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THE INFLUENCE OF METACOGNITIVE STRATEGY USE ON PRESERVICE EARLY CHILDHOOD TEACHERS' COHERENCY OF CONCEPTUAL UNDERSTANDINGS

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ABSTRACT

The purposes of the study was to examine the relationship between the coherency of preservice early childhood teachers' conceptual understandings and their level of metacognitive strategy use and the type of conceptual understandings they construct after instruction. A total of 52 preservice early childhood teachers participated in the study. Participants were enrolled in a science method course, which was part of the early childhood education program. All 52 participants were interviewed before and after instruction. Two data gathering techniques were used in the study: a self-report instrument and semi-structured interviews. To measure participants' use of metacognitive strategies, the *Motivated Strategies for Learning Questionnaire* was used. To reveal the participants' understanding of moon phases, semi-structured interviews were conducted before and after instruction. Data obtained through interviews were analyzed using constant comparative method of analysis to reveal participants conceptual profiles and the coherency of their conceptual understandings. To make statistical analysis possible, participants' pre- and post-conceptual understandings were scored with rubrics designed for this study. Quantitative data were analyzed using a partial least squares path analysis with observed variables. Results demonstrated that participants with high a metacognitive state were more likely to construct coherent mental models. In other words, these participants' conceptual understandings of the cause of lunar phases included a single, coherent, causal explanation before instruction. They were also more likely to construct coherent mental models after instruction. These results suggest that learners' metacognition should be promoted to help them construct coherent understandings of natural phenomena.

Keywords: Metacognition, Conceptual Understandings, Preservice Early Childhood Teachers

INTRODUCTION

Studies of students' understanding of various astronomy concepts, such as shape of the earth, the day and night cycle, and the cause of the moon phases, revealed that students may construct various conceptual understandings with different level of coherency (Trundle, Atwood, & Christopher, 2002: 2007; Vosniadou & Brewer, 1992). These studies showed that while some learners construct internally coherent conceptual understandings, conceptual understandings that include a single mental model, others construct incoherent conceptual understandings of astronomical phenomena, conceptual understandings that include more than one mental model. For example, Trundle and colleagues (2002, 2007) identified six types of conceptual understandings of the cause of the moon phases, two of which seem to be different from others in terms of their internal coherency: scientific with an alternative fragment and alternative fragments. Students who construct either of these two types of conceptual understandings use more than one contradictory, inconsistent mental model. These students seem not to be aware that the explanations they provide are not only scientifically inaccurate and they lack coherency.

Recent studies by Oliva (1999, 2003) suggest a relationship between the level of structural coherency of the conceptions and the characteristic of conceptual change in which learners engage. Oliva reported that students with a high level of formal reasoning ability change their alternative conceptions more easily if their initial conceptions are highly structured. In contrast, students with concrete reasoning change their alternative conceptions more easily if their initial conceptions are less structured. Likewise, Trundle et al. (2007) contended that students with a single coherent explanation for a given phenomenon before the instruction might be more likely to benefit from the instruction and engage in conceptual change. These results suggest not only a relationship between individual differences and the mechanism of conceptual change but also a relationship between the coherency of initial conceptions and the types of conceptual understandings learners hold after instruction.

The reason some learners construct internally coherent conceptions while others do not might be understood by perceiving the term metacognition in following way. Metacognition, or metacognitive awareness, can also be perceived as the learners' awareness of contradiction or conflict in the specific theory they use to construct mental models. Learners who are aware of the contradiction within the information their specific theory provides in order to construct a mental model might be more likely to select this information more carefully to construct a conceptual understanding that is internally consistent. Being metacognitively aware does not necessarily mean that the conceptual understanding constructed is consistent with the scientific explanation for the given phenomenon, rather it means constructing a conceptual understanding that is coherent and free of internal inconsistency. A coherent conceptual understanding can be scientific or alternative, but always include a single causal explanatory framework.

Students who have concepts that are categorized as scientific with an alternative fragment conceptions or alternative fragments might not be metacognitively aware that the conceptual understanding they use to explain the given phenomenon includes explanations/mental models that are not consistent with each other. Seeing internal consistency in conceptual understanding might be a function of metacognitive ability. That is, students who are metacognitively aware might be more likely to construct a conceptual understanding that is coherent, while students who are not metacognitively aware might be more likely to construct a conceptual understanding that is not coherent.

