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INITIAL IDEAS OF PROSPECTIVE PHYSICS TEACHERS CONCERNING TEACHING AND LEARNING DURING A SEMINAR FOR DEVELOPING PCK

V. Grigoriou, G. Kalkanis
University of Athens, Pedagogical Department P.E., Science Technology and Environment Section, Science Technology and Environment Laboratory, Greece
vgrigor@primedu.uoa.gr,
kalkanis@primedu.uoa.gr
e_site: http://micro-kosmos.uoa.gr

Abstract. *The purpose of this qualitative research was to discern the beliefs that Greek student Physics teachers hold at the beginning of a seminar concerning professional knowledge and instructional practices.* Six postgraduate student teachers who were at the second year of their master degree at Science Education participated and semi-constructed interviews were conducted in order to capture their views. Epigrammatically the conclusions show interesting consistency among each other's beliefs but inconsistency between their own. Students mention that they prefer an inquiry based instructional strategy, focusing especially on hands-on experiences, but later on they refer to actions that reveal a transmissive nature of instruction.

Keywords: beliefs, PCK, Physics teachers, prospective.

1. Background, framework

1.1. The concept of Pedagogical Content Knowledge

The concept of PCK (Pedagogical Content Knowledge) is an evergreen topic at the field of teaching and learning Science for more than thirty years, having led to a rising interest in what are important aspects of professional action competence of Physics teachers and how they develop.

It was proposed by Lee Shulman at the mid of 80's as "a special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" [16]. He further proposed several key elements of pedagogical content knowledge: (1) knowledge of representations of subject matter (content knowledge); (2) understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter; (3) general pedagogical knowledge (or teaching strategies); (4) curriculum knowledge; (5) knowledge of educational contexts; and (6) knowledge of the purposes of education [17].

After the initial intromission of the concept of PCK has become a widely useful and used notion and a lot of proposals have been made as didactical strategies that can materialize this basic concept. Although there has been no consensus on the PCK models and components, all scholars agree on Shulman's two key elements - that is, knowledge of representations of subject matter and understanding of specific learning difficulties and students' conceptions [19].

1.2. A seminar for developing PCK

The notion of PCK arises as one of the most crucial subdomains (e.g. [11], [17]) of teachers' professional knowledge and it becomes more appealing when it has to do with prospective Physics teachers as the demand to broaden their PCK is even more intense.

Motivated from previous research efforts ([7], [8], [9]) which imply that Greek prospective Science teachers form only a very primitive PCK, emerged the need to provide them appropriate educational support in order to expand their professional knowledge.

Therefore, a seminar was designed in order prospective Science teachers being sensitized to the notion of PCK and to align better the content matter to be taught with pedagogy so that the content might be better understood by their students. Thus, the seminar was aiming at the development of their teaching in ways that might be described as more meaningfully directed as a result of their better understanding and valuing of their PCK.

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The seminar draws attention to the value of student-teachers participating in experiences that might contribute to the development of their PCK. Its syllabus contains concepts of general didactics, educational use of technology and authentic opportunities of instruction ([10]).
Clermont, Krajcik, and Borko [5] have studied the effects of a short, intensive workshop on specific teaching strategies (i.e., chemical demonstrations). They found that the PCK of preservice science teachers participating in this workshop developed towards that of expert teachers. Van Driel J., De Jong O. & Verloop N. [20] mention that "specific courses or workshops during teacher education have the potential to affect PCK, for instance, by extending preservice teachers' knowledge of students' preconceptions or their knowledge of specific representations of subject matter."

1.3. Participants views on teaching and learning

The investigation of participants' initial perceptions about teaching and learning becomes a focal point within the context of design and implementation of a training program aiming at the development of prospective Physics teachers' PCK. Research shows that beliefs about content, about pedagogy, and about teacher education are central to teachers' development [23]. Brickhouse & Bodner [2] report the importance of beginning science teachers' beliefs about science and science teaching on classroom instruction. Britzman [3] suggests that teachers come to the classroom with deeply held beliefs about what teaching is. Wentworth & Pinnegar [21], report that teachers often made projections from their past experiences as students about how they would be or want to be in the future when they would be teachers. Older beliefs are the most resistant to change because, when they are tested, individuals tend to recall information, however conflicting, in a way that will sustain their own beliefs [15]. It is not surprising then that classroom instruction and teacher practices are consistent with the beliefs that teachers hold ([4], [6], [13]). These perceptions have already shaped their knowledge bases and direct their lesson enactment therefore their study could provide a greater insight into ways in which those views affect their teaching practices.
Thomas and Pedersen [18] stress that the prior beliefs act as a filter. Previous life experience impacts on the way preservice science teachers perceive science courses. When new information is presented to prospective teachers, only information in agreement with their prior knowledge is likely to be accepted and alien ideas will be rejected. Gullberg et al [12] underline the importance of science educators providing opportunities for prospective teachers to highlight their personal theories and beliefs and reflect upon them. Also, studies show that student-teachers are commonly disappointed with their teacher education programmes ([14], [22].

