Phi Delta Kappan*, 77, 465-467.

Tobin, K. (1996). Teacher learning, teacher education and educational reform. In Treagust, D.F., Duit, R., and Fraser, B.J. *Improving teaching and learning in science and mathematics* (pp. 175-189). New York: Teachers College Press.

Tobin, K., & Fraser, B. J. (1990). What does it mean to be an exemplary science teacher? *Journal of Research in Science Teaching, 27*(1), 3-25.

Tobin, K., & Garnett, P. (1988). Exemplary practice in science classroom. *Science Education, 72*(2), 197-208.

Tuan, H.-L., Chang, H.-P., Wang, K.-H. & Treagust, D. F. (2000). The development of an instrument for assessing students’ perceptions of teachers’ knowledge. *International Journal of Science Education, 22*(4), 385-398.

Tuan, H.L., Chang, W.H., Lee, C.K., Wang, C.Y. & Cheng, P.Y. (2000). Developing a Pedagogical Content Competence Evaluation for apprentice physical science teachers – A case study. *Proceedings of the NSC-Part D: Mathematics, Science, and Technology Education, 10*(1), 1-14.

Tuan, H. L. (1996). Investigating the nature and development of pre-service chemistry teachers’ content knowledge, pedagogical knowledge and pedagogical content knowledge. *Proceedings of National Science Council, Part D, Math-Science-Technology Education, 6*(2), 101-112.
Appendix A.

Assessing Students’ Perceptions of College Teachers’ PCK

Directions for students:
This questionnaire contains five statements about teaching practices which could take place in this class. You will be asked how often each practice takes place. There are no "right" or "wrong" answers. Your opinion is what is wanted. Think about how well each statement describes what this class is like for you. You will be asked to describe freely your personal comments to the course in the end. Be sure to give an answer for all questions.

Draw a circle around

1. if teaching practice takes place Never
2. if teaching practice takes place Seldom
3. if teaching practice takes place Sometimes
4. if teaching practice takes place Often
5. if teaching practice takes place  Always

| A. SMK (Subject Matter Knowledge) | C. IOC (Instructional Objective & Context) |
|----------------------------------|------------------------------------------|
| 1 My teacher knows the content he/she is teaching. | 1 My teacher makes me clearly understand objectives of this course. |
| 2 My teacher explains clearly the content of the subject. | 2 My teacher provides an appropriate interaction or good atmosphere. |
| 3 My teacher knows how theories or principles of the subject have been developed. | 3 My teacher pays attention to students’ reaction during class and adjusts his/her teaching attitude. |
| 4 My teacher selects the appropriate content for students. | 4 My teacher creates a classroom circumstance to promote my interest for learning. |
| 5 My teacher knows the answers to questions that we ask about the subject. | 5 My teacher prepares some additional teaching materials. |
| 6 My teacher explains the impact of subject matter on society. | 6 My teacher copes with our classroom context appropriately. |
| 7 My teacher knows the whole structure and direction of this SMK. | 7 My teacher’s belief or value in teaching is active and aggressive. |

| B. IRS (Instructional Representation & Strategies) | D. KSU (Knowledge of Students’ Understanding) |
|-----------------------------------------------|---------------------------------------------|
| 1 My teacher uses appropriate examples to explain concepts related to subject matter. | 1 My teacher realizes students’ prior knowledge before class. |
| 2 My teacher uses familiar analogies to explain concepts of subject matter. | 2 My teacher knows students’ learning difficulties of subject before class. |
| 3 My teacher’s teaching methods keep me interested in this subject. | 3 My teacher’s questions evaluate my understanding of a topic. |
| 4 My teacher provides opportunities for me to express my views during class. | 4 My teacher’s assessment methods evaluate my understanding of the subject. |
| 5 My teacher uses demonstrations to help explaining the main concept. | 5 My teacher uses different approaches (questions, discussion, etc.) to find out whether I understand. |
| 6 My teacher uses a variety of teaching approaches to transform subject matter into comprehensible knowledge. | 6 My teacher’s assignments facilitate my understanding of the subject. |
| 7 My teacher uses multimedia or technology (e.g. PowerPoint) to express the concept of subject. | 7 My teacher’s tests help me realize the learning situation. |

Comments:

In this course, if you have any learning difficulty or opinion, please describe it as follows.

_____________________________________________________________________________________________

Thanks for filling in this questionnaire