Thorley (1990) used the term “metaconceptual” to refer to the kind of awareness that permits learners to reflect on the content of their conceptions. His analysis of several discourses that took place in science classes provides examples of how metaconceptual awareness allowed students to recognize the inconsistencies in their reasoning and conceptions. Several researchers also used the term “metaconceptual awareness" to describe the learners' awareness of the difference between their alternative ideas and the scientific concepts (Vosniadou, 1994, 2007; Vosniaodu & Ioannides, 1998) and the awareness of the changes in their concepts as a result of instruction (Mason & Boscolo, 2000). Although these researchers did not establish a link between the metacognitive awareness and the coherency of conceptual understanding, they suggested that students with metacognitive awareness might be able to recognize inconsistencies between their prior knowledge and the new knowledge presented to them in science classes (Kowalski & Taylor, 2004; Pintrich, Marx, & Boyle, 1993; Vosniadou, 1994, 2007).

"Metacognition is the notion of thinking about one's own thought or thinking process" (Hennessey, 2003, p.104). For conceptual change to occur, individuals might need to be aware of the need to change and to be able to know what to change as well as to be able to construct a conceptual understanding that is coherent and consistent. This might be possible through awareness of the contradiction in one's explanation or recognizing that the learner is entertaining more than one explanation for a given phenomenon (Luques, 2003). Metacognition seems to play a vital role in learners' awareness of this contradiction as well as the conceptual understanding they construct. Therefore, in this study the relationship between the coherency of participants' conceptual understandings and their level of metacognitive strategy use and the type of conceptual understandings they construct after instruction were examined. More specifically, the following research hypotheses were tested in present study:

1. Preservice teachers' use of metacognitive strategies will have a direct influence on the coherency of their post-instruction conceptual understandings.
2. The coherency of preservice teachers' pre-instruction conceptual understandings will have a direct influence on the type of post-instruction conceptual understandings.

METHOD

This study utilized a causal comparative research design, which is an observational non-experimental research design (Cook & Campbell, 1979). A theoretical model that depicts the hypothesized relationships among the dependent and the independent variables of the study were generated and tested using a partial least square path analysis with observed variables technique.

A convenience sampling technique was used to select participants (Johnson & Christensen, 2004). Fifty-two preservice teachers participated in the study. Participants were enrolled in a science method course, which was part of the early childhood education program. Most participants were female (98%), and only one male (2%) participated in the study. Forty-nine participants (94%) were European-American, two participants (4%) were African-American, and one participant (2%) was Asian-American.

Two data gathering techniques were used in this study: a semi-structured interview and a self-report instrument. To assess the participants' conceptual understanding of lunar phases, semi-structured interviews were conducted using an interview protocol developed by Trundle, Atwood, and Christopher (2002). To assess participants' self-reported level of metacognitive strategy use the *Motivated Strategies for Learning Questionnaire* (MSLQ) was used (Pintrich, Smith, Garcia & McKeachie, 1993). Data collection procedures are described in detail below.

To reveal the participants' understandings of moon phases, semi-structured interviews were conducted before and after instruction using an interview protocol developed by Trundle and colleagues (2002).The interview protocol included three tasks that aimed to reveal the participants' understandings of the cause of the moon phases (Task 1 and 2) and sequences of phases (Task 3). In the pre and post-interviews participants were initially asked to verbally explain what they thought caused the moon phases (Task 1, pre and post). The three-dimensional models of the moon, earth, and sun were provided to the participants to support their verbal explanations about the cause of the moon phases (Task 2, pre and post). Participants then were asked to sort in the proper sequence a set of cards that depicted eight primary moon phases (Task 3, pre and post) (Trundle et al., 2002). All participants were individually interviewed in a quiet interview room. Pre-interviews lasted about 30 minutes and post-interviews lasted about 20 minutes each. Interviews were video-taped and notes were taken immediately after each interview.

The *Motivated Strategies for Learning Questionnaire* (MSLQ) designed to measure motivation and use of learning strategies by college students was used to assess the participants' level of metacognitive strategies (Pintrich et al., 1993). The MSLQ is a self-report instrument consisting of six motivation subscales (31 items), and nine learning strategies scales (50 items), for a total of 81-items. A rigorous validation process was followed to establish the psychometric properties of the MSLQ during the late 1980s with samples of close to 2000 college students. While the results of a series of exploratory and confirmatory factor analyses provided evidence for the hypothesized structure of the MSLQ, correlations between the subscales of the MSLQ and the measures of academic and aptitude measures provided evidence for the predictive validity (Duncan & McKeachie, 2005; Pintrich et al., 1991, 1993). To assess the participants' metacognition, the metacognitive self-regulation subscale was used in the present study. Subscales of the MSLQ produce scores with reliability coefficients ranging from .52 to .93 and good factor structure (Duncan & McKeachie, 2005; Pintrich et al., 1993). The reliabilities of measures in this study was α=.84. The MSLQ was administered during the science method course immediately after the instruction on lunar phases took place. Participants were prompted to consider their learning of science in general and lunar phases in particular in responding to the MSLQ items.

