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The Effects of Professors' Pedagogical Content Knowledge on Elementary Teacher Candidates' Attitude and Achievement Regarding Biology

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KEYWORDS Pedagogical Content Knowledge (PCK). Professors. Attitude and Achievement. Life Science Teaching. Biology

ABSTRACT The focus of this study was to investigate whether professors' pedagogical content knowledge has an impact on Elementary Education [ELE] teacher candidates' achievement and attitude regarding Biology course. The subjects of the present study consisted of 60 first grade ELE teacher candidates in two classes and two professors (2 males) teaching Biology in these classes. ELE teacher candidates were required to draw human body and complete the scale of attitude toward life science. On the other hand, individual interview was conducted with two professors. The results showed that ELE teacher candidates who enrolled in professor-A's (who has a student-centered approach) class had or at least tended to have more positive attitudes toward Biology than those who enrolled in professor-B's (who has a teacher-centered approach) class.ELE teacher candidates who attend professor-A class had higher achievement in the Biology course than those who attend professor-B class.The study also examined whether attitudes are associated with achievement measured by participants' drawing of human bodily function by utilizing multiple linear regression, but showed no significant effect of attitude toward life science on achievement regarding Biology.

INTRODUCTION

Knowledge about anatomy and physiology of a human body cannot be recognized only as an additional issue from the list of the academic disciplines but has a central role in a human life. The reason is that humans are living in their bodies and bodies are what make possible interactions with the others and the environment. Teaching human anatomy and physiology can be from this point regarded not only as one of the central issues in science education but in education as a whole. If someone is in search for usefulness as a criterion for inclusion of a topic in formal education then it is easy to recognize that lack of knowledge about human body and processes inside can lead to problems with person's own physical and psychological health and can cause damage to the others. The problem is even greater if we recognize that not only individuals and a couple of their relatives around them, but a society as a whole are affected. Some of the examples are the problems with body mass, birth control, recognition of pathways of the disease transmission (Chen et al. 2007; Florez et al. 2009; Mazor et al. 2010). For a teacher, human anatomy and physiology are probably one of the most complex issues to be taught. The reason is that for understanding even the basic processes, a teacher not only needs to know the basics of life science, chemistry, and physics, but social issues as well.

On the other hand, students have beforehand many misconceptions about their body (Sorgo et al. 2008) what adds additional load to teaching. The reason is that prior knowledge is not easily changed, and works as a filter for new information (Chinn and Brewer 1993). Source of misconceptions are some of them are naive presentations developed already in elementary years, some are a part of common knowledge and some can be even induced by teachers and their teaching. It cannot be declared that what students should know about their bodies at the end of their schooling should basically be basedon what Science, and later on Life science teach-

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ers had taught, but start already in early education. Basic information about human body is already a part of pre-school and elementary school curricula. So the teachers working at this level should be perfectly trained on human anatomy and physiology not only to give students basic insight into their bodies' but also to prevent their misconceptions in the future. These misconceptions developed can be so deeply rooted in early education years that teachers at upper levels cannot transform.Interest among researchers about students' conceptions about human anatomy is an evergreen theme and several research studies were undertaken on this subject last decades (Tunnicliffe and Reiss 1999; Teixeira 2000; Reiss and Tunnicliffe 2001; Reiss et al. 2002; Šorgo and Hajdinjak 2004; Prokop et al. 2009). The results of these studies revealed misconceptions and poor knowledge of students in many cases.