2. Purpose and research questions

The purpose of this qualitative research was to discern the beliefs that student Physics teachers hold at the beginning of a seminar concerning professional knowledge and instructional practices. The intent was to capture and succinctly portray the general views of teaching and learning held by each participant before they were introduced to PCK

Specifically, our research survey concerns:

- Prospective Physics teachers views on teaching.
- Prospective Physics teachers views on learning.
- Prospective Physics teachers views on teaching science.

3. Methods

In order to answer the research questions, we conducted a semi constructed interview in five Prospective Physics teachers. As semistructured interview protocols, the interviews deviated from the set questions when necessary, in order to allow each participant to add their own rich flavor to their responses.

3.1 The sample

The sample consisted of five Greek student teachers during their master degree at Science Education, who were voluntary offered to participate and had expressed their will to follow Science teacher carrier. The students would next attend the educational seminar which aims at the development of their PCK. All of them didn't have any teaching experience at all in school context, apart from tutoring high school students.

3.2 The interviews

All interviews were conducted individually and in a quiet location and generally took about an

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hour each. They were audio-recorded and also during the conduct researcher kept notes.
Interview had two parts: questions about the participants' background in science teaching; and then, questions on their views of teaching and learning. The background questions primarily investigated the participants' prior experience in teaching and learning science.
The second part of the interview consisted of questions which were designed to be open-ended to stimulate and encourage teachers to discuss and share their views. Teachers were asked to provide broad responses about what the terms 'learning' and 'teaching' meant to them. They were also asked: what are the indicators that student learning has occurred?; what knowledge and skills do successful teachers need in preparing to teach?; how has your teaching changed with experience?; how does the notion of reflection influence your views of teaching?; how do you value the role of being a professional teacher?; They were also asked whether content influences their teaching approach, how and why?; if they vary their teaching approach for certain concepts in Science or is the whole unit taught the same way?; and what difference does it make when they are teaching content that they are familiar with as opposed to content that they are not familiar with?

3.3 Analysis

Once all of the five participants' first interviews had been completed and fully transcribed, the data were organized and analyzed in individual cases.
In analyzing the data, a funneling approach was adopted [1]. Initially, the data were collated and fragmented under major views or themes for each participant and then, through the funneling process, more detail in each major view or theme was extracted. In undertaking this process, sub-themes and sub-views emerged and these were created for some of the major views and themes, thus providing a more elaborate analysis.

4. Results

For each one of the participants a comprehensive description is presented.

4.1 Jim

Jim completed a Ptychion degree (four years studies) of Physics and now he is a student at a Master degree programme at Science Education. He especially admitted that gas theory remained a difficult content area for him. It was clear from his interview that he really wanted to become a Science teacher "I wanted to become a teacher since my childhood".
Jim saw teaching as a path that will lead students to new knowledge: "I believe that (teaching) has to do with leading children's minds from their beliefs to a knowledge, which is right". He was very determined with the effort to have students the big picture of the content and not just fragmented mathematical knowledge "I don't want them just to tell me the definition or the equation. I want them to make connections". Believing in such approach, he was also aware that an important part of teaching was the method or approach used in conveying knowledge. He proposed using hands on experimentation as a prominent tool for an inquiry based learning.
It appears that Jim considers that teacher should not act as a transmitter of knowledge; he should become a facilitator of learning. Teacher should be able to transform scientific knowledge to that form that would be easily accessible from his particular students: "Me as a teacher I should make the appropriate transformation to the content. I should present it to them in a way that they can understand it, having in mind the difficulties that they make face". This remark is rather interesting because it describes quite accurate the notion of PCK, although Jim has never listen before anything about it.
When Jim was asked to describe what the term "learning" meant to him, he answered that it means conceptual change from a prior state of knowledge to a more scientific one. He wanted to link learning with students' ability to explain the real world and all these been seeing from the angle of the scientific methods: "I should provide students the right 'accoutrements' and knowledge so that they can interpret phenomena that happen in their environment. It is not (learning) just a matter of equations".
Jim believes that the experience that a teacher gains throughout the years, affects directly teacher's practices, expanding his professional knowledge: "I have learnt a lot from all these years as a tutor. Now I can see details that in the past seemed meaningless to me. I have also learnt a lot from my colleagues".