The framework of codes developed in previous lunar concepts studies and constant comparative analysis were used to analyze the participants' pre and post conceptual understandings of the cause of the lunar phases in the study (Glaser & Strauss, 1967; Trundle et al., 2002, 2007). To demonstrate the dependability of the coding of the data, inter-rater reliability was calculated using Cohen's (1968) weighted kappa statistics. Thirty-three percent of the pre and 23% of the post interviews were independently analyzed by two researchers. Cohen's weighted kappa was .83 for the pre interview codings and .93 for the post interview codings, indicating high inter-rater reliability between the two coders. To make statistical analysis possible, participants' pre-, and post conceptual understandings were scored with a rubric, which was designed for this study. In this study participants were given scores ranging from 0 to 10 based on the number of scientific elements and alternative mental models included in their conceptual understanding. These scores were used in the statistical analysis performed in the study.

Partial least squares path modeling with observed variables (PLS-PM) was used to test the research hypotheses. PLS-PM is a type of path analysis, which allows researchers to model and test the relationship between observed variables (Joreskog & Wold, 1982; Lohmoller, 1989). PLS-PM employs the partial least square method of estimation to analyze the variance matrix and it utilizes principal component analysis rather than common factor analysis in estimating latent variable scores (Lohmoller, 1989; Falk & Miller, 1992). Wold (1989) stated that PLS-PM was specifically designed for social science research as the models developed in social science studies are often complex, open-systems, and researchers usually analyze data from small samples. This technique allows researchers to evaluate the explanatory or predictive power of models as a whole as well as the unique contribution of each independent variable to the overall model. Considering the exploratory and predictive purposes of the study and the small sample size, the PLS-PM technique was employed as the main statistical analysis tool for the study. A PLS-PM analysis was performed using the SmartPLS software (Ringle, Wende, & Will, 2005).

FINDINGS AND COMMENTS

Conceptual Profiles and the Coherency of Participants Conceptual Understandings

Participants' conceptual understandings of the cause of the moon phases were identified as scientific if they included all four critical elements that define a scientific conceptual understanding. Participants' conceptual understanding of the cause of the moon phases was identified as scientific fragments if it included some but not all four of the scientific elements and included no alternative ideas. Participants' conceptual understandings were categorized as scientific with an alternative fragment if they included all four elements of scientific understanding along with an alternative fragment. A conceptual understanding that included some but not all four elements of scientific understanding along with an alternative mental model was categorized as alternative with scientific fragments. Participants' conceptual understandings were categorized as alternative if they did not exhibit any of the scientific elements and they explained the cause of the moon phases with a single alternative mental model that was contrary to a scientific explanation. Participants' conceptual understandings that included fragments of more than one alternative mental model were categorized as alternative fragments. Table 1 summarizes the results of the analysis of the pre- and post-interviews.

Table 1. Profiles of Participants' Conceptual Understanding

Conceptual Understanding	**Percentages**	
	Pre-interview (n=52)	**Post-interview (n=52)**
Scientific	6 (12%)	25 (48%)
Scientific Fragments	2 (4%)	13 (25%)
Scientific with Alternative Fragment	0 (0%)	1 (2%)
Alternative with Scientific Fragments	8 (15%)	10 (19%)
Alternative	27 (52%)	1 (2%)
Alternative Fragments	9 (17%)	2 (4%)

For the current study, coherency of conceptual understanding was defined as having a single mental model within a conceptual understanding. Based on the number of mental models they included, participants' conceptual understandings were assigned into either coherent conceptual understanding (single mental model) or incoherent conceptual understanding (more than one mental model) category. Results demonstrated that nine participants (17%) had incoherent conceptual understandings before the instruction. That is, they entertain two or more alternative conceptual understandings for the cause of the lunar phases. After the instruction, only two participants (4%) had incoherent conceptual understandings.

Partial Least Squares Path Modeling with Observed Variables

A PLS-PM analysis with observed variables was conducted to test the research hypotheses that dealt with the relationship between the coherency of participants' conceptual understandings and their level of metacognitive strategy use. For the PLS-PM analysis, group membership was identified through dummy coding. The group that contained participants with incoherent conceptual understanding was chosen as a reference group. The results of each hypothesis test are provided below.

