Creative Cognition and Science Motivation: Structural Equation Model

The aim of this study is to investigate the relationship between creative cognition and science motivation. There is a considerable gap between them whose relations haven't been found out in terms of cognition and motivation. This study attempts to fill the gap by investigating the role of science motivation on creative cognition. The study was conducted on 265 high school students. Creative Cognition Scale and Science Motivation Scale were applied to the participants. The relationship between creative cognition and science motivation was examined by correlation and structural equation modeling analysis. Correlation and structural equation modeling results showed a positive correlation between science motivation with sub-dimensions and creative cognition. The findings were discussed in accordance with literature.

Keywords: science motivation, creative cognition, structural equation.

Introduction

Science learning plays an important role to face challenges of globalization. It includes a lot of factors which are the determinants of science learning quality and process (Chan & Norlizah, 2017). In fact science motivation is usually defined as an internal state which directs and sustains science learning behavior (Glynn, Brickman, Armstrong & Taasoobshirazi, 2011). Motivation has significant influence on science learning achievement. Talent and ambition are necessary in learning as well as environmental and social contribution (Maehr, 1989). Motivation of learning science has a positive influence on academic success. Motivation variable can't be observed directly. It is the most important component which is in purposive activities to receive a good result in education activities (Arslan, 2015).

Therefore it is significant to encourage students to comprehend science notions to recognize the significance of science and improvement in technology by leading them through right motivation. Student cognition and the affective components of cognition are addressed together by researches in science teaching and learning (Arslan & Akcaalan & Yurdakul, 2017). Students acquire creative cognition thanks to the cognition of motivation in science. Creativity is defined as a tendency to propose original solutions and new products (Sligh, 2003). The idea of innovation is connected with the notion of creativity. In other words, being creative requires producing or thinking about something new (Welling, 2007). The most important point is that motivation leads to creativity in the process of science learning.

Lack of motivation in science could interfere with the scientific literacy needed for responsible decision-making and behavior. Hence, it causes a decrease in the motivation to choose a career related to science. A paradigm for counteracting, it might lie in better methods of evaluating motivation in science to comprehend students' needs for reconciled teaching programs and methods.

It is to be characterized motivated and unmotivated students as soon as possible analyzing certain aspects of motivation to support students in a projected aspect (Schumm & Bogner, 2016).

A desire of science learning is the motivation of the students. They launch forming their motivation towards science learning in their first year of school (Patrick & Mantzicopoulos & Samarapungavan, 2009). However, various factors might affect their motivation towards science learning. Findings show that the motivation factors such as self-determination, self-efficacy, motivation of intrinsic, motivation of career and motivation of grade play important roles for students' science accomplishment. According to a study, it has been examined the dimension of social impulse which conducts the relationship of position and motivation of science and self-reliance. The results showed impulse from parents, instructors, school, and friends have been each unconnected variables of science motivation (Stake, 2006). Examining the relationship between achievement goals and science motivation has been achieved in another study. Research findings of correlation and regression analyses validated the hypothesis and the significance of achievement goals to get a clear comprehension of science motivation. The results of the study have validated that the science motivation's significant predictor has been related to achievement goals. The motivation of common interest has been based on the singular antecedents and consequences of students' goal agreement for the achievement of the theory (Arslan & Akcaalan & Yurdakul, 2017).

Creativity is a complex process based on individual thinking, influenced by many other factors such as environment, culture, and individual competences as well as thoughts (Sligh, 2003; Sternberg, 1989). Mental processes are regarded as the essence and stimulus of creative effort in spite of all these various factors. Although many useful approaches have been put forward to understand creativity, the creative cognitive approach is of great importance because it focuses on the cognitive processes and structures underlying creative thinking. Creative cognitive approach has been proposed in creativity studies as the concept of creativity evolves over time. This approach suggests that creativity is a human-specific universal trait and a multidimensional structure based on multiple cognitive processes (Finke, Ward and Smith, 1992; Sligh, 2003). The creative cognition approach deals with the use of thinking strategies and creative techniques which enable creativity (Davis, 2004; Moneta and Rogaten, 2013).