In agreement with several conventional ways of gathering information about students' knowledge (White and Gunstone 1994), these studies also differ in using different methods to examine children's mental models. In several investigations, Tunnicliffe and Reiss (1999a, b), Reiss and Tunnicliffe (1999, 2001), and Šorgo and Hajdinjak (2006), used the method of children drawing where they asked children "Draw what you think is inside your body". Their approach has been criticized by Khwaja and Saxton (2001) who found out that the type of the task could significantly affect results obtained in these studies. They showed that if the question is more specific ("Draw the bones that are inside your body"), children's expression of mental model of a particular organ system is on a higher level and thus more appropriate in comparison with Reiss and Tunnicliffe's (1999) "general instruction." Furthermore, Prokop and Fanèovièová (2006) did not find correlation between what students drew and what he/she knew about particular organ or organ system. Thus, more frequent drawings of some organs (for example, a heart) do not mean that these organs are better understood by students. In addition, Bahar et al. (2008) investigated the university students' understanding of heart. They asked the students to draw the shape and the parts of hart for data collection. More recently, Prokop et al. (2009) used drawing method to collect data from the examples with pupils aged 10-14 years. They obtained data from two different perspectives; one based ongeneral instruction for students (*What you think is inside your body*) and another more specific instruction (for example, *Draw bones that are inside your body*). They found that more specific instruction lead to more precise drawings of particular organ systems supporting earlier criticisms of Khwaja and Saxton (2001) and Prokop and Fanèovièová (2006). The findings from these studies do not feed only scientific curiosity but can be regarded as lighting houses for practitioners to prepare lessons plans and strategies for assessment of their teaching practices.

To overcome rote memorization and learning of facts about human body and to enhance understanding of relations among different body parts and connections between anatomical structures and functions teachers not only have to possess content knowledge about human body but have to be equipped with instructional strategies (pedagogy). The relationship between instructors' pedagogical content knowledge (PCK) and learners' understanding ofthe subject has been investigated for some decades within the scientific community. Last decades, researchers have revealed the positive effects of teaching approaches adopted by the instructors on student achievement, retention and attitudes in environmental education (Erdogan and Usak 2009). There are some other factors (for example, traditional vs. alternative assessment techniques), which are examined by researchers and educators and claimed to have an impact on studentachievement and attitudes toward science. PCK is one of these factors playing an important role in teaching and learning process (Usak et al. 2011)

According to Shulman (1987) the knowledge bases for the teaching profession consisted of seven components; content knowledge, pedagogical content knowledge, curriculum knowledge (content related) and general pedagogy, learners and their characteristics, educational contexts and educational purposes.The concept of "pedagogical content knowledge" (PCK) was first introduced by Shulman (1986) and defined as teachers' ways of representing and formulating the subject-matter knowledge in the context of facilitating student learning (Shulman 1986). Grossman (1990) stated that PCK consists of knowledge of strategies and representations for teaching particular topics and knowledge of students' understanding, conceptions, and misconceptions of these topics. He determined that PCK

is generated and developed from the sources as observation of classes both as a student and as a student teacher often leading to tacit and conservative PCK; disciplinary education which may lead to personal preferences for specific purposes or topics; specific courses during teacher education of which the impact is normally unknown and classroom teaching experience. The other conceptualization of PCK in the literature is proposed by Driel et al. (1998) concluding that all scholars agree on the components of PCK as the knowledge of students' learning difficulties, conception and misconceptions of the topic and the knowledge for representing specific topics.

A review of research studies on PCK revealed to includea wide variety of ages from elementary school to higher education (for example, Driel et al. 1998; Usak 2009; Usak et al. 2011). Although importance of many components of PCK, especially the content included in elementarycurriculum (what to teach) and the teaching pedagogies used to teach such content (how to teach), are usually emphasized separately in different research (Bredekamp and Rosegrant 1992; Conezio and French 2002; Hoorn et al. 1993; Huffman 2002; Tsitouridou 1999), there are very few studies about PCK in elementarylevel.

Cochran et all. (1993) proposed an integrative model for teacher preparation helping teachers develop PCK. Many researchers were agreed that the research on topic-related PCK may complement with the research on student learning of specific topics, and there was bidirectional process involving deepening of subject matter knowledge and increasing awareness of pedagogical issues (Van Driel et al. 1998; Van Driel et al. 2002; Sperandeo-Mineo et al. 2006; Henze et al. 2008). Another study conducted by Abd-El-Khalick (2006) emphasized that the role of teaching experience in developing teachers' PCK should be incorporated into theorizing the construct of PCK. Similarly, Driel (2005) deduced that the pre-service teachers developed variously their PCK through learning from teaching. The relationship between subject matter and pedagogical content knowledge has also been investigated by some researchers. For example, Segall (2004), argued that the focus of teacher education on pedagogical content knowledge should move beyond the idea of teaching students pedagogical content knowledge to help them recognize their inherently pedagogical natureand its implications for (and in) teaching.