While the direct effect of metacognitive strategies on the coherency of pre-conceptual understandings was not statistically significant ($\beta=0.18$, $t= 1.34$, $p=0.186$), the direct effect of metacognitive strategies on the coherency of post-conceptual understandings was statistically significant ($\beta=0.29$, $t= 2.12$, $p=.039$). According to Cohen (1988) this is very close to a moderate effect.

A similar result was obtained for the hypothesis that tested the relationship between the coherency of participants' initial conceptual understanding and the type of conceptual understanding participants constructed after the instruction. The coherency of pre-conceptual understanding was statistically significant predictor of the type of conceptual understandings participants held after instruction ($\beta=0.53$, $t= 4.45$, $p<.001$).

According to Cohen (1988) this is a strong effect. Figure 1 illustrates the results of the PLS-PM analysis.

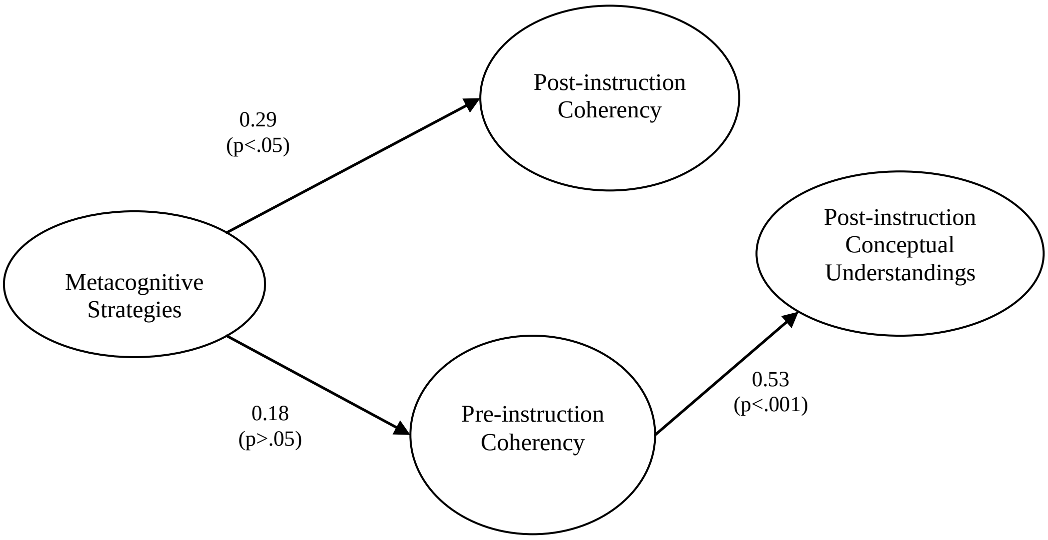

Figure 1 Metacognitive strategies and the coherency of conceptual understandings

CONCLUSION AND RECOMMENDATIONS

Results demonstrated that the direct effect of metacognitive strategies on the coherency of pre-conceptual understandings was not statistically significant. However, there was a statistically significant direct effect of metacognitive strategies on the coherency of post-conceptual understandings with a close to moderate effect size. These results suggest that participants with high metacognitive state were more likely to construct coherent mental models. In other words, these participants' conceptual understandings of the cause of lunar phases included a single, coherent, causal explanation. This finding seems to support the hypothesis proposed by previous studies that metacognition might play a vital role in learners' awareness of the contradictions in their causal explanations and it might facilitate the construction of coherent mental models (Luques, 2003; Mason & Boscolo, 2000; Vosniadou, 1994, 2007).

The relationship between the coherency of participants' initial conceptual understanding and the type of conceptual understanding participants constructed after the instruction was also statistically significant with a strong effect size. The coherency of pre-conceptual understanding was a statistically significant predictor of the type of conceptual understandings participants held after instruction. This finding is consistent with the predictions of the previous studies (Oliva, 1999; 2003; Trundle et al., 2007) and suggests that participants who held a coherent mental model of the cause of the lunar phases, whether scientific or not, were more likely to construct scientific conceptual understanding after instruction.

In the present study participants who frequently use metacognitive strategies were more likely to have coherent conceptual understandings after instruction. These results suggest that learners' metacognitive strategy use and metaconceptual awareness should be promoted to help them construct coherent understandings of natural phenomena. Previous studies indicate that metacognitive thinking can be taught and promoted with the teaching of science concepts (Beeth, 1998a, b; Hewson, Beeth, & Thorley, 1998). Likewise, the use of metacognitive strategies can be modeled and promoted in instructional strategies to increase the probability of students constructing coherent understandings of natural phenomena.