Researching creativity scientifically provides three basic benefits as far as creative cognition researchers concerned: The methods and concepts of cognitive science contribute to the understanding of creativity. The same structures and processes involved in everyday cognition can be used to understand creative thinking. This method can increase the ability to ask creativity questions by considering cognition within the scope of creativity. The creative cognition approach may lead to improve creativity through a better understanding of the underlying processes of creativity (Sligh, 2003; Finke, Smith and Ward, 1995). Creative cognition is based on the principle that creativity is not only a characteristic of gifted individuals but a normal process that every individual can have (Berman, 2010; Kara, 2019).

Many attempts have been made to make sense of creativity throughout human history. Although the interest in human creativity has never diminished, modern creativity researchers have not yet reached a definitive decision on the definition of creativity. *Creativity*, which is new (original or unexpected), appropriate (useful or meets the limitations of the task), (Kharkhurin, 2005; Sternberg and Lubart, 1995) and applicable (Kharkhurin, 2005; Martindale, 1989), is the ability to produce jobs with its most common definition.

There is a consensus in the literature that there is a complex process involving problem definition and redefinition, divergent thinking, synthesis, restructuring, analysis and evaluation (Getzels and Csikszentmihalyi, 1976; Kharkhurin, 2005; Lubart, 1994; Ochse, 1990; Sternberg and Lubart, 1995) about creative thinking. Therefore, the creative process on Guilford's (1950) proposal; it can be studied effectively by examining the sub-processes that play a role in creative work. A number of studies have been conducted over the last 50 years, which examine the sub-processes that are effective in creativity. However, most of these models focus on similar processes. For example; in his model, Mednick (1962) mentioned distant connotations and defined it as the ability of creative individuals to relate ideas or objects that are not related to each other. Many of these models seem to come together in the idea of dealing with different often unrelated concepts or categories that could create a new space in which original or new ideas can be put forward despite many proposed models.

Other models focus on the mechanism underlying the ability to activate various unrelated concepts simultaneously (Kharkhurin, 2005; Lubart and Getz, 1997; Ward et al., 1997; Weisberg, 1993). Although all of these models are quite complex and do not provide clear information about the sub-processes of creative thinking, they all seem to focus on one feature in general: creative thinking is the ability to form relationships that combine concepts in categories that are not linked. Relationships between concepts are assumed to be an unconscious process through conceptual networks. These sub processes are likened to divergent thinking, which involves a comprehensive search of information and the generation of innumerable alternative answers to problems (Guilford, 1967; Kharkhurin, 2005). Guilford; comprehended the ability of divergent thinking as a key component of creativity and defined it in four main characteristics: fluency (the ability to produce a large number of ideas or solutions to a problem in a short time); flexibility (the capacity to think of several approaches to a problem in succession); originality (tendency to produce ideas different from most people) and evaluation (the ability to think and apply details of an idea).

Guilford compares divergent thinking with convergent thinking defined as the ability to combine all possible alternatives into a single solution. Therefore, divergent thinking remains one of the constant concepts of the creativity literature. Mumford, Mobley, Uhlman, Reiter-Palmon, and Doares (1991) show a variety of ways that differentiate the creative problem-solving process from the standard non-creative process. The most important difference is based on the ability to initiate divergent and convergent thinking, which creates an active and demanding process that enables new, alternative solutions. However, in routine problem solving, people apply the way of researching previously acquired methods and available solutions, which often involve convergent thinking (Kharkhurin, 2005; Mayer, 1999).

Theory of the Study

While many theories have emerged to explain how learning occurs, the most commonly used theories in science teaching are those developed by Jean Piaget, Jerome Bruner, Robert Gagné and David Ausubel. In this study, the the conditions of learning theory developed by Gagné has been used in accordance with framework of the study processes. Gagné 's book, The Conditions of Learning (Gagné, 1985) identified the mental conditions for learning. They have been based on the information processing model of the mental events which happen as adults are presented with various stimuli. Gagné made out a nine-step process called the events of instruction. It correlates to and addresses the conditions of learning.