In science education literature, a few scholars have recently studied science teachers' subject matter knowledge (SMK) and PCK. Rollnick et al. (2008) have used case studies to explore the influence of subject matter knowledge on pedagogical knowledge (PCK). They were finding out the teachers' practice, especially to highlight the role of SMK, and therefore offer interesting insights into the nature of PCK and its influence on science teaching.

Käpylä et al. (2008) have sought to investigate the effect of the amount and quality of content knowledge on pedagogical content knowledge, in which are photosynthesis and plant growth used as an example. Their sample consisted of 10 elementary and 10 secondary (life science) pre-service students. They found out that elementary pre-service teachers were not aware of students' conceptual difficulties and had problems in choosing the most important content.

In addition, Park and Oliver (2007) indicated that PCK was developed through reflection-in-action and reflection-on-action within given instructional contexts, teacher efficacy emerged as an affective affiliate of PCK, students had an important impact on PCK development, students' misconceptions played a significant role in shaping PCK and PCK was idiosyncratic in some aspects of its enactment. Loughran et al. (2001) examined science teachers' PCK and ways in which their knowledge might be captured, articulated and portrayed to others. The results of this study offered new ways of conceptualizing what pedagogical content knowledge is and how it might be captured, documented and disseminated. Similarly, Drechsler and Driel (2008) investigated PCK of nine experienced chemistry teachers. The results showed that, although all teachers recognized some of the students' difficulties as confusion between models, only a few chose to emphasize the different models of acids and bases. Most of the teachers thought it was sufficient to distinguish clearly between the phenomenological level and the particle level.

Effects of Elementary Teachers' PCK on Student Achievement

Pedagogical content knowledge is the knowledge of how to teach (Lenhart 2010). For Elementary students teaching how to teach is much more important than what to teach, since if one teacher know his/her subject area very well, but

has lack of knowledge on how to teach, s/he cannot be effective in the class and during the instruction.

As far as elementary students' achievement in the subject of science considered, by the end of the elementary school students should know that, when a new material is made by combining two or more materials, it has futures that are different from the original materials. Because of that, a lot of different materials can be made from a few simple types of materials. Varieties of changes occur faster under hotter conditions. Before learning these content areas, students in earlier grades have already learned about objects in terms of the materials that they are made of and their physical properties. Students should also know that when reactions are done to change some of the properties "not all materials respond the same way to same reactions conditions. (Ogletree 2007)

Effective Elementary teachers of specific important concept areas of science must take into consideration that, in young children, abstract thinking does not emerge until the ages of 7 and 8 and does not increase to a large degree before the age of 9 NAEYC (2009). Elementary teachers need avoid abstract teaching and provide more hands on activities for students before the age of 9. Knowing the pedagogical content knowledge and *developmentally appropriate curriculum* for before and after the age of 9 can assist elementary teachers reach a higher degree of student achievement.

As NAEYC (2009) defines it, *developmentally appropriate practice* (DAP) is a framework of principles and guidelines for best practice in the care and education of young children. It is grounded both in the research on how young children develop and learn and in what is known about education effectiveness. The principles and guidelines outline practice that promotes young children's *optimal* learning and development.

Effective Elementary teachers of specific important concept areas of science must have an adequate level of PCK to assist students in constructing knowledge that can be demonstrated in measures of learning outcomes. It is important to examine the needs of elementary teachers to prepare them for teaching specific science concepts. (Ogletree 2007)

Knowing the pedagogical content knowledge in each of the important concept areas of science can assist college professors of Elementary Education departments in developing helpful curriculum materials for pre-service elementary teachers to teach science concepts in a way that enhances students' learning and development.