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4.2 Bill

Bill more or less shares the same background with Jim as both of them have attended the same studies. He stated that he likes Physics but he is not very keen on Chemistry and Biology. Later on he continues saying: "To be honest, I believe that Physics is more important than other disciplines".

What he likes about teaching is that he can lead students to format a framework of explanations with a wide field of application. For him it is of high priority to familiarize students with scientific method, which he considers to be the most valuable tool to explain the world and it can be used in a great variety of circumstances, not only for the natural world: "Science has a particular structure and use specific methods that I really want students to learn. It is useful for them; they can use it anywhere". He mentioned that a good teacher should make appropriate links across disciplines and everyday life, helping students to appreciate Science accordingly.

Bill recognized that teaching is difficult. He believed that teacher must have a very well developed content knowledge, which is much more important than the pedagogical knowledge "If you have the content, then the rest will follow". Later on he expressed the opinion that content doesn't make any difference at the instructional approach, as long as teacher is suitably prepared at the content knowledge; "It doesn't matter if you have to teach electricity or mechanics; you will use the same method. All it matters is to know the subject".

Bill described learning as acquiring new knowledge and handling adequately the scientific method. Learning has to do with what a student experiences: "Learning is what a student experiences, so it has to do with students". He placed a great emphasis on students' misconceptions especially at the actions that he should take in order to address them and less at the required actions to expose them. The most supportive tools to this direction were experimentation and putting triggering questions: "When students start experiments, you can define their misconceptions. Also, you can ask them questions in order to reveal them".

He felt rather comfortable with technology and he believed that it could promote students' learning, especially simulations: "It is easy for me to make a quick simulation e.g. to show chemical bond at the molecule of water and then explain why water is such a good solvent". He believed that teaching should be more inquiry-based rather than having students rote learn

4.3 Jenny

Jenny was also a postgraduate Physicist who is continuing her studies for a master degree at Science Education. She doesn't feel very confident with her content knowledge, nor with the pedagogical knowledge that is required to teach in primary school, recognizing that she feels more comfortable with a traditional instruction with exercises and equations rather than 'teaching for understanding'. She states that University faculties don't provide to their students the required professional knowledge in order to become successful teachers.

Jenny said that she enjoys teaching but not in the way that she had experienced in her childhood or during tutoring high school students. She believes that teaching is interesting because the teacher has to know his students and engage them with Science: "Teaching means that you have to understand students, trying to find what they are thinking and how you can help them". Jenny specifically pointed out that the teacher's role has to do with organizing appropriate strategies in order to structure and sequence teaching in a way that might enhance the learning process. She recognizes that students face difficulties in certain topics of the content and she is very conscious about their misconceptions.

Learning for Jenny is the process that students experience in order to expand their knowledge. Learning has to do with the student. When it comes to the point to mention some indicators of students learning, she answers: "Their ability to apply their knowledge". She also declares that learning has happened when students maintain for a long period their knowledge.

4.4 Julia

Julia was the only participant who wasn't a Physicist. She was a Geologist who was also continuing her studies for a master degree at Science Education. She had also made some studies in drama, which she considered quite useful for her professional knowledge.

At the interview she mentioned with enthusiasm that she really enjoyed teaching "I really like teaching! Yes!". Julia said that she likes to contribute to students' learning and that she finds

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Science stimulating for both the teacher and the students, contrary to other lessons such as language. For Julia it is important her students to recognize her efforts: "You see, I would like my students to remember me in the future, as their favorite teacher".

Julia appeared to subscribe to the view that learning is a personal issue which means that the teacher has to personalize his teaching in order to facilitate each one student and to recognize the difficulties he might face. She considers that learning happens when students are becoming able to apply their knowledge in everyday problems and link it with other principles: "For me, I assume that a student has learnt when he can link his knowledge with other facts, when he can answer questions from real life".

Julia viewed teaching as a 'facilitating action' that teacher should make the appropriate decisions in order to engage students with Science. She mentions that teaching must be interesting and that could happen with interactivity: "Teaching as telling is much more bored as opposed to teaching for learning."

Teaching is for her an action which requires an expanded content knowledge, alongside with self-confidence and experience. She reverts to experience later on when she mentions that she had expanded her professional knowledge more because of her gaining experience as a tutor, than because of her studies at the master degree programme: "I compare myself know with myself five years ago and I find her much better, leaving apart my studies. Experience is a very important factor (for teaching)". She recognizes teaching as a demanding procedure, which during the ages as teacher gains more experience becomes easier to perform.