According to Gagné, learning takes place through the interaction of external and internal factors. Learning is understood from observable behavior and defends the assumption that it takes place in the brain. It defends its effectiveness in internal conditions as well as external conditions for learning. Gagné provides instances of events for each category of learning outcomes (Gagné, 1985). Gagné (1965) thinks that what is taught to children should be similar to what scientists do (as long as they spend in scientific activities). The most important contribution of Gagné to science teaching is that it states that learning should be done in a gradual order from simple to complex. The important thing here is to determine the target that should be reached at the end of the education and to organize the teaching activities accordingly. According to this view, it is the most important point in order to reach the goal that is desired to be reached at the end and other sub-goals hierarchically from simple to complex in order to reach it (Turgut & Gürbüz, 2011). Therefore, learning should be gradual and the theory outlines nine instructional events and corresponding cognitive processes (Gagné, Briggs & Wager, 1992):

- Gaining attention (reception)
- Informing learners of the objective (expectancy)
- Stimulating recall of prior learning (retrieval)
- Presenting the stimulus (selective perception)
- Providing learning guidance (semantic encoding)
- Eliciting performance (responding)
- Providing feedback (reinforcement)

- Assessing performance (retrieval)
- Enhancing retention and transfer (generalization).

In progressive learning, the learning objectives are determined by the teacher according to the individual's situation and the learning process is designed and realized by clearly specifying the behavioral changes predicted in the individual. Teachers should first determine the main purpose related to the subject, divide the subject into sub-objectives and determine the location of the students in this octet hierarchy and plan the teaching accordingly while planning the in-class activities. As a result, it is emphasized in Gagné's learning theory that students should participate in learning activities effectively and come ready for the lesson in their learning, that is, they should take prior knowledge and responsibility (Turgut & Gürbüz, 2011).

Gagné's model of learning is objective which can be easily evaluated as the required learning is observable and can be measured, task -focused models. He proposed that the information processing model of learning could be combined with behaviorist concepts. Behaviorist concepts are concerned with instructional activity items.

Instructional activity items are attracting attention, informing the target, associating with previous learning, presenting content, guiding, revealing performance, providing feedback, and performance evaluation. *Attracting attention* is stimulating motivation such as story, memory, telling jokes, asking riddles, wearing different clothes. *Informing the target* is providing motivation, specifying the target. *Associating with previous learning* is linked with short-term memory activated, prerequisite learning remembered. *Presenting content* is offering stimulating materials. *Guiding* is coding information into long-term memory and guiding learning. *Revealing performance* is the student applies what he has learned and has the opportunity to demonstrate problem solving behavior. *Providing feedback* is to provide support and assessment for correct performance. *Performance evaluation* is the process and product which are evaluated. *Ensuring the permanence and transfer of the learning* is strengthening recall and transfer.

Gagne translated the informational processing model into an instructional model called phases of learning that is the nine events are broken down into three phases. The first one is the pre-instructional phase, the second one is the instructional phase and the third one is the post instructional phase. When the first phase called pre-instructional phase has been taken into consideration to gain attention, to inform learners of the objectives and to stimulate recall prior learning are the main themes of it. To present the stimulus, to provide learning guidance to elicit student performance and to provide feedback are the main themes of the second phase to be addressed. For the post instructional phase; to asses performance, enhance retention, and transfer (generalization) are the main themes of Gagné's model of learning (http://fpmipa.upi.edu/data/report_activity/9875881844.pdf, learning theories, accessed 29 January, 2020).

Robert Gagné followed a series of events which outline a systematic instructional design process which share the behaviorist approach to learning, with a focus on the outcomes or behaviors of instruction or training. Each of the nine events of instruction is highlighted, followed by similar methods to help comprehend the basic framework of this study. Gagné's nine events in conjunction with structural equation model design engaging and meaningful processes of the study.

In this study, creative cognition and science motivation in the early process of education may subsequently predict a student's future feeling toward similar relationships and attitudes through the theory. This suggests that there is potential for the students to continue throughout schooling without being identified as running the risk of underachievement. In turn, this may seriously impact the provisions subcomponent of the environmental catalyst. If the identification process is significantly damaged as a result of a negative structural equation, through things such as student demotivation and underachievement, then a school may not justify the need to provide necessary provisions to support science motivation.