Ogletree (2007) study investigated the impact of elementary teachers' existing PCK when teaching chemical changes as part of properties and changes in matter in a physical science unit for fifth grade students. The study participants were 18 fifth grade science teachers in a suburban intermediate school in the Southeastern United States. A sample of seven teachers was selected to participate. Study included background and demographic questions, individual structured interviews, classroom observations, narrative forms of teachers' thoughts and actions, PCK rubric scores, teachers' journals, and students' responses to questions about chemical changes and reactions.

Ogletree (2007) study supported the need to strengthen teachers' pedagogical content knowledge when teaching science concepts. The research found that:

There are characteristics of participant teachers' backgrounds that affected their teaching of chemical change. These teachers did not have enough content knowledge in physical science, specifically chemical change, because they had not taken satisfactory university courses towards this subject. Not having professional development in physical science prevented these teachers from knowing about various ways of presenting science concepts.

Content knowledge, knowledge of students' cognitiveskills, knowledge of how to present science concepts for student learning developed through professional development, collaboration, and leadership roles were characteristics of PCK that caused differences in student achievement.

Teachers used hands-on activities and allowed students verbally participate had higher PCK scores. Science PCK of these teachers impacted student achievement (Ogletree 2007).

As aforementioned, limited research on the PCK of elementary teachers candidates were undertaken and this research focused upon different facets of PCK, there is no research found thatspecifically examines PCK of university scholars and its relationship with Elementary [ELE] teacher candidates' achievement and atti-

tude towardlife sciencemore specifically the Human Anatomy and Physiology course, which is one of the required courses for ELE teacher candidates in Turkey. The question remains,if university scholars are producing misconceptions or alternativeswith their own way of teaching. The current study aims to address the gap in the literature and fill it at least a little by focusing on ELE teacher candidates' PCK in the discipline of life science, more specifically Human Anatomy and Physiology in this study.It is essential to state that since the course called "the Human Anatomy and Physiology course" involved the discipline of biology, the terms "biology" and "human anatomy and physiology" will be used interchangeably in this study.

Objectives

This study focused on revealingwhether professors' pedagogical content knowledge regarding Human Anatomy and Physiology subject in the Biology course has an impact on ELE teacher candidates' achievement and attitude regarding biology course, acknowledging that raising their achievement is only one of many facets of teachers' job.For several years, teachers' pedagogical content knowledge has been assessed through variety of ways and using instruments. Except for few studies that utilized mixed research approach (Abd-El-Khalick 2006), researchers generally tended to use research designs within the qualitative research paradigm to collect data for PCK studies (Usak 2009; Lee and Luft 2008; Binderghal and Eilks 2009). In the present study, both qualitative and quantitative methods were mixed to serve in-depth understanding and insight regarding the purpose and to triangulate the results. Qualitative method was preferred to examine professors' PCK on Human Anatomy and Physiology while quantitative method was used to explore the effects of professors' PCK on ELE teacher candidates' achievement and attitudes toward Human Anatomy and Physiology. Four research questions addressed in the study were as follows:

1. What is the professors' PCK level regarding biology?
2. To what extend does the effect of professor A differ from professor B regarding ELEteacher candidates' achievement in the biology course?
3. To what extend does the effect of professor A differ from professor B regarding ELE teacher candidates' attitudes toward the biology course?
4. Do ELE teacher candidates' attitudes toward biology influence their achievement on human body and organs?

MATERIAL AND METHODS

Design and Subjects of the Study

The subjects of the present study consisted of 60 (37 male, 23 female) first grade ELE teacher candidates in two classes, and of two professors (both are males) teaching *human body and organs* to these classes. The average age of ELE teacher candidates was 20.5. Professor-B has been experienced on anatomy, general life science and life science education for 15 years whereas professor-A has been experienced on Basic Science for 18 years. Two classes were already existed, but at the end of the semester, two professors were randomly assigned to these classes without looking at the background of the students in that class. There were 29 ELE teacher candidates in the class-A offered by professor-A while there were 30 ELE teacher candidates in the class by professor-B. Moreover, some of the external factors (for example, assigned homework, in-class work hours, course book and grading) that can have an impact on achievement were controlled.