When she is called to describe what knowledge and skills do successful teachers need in preparing to teach, she is referring to actions such as self-reflection, producing his own educational material and above all to consider his students. For Julia is important that the teacher would take seriously account the conditions that take place in the classroom and therefore change his planning according to the circumstances. Thence, she plumped for a flexible teacher who ranks higher students stimulation and engagement with Science.

4.5 Mary

Mary was also a postgraduate Physicist who is continuing her studies for a master degree at Science Education. She doesn't feel very confident with her content knowledge, especially with Chemistry and Biology. She says: "I would grade my knowledge in Physics with five, while I will give only one to Chemistry and Biology". She also describes herself as a person with low self-estimation. She really enjoys teaching Science, as "It has always been a dream for me"; she likes the contact with the children and especially with students at high school. It is important for her students to appreciate her: "I want my students to remember me".

Mary viewed teaching as a means of assisting students to broaden their knowledge: "Teacher's role is to support student to acquire new knowledge that they can use it later in the following school years". At the first years she considered teaching as a rather easy activity, but later on while she continued her studies she started to recognize significant difficulties. She mentions that a successful teacher should plan his actions so that students would move beyond boniness to a deeper formation of knowledge. Experimentation could be a valuable tool at this effort.

Mary described learning as a personal activity that students experience and expands their existing knowledge: "Learning is something that you experience and from now on is belongs to you forever". It links learning with students: "Learning has to do with the students and how they can assimilate new knowledge"; and teaching with the teacher: "Teaching is a matter of the teacher. Teaching is a tool and learning is a path".

5. Conclusions

Results show interesting consistency among each other's beliefs in the areas of teaching and learning that concerns students' engagement with Science. They all demonstrate views which suggest that teaching should be attractive and that teacher's role is to provide a facilitating learning through assisting and guiding the students.

A prominent educational means to achieve that goal are practical activities, so they highly value the act of 'doing' more so than just 'hearing' about the content. They feel rather confident in preparing and performing appropriate experimentation and they all adopt physical experimentation rather than virtual, whereas this is feasible.

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They are of the opinion that knowledge should not be static, in the contrary it should be in a dynamic relation with real life, exciting students' curiosity and stimulating their learning in meaningful ways. They don't only want to show that science is relevant in their lives, but they also want to lead students to trust science methods in a variety of circumstances.

Another common belief is that the teacher should have an extended knowledge of content, a prerequisite for them in order to make fruitful links and projections with other disciplines and also to confront students' misconceptions. Content knowledge is acknowledged by the participants as a focal point mentioning it when they are asked to describe teaching difficulties. But they don't all agree at the statement that their teaching approaches were influenced by this knowledge.

When they are asked to describe teaching and learning generally, they repeatedly state views which reveal that their teaching is student oriented. But unfortunately, when they are asked to depict specific actions that they are willing to take at specific circumstances, they often describe educational strategies which elevate the transmissive delivery of content. This could mean that their pedagogical knowledge is not only limited but also fragmented, showing inconsistency between their own views.

Also, it is interesting the fact that although they noted reflection as an important procedure which would help them to evaluate and refine their skills, they hardly mentioned that they would use reflection's conclusions when they would come to prepare their lesson, nor that they take notes after the lesson enactment. This could mean that reflection is an emotional approach for them, that takes place after a lesson and they don't use it as criterion in future instruction.

6. Discussion-Implications

As it has been mentioned previously the investigation of participants' initial perceptions about teaching and learning becomes a focal point within the context of design and implementation of a training program aiming at the development of prospective Physics teachers' PCK.

First of all it would provide the required information about their beliefs and their expectations, which will contribute at the syllabus' formation. It is more likely then that the information that would be presented to them would be more easily accepted.

Secondly, it is a starting point for the effort to portray attitudes that might reveal aspects of PCK. Of course, this documentation could not act as the unique resource for capturing PCK, but it could be used auxiliary with other means, such as lesson preparation tasks, reflection upon videotaped lessons, discussions with experienced teachers.

A concern that might arise according to the followed methodology is its phenomenological nature. This means that researcher is forming careful descriptions from the participants' perspective on the phenomena which they experienced. A danger with interviews is that the interviewee may provide the interviewer with information that they perceive the researcher wants to hear. Another weakness of these studies might be in the researcher's interpretation and analysis of the data. These weaknesses can be limited if other sources of data, like these that are stated previously, would be used in parallel, so that through triangulation would be provided better credibility to the methodological design of the study.

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