Present Study

The current study attempts to fill the gap by investigating the role of science motivation on creative cognition. The goal of present study is to explore correlation and variance analysis effect of science motivation on creative cognition. The study poses the following hypotheses:

Hypothesis 1: Science motivation is positively associated with creative cognition.
Hypothesis 2: Intrinsic motivation and personal relevance is positively associated with creative cognition.
Hypothesis 3: Self-efficacy and assessment anxiety is positively associated with creative cognition.
Hypothesis 4: Grade motivation is positively associated with creative cognition.

Methodology

Study Group

265 high school students participated in this study. 197 (74%) of the students were female and 68 (26%) were male. The ages of the students ranged between 13 and 18 years. The average age of the students is 15.4. The students with the number of 94 (36%) are 9th grade, 93 (35%) are 10th grade, 78 (29%) are 11th grade students.

Measuring Tools

Creative Cognition Scale

In the study, Creative Cognition Scale developed by Rogaten and Moneta (2015) and adapted to Turkish by Arslan and Ünal (2016) were used to measure the creative cognition levels of students. This tool is a self-assessment scale, which is used in the form of paper and pencil test, in which the participants describe their own situations. The scale is answered by marking one of the numbers 1-5 according to the 5-point Likert rating. The scale items are graded from 1 to 5 as "Never", "Always. The 5 items that form the scale are collected in one dimension and express a general creative cognition score. The Cronbach alpha internal consistency reliability coefficients calculated for the Turkish form of the Creative Cognition Scale were found to be .71 for the total score of the scale. The corrected item-total correlation of the scale is between .53 and .48 (Arslan and Ünal, 2016). In the confirmatory factor analysis applied to determine the fit of the 5-item model, the fit index values were found as: (x2 = 19.15, sd = 6, RMSEA = 0.096, NFI = .92, NNFI = .91, CFI = .94, IFI = .95, SRMR = .09) (Arslan and Unal, 2016).

Science Motivation Scale

Science Motivation Scale is a 21 item paper-and-pencil scale. It was adapted to Turkish by Arslan, Yılmaz, Akcaalan, Yılan and Cavdar. This scale has four sub-scales. For confirmatory factor analysis of the Turkish version of the Science Motivation Scale was calculated and analysis showed that the items loaded on four factors. Results of confirmatory factor analysis showed that the six-dimensional model was well fit. Cronbach coefficient alpha was 0.91. the

resulting matrix of correlations was appropriate for factor analysis by means of a Bartlett's test of sphericity, x^2:12,064.16, df =435, p <0.001, and a Kaiser–Meyer–Olkin measure of sampling adequacy, KMO=0.93. All factors accounted for 60.23% of variance.

Process

Participants were selected by appropriate sampling method. Appropriate sampling is one of the non-random sampling techniques and the researcher selects participants that are convenient and easy to reach for him / her. The students completed the questionnaires anonymously. Data were analyzed by correlation and multiple regressions.