Data Collection Instruments

Various data collection instruments were utilized in order to triangulate the data collected from both students and instructors. ELE teacher candidates were required to draw human body and complete the scale of attitude toward biology. On the other hand, individual interview was conducted with two professors.

Drawing Form

ELE teacher candidates were given a sheet on which "*Draw what you think is inside your body*?" was written and they were required to draw the inside of human body. Their drawings were scored across seven point scoring rubric developed and used by Reiss and Tunnicliffe (2001) to examine general knowledge about *human body and organs* (Table 1).

Table 1: Seven point scoring rubric for organ systems

Level 1	No representation of internal structure
Level 2	One or more organs (for example, bones and blood) placed at random
Level 3	One internal organ (for example, brain or heart) in appropriate position
Level 4	Two or more internal organs (for example, stomach and intestine) in appropriate positions but no relationships indicated between them
Level 5	One system indicated (for example, gut connecting head to anus or connections between heart and blood vessels)
Level 6	Two or three major systems indicated out of skeletal, circulatory, digestive, gaseous exchange, reproductive, excretory and nervous
Level 7	Comprehensive representation with four or more systems indicated out of skeletal, circulatory, digestive, gaseous exchange, reproductive, excretory and nervous

Biology Attitude Questionnaire (BAQ)

In order to investigate ELE teacher candidates' attitudes toward life science, *Biology Attitude Questionnaire (BAQ)* consisting of 17 items developed by Prokop et al. (2007) was utilized. The items in the instrument were designed on a five-point (1-strongly disagree and 5-strongly agree) Likert-type scale. Original form of the instrument was developed in English, later translated into Slovakian (Prokop et al. 2007), and finally translated and adapted into Turkish (Usak et al. 2009). The BAQ includes both positive and negative items. After implementation, these negative items were reversed for calculating overall score. As indicated in original development process, BAQ includes three sub-dimensions such as interest, importanceand difficulty. Turkish version of BAQ was earlier used in a study with a large sample of Turkish university students (n = 1301) and three factors that had slightly different factor loadings from the original ones in the study of Prokop et al. (2007) emerged (Usak et al. 2009). These new factors were named according to the common characteristics of the items loaded on that factor; Importance of Biology (α = .81), Interest in Biology (= .83) and Understanding of Biology Processes (= .61). For the present study, no additional factor analysis was conducted and same factor structure was used.

Interview and Checklist

Individual interview, which was developed to investigate instructors' PCK on biology, included two open-ended questions along with one check list consisting of 17 items. The interview was individually conducted with professors at scheduled time in professors' office. Before carrying out the interview, each participating instructor was informed about the purpose of the study and the items in the interview schedule. During the interview, the professors were asked to assess the ways (methods and techniques) in which the strategies and representations for teaching on the subject of *human body and organs*, and to indicate best measurement and evaluation techniques for this course offered to ELE teacher candidates. Furthermore, prompt questions, which deepened the interview, were also asked when the professors had difficulty while responding. Two questions were successively asked to the participants and then they were required to fill checklist developed by researchers based on the study of Hashweh (2005) regarding photosynthesis. For the present study, Hashweh's checklist was adapted to *human body and organs*. In the checklist, the professors were asked to consider their instructional approach and fill out list of items regarding *human body and organs*.

Data Collection and Analysis

Drawing form and BAQ were together administrated in the classroom environment in the fall semester of 2008. On the other hand, the interview along with the checklist was conducted with the professors at scheduled time in professors' office. Quantitative data were entered to MS-Excel program and data set was constructed. Data were initially analyzed with regard to missing data and outliers. After cleaning process, data set was subjected to descriptive (particularly mean and frequency) firstly and then inferential (particularly correlation) statistics. The qualitative data gathered through interview was initially transcribed verbatim and later subjected to content analysis. The researchers have categorized the interview transcripts according to PCK dimensions established in the previous studies (Hasweh 2005; Usak 2009) to ensure the consistency.