Author Note

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ÜSTBİLİŞSEL STRATEJİ KULLANIMININ OKUL ÖNCESİ EĞİTİMİ ÖĞRETMENİ ADAYLARININ KAVRAMSAL ANLAYIŞLARININ TUTARLIĞINA ETKİSİ

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Genişletilmiş Özet

Problem: Öğrencilerin, dünyanın şekli, gündüz ve gece döngüsü ve ayın evreleri gibi çeşitli astronomi kavramlarına ilişkin anlayışlarını inceleyen araştırmalar öğrencilerin farklı düzeydeki tutarlıkta kavramsal anlayışlar oluşturduklarını ortaya koymuştur. Bazı öğrenciler tek bir zihinsel modelden oluşan içsel olarak tutarlı kavramsal anlayışlar oluştururken diğerleri birden fazla zihinsel modelleri içerebilen içsel olarak tutarsız kavramsal anlayışlar oluşturmaktadır. Alan yazın üstbilişsel becerilerin öğrencilerin kavramsal anlayışlarının yapısı ile ilişkili olabileceğini önermektedir. Bu çalışmada okul öncesi eğitimi öğretmen adaylarının üstbilişsel stratejileri kullanma düzeylerinin onların kavramsal anlayışlarının tutarlığı üzerine olan etkisini incelemek amaçlanmıştır. Araştırmada ayrıca katılımcıların ayın evrelerine ilişkin öğretim almadan önceki kavramsal anlayışlarının tutarlığının onların öğretim aldıktan sonraki kavramsal anlayışları üzerine olan etkisi de incelenmiştir. 53

Yöntem: Bu çalışmada deneysel olmayan ex-post-facto araştırma deseni kullanılmıştır. Araştırma değişkenleri arasındaki ilişkiler modellenmiş ve kısmi en küçük kareler yol analizi tekniği ile test edilmiştir. Araştırmada katılımcıların ayın evrelerine ilişkin kavramsal anlayışları yarı yapılandırılmış bireysel görüşme yöntemi ile değerlendirilmiştir. Görüşmeler ayın evrelerine ilişkin verilen öğretimden önce ve sonra olmak üzere toplam 52 okul öncesi eğitimi öğretmen adayı ile iki kez yapılmıştır. Görüşmelerden elde edilen veriler sürekli mukayese yöntemi ile analiz edilmiş ve dereceli puanlama anahtarı kullanılarak puanlanmıştır. Katılımcıların üstbilişsel stratejileri kullanma becerileri Güdülenme ve Öğrenme Stratejileri Ölçeğinin Üstbiliş alt ölçeği ile değerlendirilmiştir. Kısmi en küçük kareler yol analizi SmartPLS yazılımı kullanılarak gerçekleştirilmiştir.

Bulgular: Araştırmaya katılan öğretmen adaylarının dokuz tanesinin öğretim öncesinde içsel olarak tutarlı olmayan kavramsal anlayışa sahip oldukları tespit edilmiştir. Öğretim sonrasında içsel olarak tutarlı olmayan kavramsal anlayışa sahip katılımcı sayısının iki olduğu gözlenmiştir. Sonuçlar üstbilişsel strateji kullanımının katılımcıların öğretim öncesi kavramsal anlayışlarının içsel tutarlığını yordamadığını, fakat öğretim sonrası kavramsal anlayışlarının içsel tutarlığının anlamlı bir yordayıcısı olduğunu göstermiştir. Buna ek olarak, araştırmada ayrıca, katılımcıların öğretim öncesi kavramsal anlayışlarının içsel tutarlığının onların öğretim sonrası kavramsal anlayışlarının içsel tutarlıklarının anlamlı bir yordayıcısı olduğu da bulunmuştur.

Sonuç ve Öneriler: Bu çalışmanın bulguları, üstbiliş ve kavramsal anlayışın yapısı arasında ilişki olabileceğini ifade edilen alan yazını desteklemektedir. Araştırmada üstbilişsel stratejileri sıklıkla kullanan katılımcıların kullanmayanlara göre daha büyük olasılıkla içsel olarak tutarlı kavramsal anlayışlar geliştirebileceği bulunmuştur. Bu nedenle öğrencilerin içsel olarak tutarlı kavramsal anlayışlar geliştirmesini desteklemek için onları üstbilişsel stratejileri kullanmaya teşvik edici ortamlar hazırlanmalı ve bu ortamlar öğretim etkinliklerinin bir parçası haline getirilmelidir.

Anahtar Kelimeler: Üstbiliş, Kavramsal Anlayış, Okul Öncesi Eğitimi Öğretmen Adayları