Findings

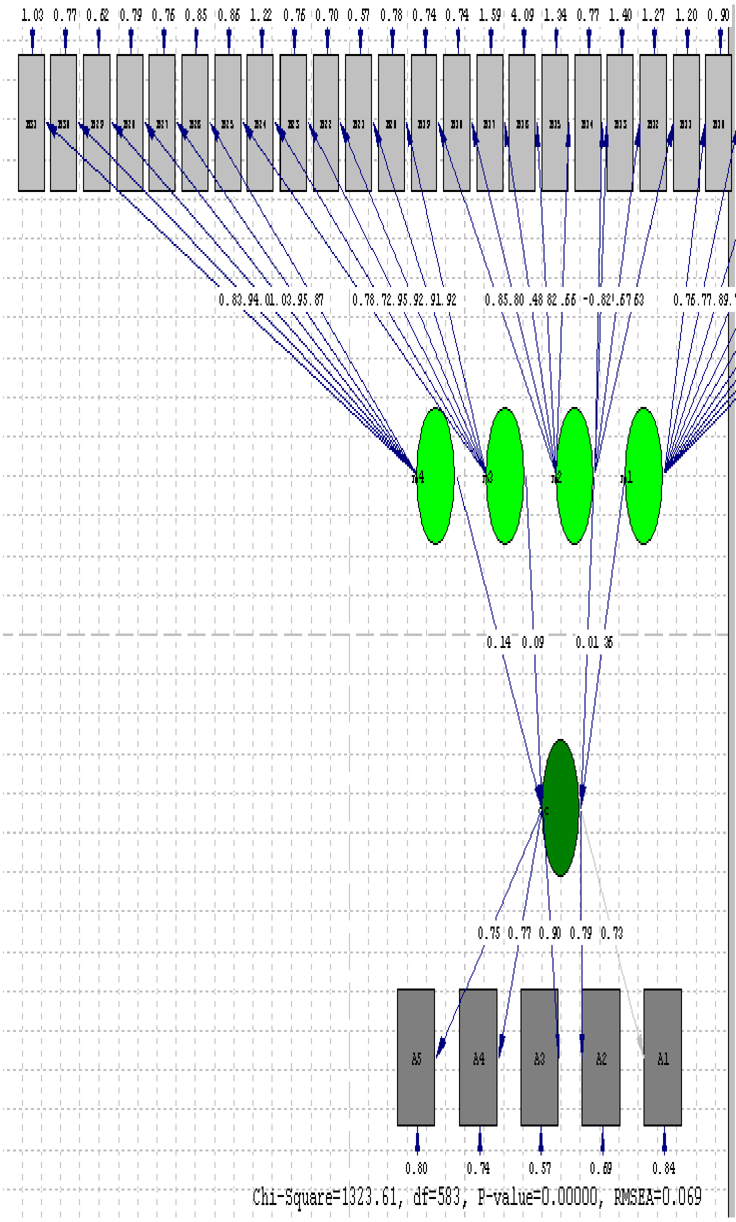
Table 1. *Descriptive Statistics and Inter-correlations of the Variables*

Variables					
Intrinsic motivation and personal relevance					
Self-efficacy and assessment anxiety					
Self-determination					
Grade motivation					
Creative cognition					
Intrinsic motivation and Personal relevance	—				
Self-efficacy and assessment anxiety	.17**	—			
Self-determination	.57**	.12 **	—		
Grade motivation	.71**	.19**	.71**	—	
Creative cognition	.47**	.11**	.41**	.45**	—

***p*<.01

According to the results of the correlation analysis given in Table 1, a positive relationship was found between science motivation with sub-dimensions of students and creative cognition levels. Intrinsic motivation and personal relevance (r=.47), self-efficacy and assessment anxiety (r=.11), self-determination (r=.41), and grade motivation (r=.45) related positively associated with creative cognition.

Figure 1. Path analysis between science motivation and creative cognition (c=creative cognition;n1,n2,n3,n4 sub dimensions of the science motivation).



Before applying path analysis, the assumptions of path analysis were investigated. Multivariate normality tests which check a given set of data for similarity to the multivariate normal distribution were conducted via LISREL. The results of the multivariate normality tests indicated that there was sufficient evidence that the data are multivariate normally distributed. Multivariate outliers were investigated using the Mahalanobis distance. Here, the influential outliers are concerning because they have the potential not only to bias the model, but also to affect the major assumptions.

Specifically, ten cases for dimensions of burnout were a significant distance from the model. Box's M test for equality of variance-covariance matrices was used to test for homoscedasticity. Based on a statistically significant ($p<.05$), the Box's M test indicates a homoscedasticity assumption violation, indicating that the data meet the criteria for homoscedasticity. In order to test the hypothesis model of whether science motivation would be associated positively with creative cognition, a path analysis was used. Using path analysis, all the parameters of models can be tested simultaneously in a single step. The specifications on the model were to search for direct paths from science motivation to creative cognition. The results of the test as to whether science motivation has a direct effect on creative cognition are presented in Figure 1. Figure 1 shows that the model is saturated (i.e., there are no unused degrees of freedom).