RESULTS

Results on Analysis of Professor's PCK of Biology (Subject of Human Body and Organs)

Professor A: The scholar obtained his PhD fromaSchool of Medical Science in Turkey. He

has been working on biology in the area of Science Faculty for about 18 years. He described this teaching approach as student-centered instruction. Professor A used the book of human anatomy, educational technology, and his lecture notes for this course. He indicated the importance of Bruner's meaningful learning by linking previous learning experiences and new learning subject though using real life examples. He generally described the course as

"*I always start my course with question for examining the student's previous experiences and learning about this course. I organized my course based on my students' needs and their previous experiences. Sometimes, I summarize this course due to the fact that students overlook or forget some issues……"*

Professor B: This scholar obtained his BSc and MSc from department of biology, and PhD from department of biology education in Turkey. He has been studying anatomy, general life science and biology education for about 15 years. He described his teaching approach as teacher-centered instruction. Professor B used the book of biology (*human body and organs*), as main source for this course. He generally described the course as

"I used one book as main course. I do not need another supporting material for this course, because I am an expert on the whole subject of human anatomy. Sometimes, I ask question to students for awaking them. I give example from their real life and their body. Until today, I have not used any educational technology, in my classes, since I believe that the book is enough for this course."

In terms of educational technology the professor stated that he used the book and pictures only, but not computer, data show, or video in his class. He saw himself as the authority of the subject matter he taught.

Based on the results obtained from interview and check list, two professors' approach regarding learning, teaching activities and assessment in the subject of *human body and organs* are presented in Table 2.

Results on Analysis of ELE Teacher Candidates' Attitude toward Biology

The 2X2 MANOVA was performed to examine effect of gender and type of professor on ELE teacher candidates' attitudes toward the biology course. The total mean score of three sub-dimensions of BAQ was defined as dependent variables. There was no single effect of gender ($F(3, 54) = 1.97$, $p = 0.13$, partial eta-squared = 0.10) and no interaction effect ($F(3, 54) = 1.32$, $p = 0.28$, partial eta-squared = 0.07) on attitude score. On the other hand, the main ef-

Table 2: Professors' styles of teaching the topic "Human Organ System"

		Professor A	*Professor B*
Lesson Type	Student-centered instruction	X	-
	Teacher-centered instruction	-	X
	Developmental lesson first day to teach each system	X	X
	Laboratory on second	X	-
	Worksheets, followed by revision and mini-lecture on third	X	-
	Summarized the topic at the end of the class	X	Some times
Explanations, Representations and Teaching Strategies	To emphasize that studying and organizing organs with each other, I use a film regarding internal balance of human body	X	-
	To confront misconception of human organ system, I show each system location on the atlas of human anatomy	X	-
	To explanation the place of human organ in the body, I use picture or film	X	X
Activities and Assignments	Activity of making the model of human body	X	X
	Examining the epithelium of mouth under microscope	X	-
Assessment	Open-ended Questions that I use to asses understanding of human organ system or activity and properties of the system	X	X
	I use different type questionnaire (that is, open-ended, multiple choice, concept map etc.)	X	-
Educational Materials and Technology	Computers, Data show	X	-
	Book	X	X
	Pictures	X	X
	Video	X	-

fect of professor was significant (F (3, 54) = 17.36, $p < 0.001$, partial eta-squared = 0.49). As shown in Figure 1, the ELE teacher candidates in the class of Professor-A had more positive attitudes toward the biology course than those in the class of Professor-B. The univariate analysis for each dependent variable (so called sub-scale) revealed that the significant differences were pronounced especially in the sub-scales "*Interest in Biology*" and "*Understanding of Biology Processes*" in favor of the students enrolled in the class where Professor A was teaching. Visual analysis of mean scores suggests that those in the class of Professor-A were predominantly interested in understanding of biological processes, while overall interest in biology was somewhat lower.

Looking at the mean scores of pooled data (gender and professor) of each item separately (note that negative items were re-scored), it was found that four items scored negatively (mean score < 3.0, range 1.47 – 2.92). These include "I like biology more than other subjects (Item 1)", Biology is not important in comparison with other courses (Item 10)", "Nobody needs biology knowledge (Item 13)" and "Biology is one of the most easiest courses for me (Item 17)". Considering that only two of these four items have negative wording (that is, item 10 and 13), it does not mean that these items were misunderstood by participants. However, it would mean that liking biology is in strong competition with other subjects and that biology is not easy for student learning. On the other hand, four items (Item 15, 8, 12, and 9) with best mean scores (range 3.86 – 3.91) indicate that biology processes are interesting for ELE teacher candidates and that they believe that biology is useful for solving both environmental problems and our everyday lives.

Results on Analysis of ELE Teacher Candidates' Understanding of Human Organs

ELE teacher candidates' drawings, which reflected their understanding on human body and organs, were scored based on the rubric given in Table 1. Later, 2 x 2 ANOVA was conducted in order to assess the single and interaction effect of gender and type of professor on ELE teacher candidates' understandings of human organs. The result revealed that there is so statistical mean difference between male and female ELE teacher candidates [F (1, 56) = 1.72, $p = 0.20$]. The interaction effect of gender and type of professor on ELE teacher candidates' understanding was found to be insignificant [F (1, 56) = 1.03, $p = 0.32$]. On the other hand, shown in Figure 2, those in the class of Professor-A scored much higher understanding level of human organs than those in the class of professor-B [F (1, 56) = 40.67, $p < 0.001$, partial eta-squared = 0.42). The effects of type of Professor on ELE teacher candidates' drawing (understanding of organs) were also clearly confirmed by comparing of the distribution of drawing scores. While drawings' of ELE teacher candidates in the class of professor-A had included comprehensive presentations of at least two (Level 6, 28 %), four or more bodily systems (Level 7, 31 %), no one in the class of Professor-B received score 7 and

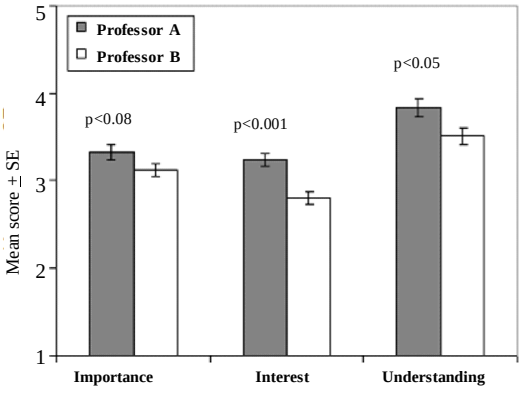

Fig. 1. Differences between the pre-service teachers in two classes

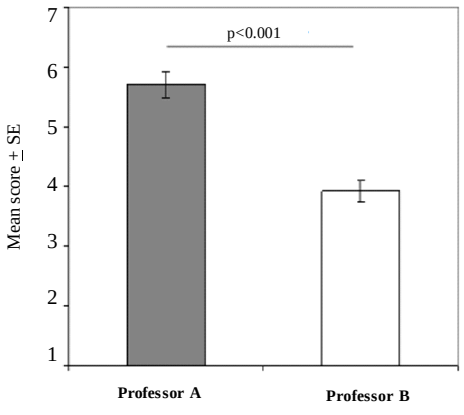

Fig. 2. Differences between two scholars in two classes

only one ELE teacher candidate (3 %) had the drawing with two major systems (Level 6). Conversely, no one in the class of Professor-A drew human body system with the score lower than level 4, but 35 % those in the class of professor-B scored between 2 and 3 (that is, these ELE teacher candidates placed organs randomly or placed one internal organ in appropriate position). Differences in the score distribution between the two group of ELE teacher candidates with regard to types of professor were also highly statistically significant (Chi-square test, χ^2=27.32, df = 5, p < 0.001).