Consequently, the fit of the model is necessarily perfect ($\chi2$ = 1323.61, df = 583,RMSEA=0.069, p = .000, NFI =. 93,NNFI =.96,CFI = .96,IFI = .96,RFI = .92,SRMR = .061) with the model accounting for 26% of creative cognition variance. It can be seen that science motivation has both significant and positive effects on creative cognition. On the other hand, creative cognition was predicted positively through science motivation.

Discussion

In this study, the relationship between creative cognition and science motivation was investigated. The findings of the study showed that there is a positive relationship between science motivation and creative cognition. Creative cognition is explained 26 % by science motivation sub-dimensions. These results reveal the importance of science motivation among relational creative cognitive characteristics. Cognition and motivation usually have little essential relationship with each other. Their relationship has to be handled through the right channels to reach the right aim. Motivation fundamentally is about energizing and directing an action system while cognition consists of manipulating encoded symbols. There has been almost a false phenomenon about them: cognition and motivation have evolved together and they develop together. That's why, eventually, they must be more exceedingly integrated in order for their co-evolution and co-development to remain coordinated (Bickhard, 2002). Creativity can be thought to be result-oriented by expressing it as the production of new ideas (Welling, 2007). It can be stated that creativity studies, which are mostly result oriented, ignore the creative cognition which focuses on the process. When the educational dimension is considered, the process of generating creative ideas and taking into consideration the motivation of the student and carrying out studies to improve it allow the development of a greater number of creative individuals.

Students need to invest significant mental effort and persist in the search for solutions to the problems for a learning sciences approach to work

(Blumenfeld & Kempler & Krajcik, 2006). Latest planned environments based on learning sciences principles require students to be more motivated than do traditional environments (Blumenfeld, et al.,1991). Lots of classroom activities in which students eagerly participate do not certainly get students cognitively engaged. The notion of cognitive engagement matches ideas from motivation research with ideas regarding learning strategy use (Blumenfeld, et al., 2006). While employing the necessary cognitive, metacogntive, and volitional strategies that promote understanding, it includes students' willingness to invest and exert effort in learning (Frederics & Blumenfeld & Paris, 2004).

Terms of cognition and motivation do not compose explicit subsystems of the processes. They are features of one underlying ontology of interactive systems, instead. Such a notion carries forward the basic process commitments that are urged on psychological studies by both historical and metaphysical considerations, accommodates the interactive-process model of the nature of representation and cognition. It also accounts for higher order motivation as generated of the interactions among processes of knowing, learning, and emotions (Bickhard, 2002).

Niegel, Behairy and Szalma (2017) tested intrinsic motivation, self-esteem, need for cognition and achievement motivation as a set in the explanation of student performance as measured by high school GPA, major GPA, overall GPA, ACT score, and SAT score comprehending academic performance. They found that achievement motivation and need for cognition were significant in the prediction of standardized test performance based on correlational and regression analyses. It supports the findings of our study as it was found a positive correlation between cognition and motivation. They also found that achievement motivation was positively correlated with all measures of student motivation.

Illner (2002), in his study, searcher for the cognitive challenges of PhD students in terms of motivation through case examples following project and time management, creative and scientific writing and presentation skills. These strategies stimulated motivation and they were proved to be successful and efficient in accordance with positive correlation between motivation and cognition as in our study.

Kalantzi-Azizi and Karademas (1999) developed a program concerned motivation incentives which include enactive attainments, vicarious experiences, verbal persuasion and psychological state. The program provided cognitive behavioral strategies such as cognitive education and cognitive restructuring. It supports our study in terms of positive correlation between motivation and cognition as well. Other studies; Hemodynamic neuroimaging studies of reward tasks (Miller et al., 2013; Wacker et al., 2009) are also in accordance with our study based on positive correlation. In these studies, hemodynamic neuroimaging studies of reward tasks showed depression was related to decreased activation in key brain areas associated with the processing of reward-related information, peculiarly nucleus accumbens and caudate, as well as decreased activation in left PFC, a sphere which was related to approach-related motivation and the processing of positive stimuli.

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