The Relationship between Teacher Candidates' Attitude toward Biology and Knowledge on Human Body and Organs

To examine whether attitudes are associated with achievement measured by participants' drawing of human body function, multiple linear regression was conducted. Since professor-A and-B did make difference in both ELE teacher candidates' attitudes toward life science and their achievement of human body, the two different multiple regressionfor each professor- A and -B subgroups, with mean scores of three attitude dimensions as predictors and drawing scores as dependent variable, performed separately. The multiple regression models for both the ELE teacher candidates in the class of professor - A (R^2 = 0.027, F(3.25) = 0.23, p = 0.87) and those in the class of professor-B ((R^2 = 0.087, F(3,27) = 0.86, p = 0.47) yielded non-significant results. Even after pooling data together and controlling them for effect of gender and professor, no significant effect of attitudes on achievement was derived (R^2 = 0.039, F(3.56) = 0.75, p = 0.53).

DISCUSSION

This study examined how ELE teacher candidates' knowledge and attitudes regarding the biology was impacted by professors' PCK, which is teachers' ways of representing and formulating the subject-matter knowledge in the context of facilitating student learning (Shulman 1986). More specifically this study focused on revealing whether professors' pedagogical content knowledge on human anatomy is a factor contributing to ELE teacher candidates' achievement in human body and organs. This study made use of mixed-method methodology and involved 60 freshmenELE teacher candidates taking Human Anatomy and Physiology classes taught by two different professors in two classes.

ELE teacher candidates who enrolled in professor-A's class had or at least tended to have more positive attitudes toward biology than those who enrolled in Professor-B's class. These differences were pronounced especially in dimensions "Interest in Biology" and "Understanding of Biology Processes." These results refer that biology processes were observed to be interesting for ELE teacher candidates and biology were assumed to be useful for solving the issues associated with both environment and our everyday lives; liking biology is in strong competition with other subjects and that biology is not easy for student learning. It can be stated that the effect of Professor-A differs from professor-B with regard to ELE teacher candidates' attitudes toward biology at some degree but there is no gender difference on ELE teacher candidates' attitudes toward biology. It is essential to point out that professor-A with stronger PCK using a student-centered approach have more positive effect on ELE teacher candidates' attitudes toward life science than professor-B, who uses a teacher-centered approach to instruction. This result suggest that the instructor who is equipped with adequate content knowledge, using student-centered instruction and making use of variety of instructional materials may contribute to development of students' attitude and achievement in subject matter than the one who sees himself as the authority, tends to use textbook as primary resource and has teacher-centered instruction.

In parallel with the current study results, Lenhart (2010) study investigated the relationship between middle school math teachers' PCK as gathered from a teacher assessment and student Standards of Learning scores. Nine middle-school math teachers at two rural schools were assessed for their PCK in geometry. The results showed that there is a relationship between teacher PCK and student achievement in geometry. Ogletree (2007) study results also showed that elementary teacher PCK impacted student achievement in science.

Furthermore, this study shows that ELE teacher candidates' achievement in the Human Anatomy and Physiology course changed depending on which professor taught in their class. In other words, the effect of Professor-A differs

from Professor-B with regard to ELE teacher candidates' achievement in the Human Anatomy and Physiology course at some degree. In other words, the study showed that ELE teacher candidates who attended professor-A class had higher success in the Human Anatomy and Physiology course than those who attend Professor-B class.

The study also examined whether attitudes are associated with achievement measured by participants' drawing of human bodily function by utilizing multiple linear regression and showed no significant effect of attitude toward life science on achievement regarding human anatomy and physiology. This study is limited with the results obtained through the use of individual interviews, checklist, drawings and attitude questionnaire. Further research involving series of in-class observation is needed to address "How is theoretical PCK reflected in teaching practice: A difference between perceived importance and realized practice?"

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