Research Article

Investigation of Effect of Spatial Intelligence on Amount of Application of Meta-Cognitive Strategies in Students

Bahman Saeidi Pour[1], Hanieh Shahsavari[2]*

Abstract

Introduction: Introduction: Intelligence and its various aspects are some parts of human existence that has a prominent role in the prosperity of human life in all areas of life. The purpose of this study was to evaluate the influence of spatial intelligence on the extent of the use of meta-cognitive strategies.

Methods: To collect data, the researcher made a questionnaire that was used to measure spatial intelligence. The stability of the research instrument on the basis of Alfa Chronbach coefficient was about 84%. To assess students' meta-cognition, Pint rich and De Grout's questionnaire was used. The general validity of this questionnaire in the last application was 89%. Reliability of the research instrument was improved using amending ideas of research committee so that it could determine 75% of the reach variable variances.

Results: Results were analyzed using the multivariable regression analysis methods and path analysis. Finally the proposed fit model was analyzed using LISREL software. Findings showed that spatial intelligence has a significant and positive effect on meta-cognitive strategies.

According to the obtained results, we can say that the research model has had good fit from the real world data.

Conclusion: Thus, it was concluded that spatial intelligence has had significant effects on the use of meta-cognitive strategies, and thus, lead to improve student learning.

Keywords

Spatial, Intelligence, Meta-Cognitive, Strategies, Students

Introduction

In the new theories of intelligence psychology most of the people believe that a main part of intellectual behaviors are formed by cognitive functions. Importance of new approaches is that according to this belief against natural abilities of individual that is hereditary and unchangeable, cognitive functions are acquisitive and changeable; therefore, intellectual actions can be educated and learnt [1].

[1]Assistant Professor, PhD of Educational Administration, Department of Educational Science, Payame Noor University.
[2*]Corresponding author: PhD Student of Planning for Distance Education, Department of Educational Science, Payame Noor University
hanieh.shahsavari@gmail.com

One of the most important developments of the second half of 20th century is the emergence of theories that emphasizes on cognitive processes. General strategies of learning that are divided into three main groups of repetition, revision, and extension and organization are known as cognitive strategies. Meta-cognitive consists of programming, leading, supervision and modifying processes and cognitive activities. The simplest meaning of meta-cognition is cognition and knowing cognition. Comparing cognition with meta-cognition provides a better understanding of it. Generally, cognition means knowing, and includes mental activities such as problem-solving, creativity, comprehension, deduction, relationship and argument, while meta-cognition is knowledge about the entire cognitive processes. Meta-cognitive knowledge along with meta-cognitive experiences plays a significant role on leading, stringing, supervision and modifying processes and cognitive activities. Such processes are called meta-cognition and were expressed by Flawell for the first time [2]. Seif defined strategy as a general role or a set of operations that are designed to reach a certain goal. Strategies that can help the understanding of students and improve their problem solving using appropriate patterns according to situations are important. To the extent that appropriate domains used by students are greater, then their achievement in problem-solving, reading, understanding and memorizing will be increased [1]. Meta-cognitive strategies are called applicable or controller strategies which in Flawell are the same abilities and necessary science for selection, application, evaluation, and supervision of cognitive strategies [2]. Seif stated that meta-cognitive strategies are strategies that are used for supervising cognitive strategies. He introduced them in the form of three sets of strategies including programing strategies, control and supervision strategies, and regulating strategy. Contrastingly cognitive strategies are learning strategies that against them meta-cognitive strategies are tactics that could be analyzed in three categories: 1. Programing strategies, 2. Supervision and evaluating strategies, and 3. Self-regulating strategies [1].

But, a considerable point that is posed regarding meta-cognition is its relationship to intelligence. Gardner, the psychologist of Harvard University, offering his 9 dimensional intelligence did not agree with the application of intelligence as a weak description of an individual's capacity for learning. The basis of Gardner's multiple intelligence is the point that people learn from similar information resources differently. Also, this pattern causes the grouping of individuals according to their application of knowledge and using learning styles in situations and different textures. Gardner defined intelligence as the ability to solve problems that an individual is facing in the real life as well as the ability of partaking in an action or offering a service that is valuable in the culture of individual and taking the last step in complementing history of intelligence it is possible to develop different dimensions of human activities [3]. According to Gardner's theory there are several types of intelligence that are independent and reared and compounded by individuals and different cultures. Gardner divides different types of intelligence in the 9 fold classes including verbal-language, logical-mathematical, spatial, musical, physical-kinematics, and interpersonal, intrapersonal, naturalistic, and existential intelligence [4]. It means that personal learning changes depending on human potential in which personal differences are biological and psychological and result from cultural factors which influence a set skills and abilities. Multiple intelligences was offered as one of the intelligence theories that specifically emphasizes on distinguishing differences of individuals and hence is an affective and logical approach rather than unique learners

in the classroom. This theory in a rich and flexible form has many applications for instructors and learners regarding teaching and learning. Every person will be born with 9 types of intelligence, which can be modified and grown, and also has taken educational instructors and developed them. They intend to involve students in the process of learning in different forms to know how students make use of the types of intelligence and have an essential role in affective education. Advantages of such estimation and awareness are twofold. First, if educators became familiar with positive points of learners, they can be better ready for teaching and they will be potent to find appropriate educational issues based on their strengths, second, students will be aware of their strengths and became capable of reinforcing their learning [5]. From among the nine types of intelligence, visual-spatial intelligence refers to ability of perceiving visual issues and perceiving imagining patterns and also appropriate using of spatial patterns and orienting capability, perception and imagining constructs from different dimensions. This intelligence component enables individual in recognition of details, imagination and changing visual things mentally. This dimension covers dimensions such as completing puzzles, reading, writing, understanding tables and diagrams, designing, painting, manipulating images, imagining different issues in mind, distinguishing differences between similar things, interpreting visual images and proper sense of seeking directions [3]. Gardner defined spatial intelligence as recognizing ability of small and large visual patterns. He indicated that shipping, air forcing, sculpturing, dentistry, chess playing and architecture all require a great deal of spatial intelligence [6]. Purpose of this study is to analyze the effect of spatial intelligence on the rate of applying meta-cognitive strategies. Studies regarding special intelligence showed that imagining and spatial sectioning has two main and dimensions of this type of intelligence. Spatial imagination is the ability to imagine circulating a thing by activities which are limited to mental circulating. Also, this point should be recommended that spatial imagination about one simple layer agent and multi-dimensional issue will be performed and spatial sectioning is the fast ability of researching one ground for routing visually and rejecting wrong guidance in this ground [3]. Researchers of cognition and meta-cognition showed that the application of metacognitive strategies increases the rate of the learners' learning. Smith, Odhiambo and Khatib in line with estimations affected by meta-cognition of students on their educational situations collected some information about strategies and metacognitive functions used by students. Result of this study represented significant differences between successful and unsuccessful students in this respect [7]. Yin and Agnes studied awareness and the use of meta-cognitive strategies by weak and strong students in reading and understanding the concepts of English language in Singaporian schools. Result of this study showed that strong students were more aware of their meta-cognition than weak students, but regarding the usage of metacognitive strategies no significant difference was observed between the two groups [8]. Also studies about relationship between intelligence and metacognitive as a predictor of learning was performed and resulted in offering 3 models in this respect [9]. The first model considers metacognitive skill as representation of intelligence ability. According to this model metacognitive skills have no predicting value for learning independent from intelligence abilities. The second model which intellectual ability and metacognitive skills are totally direct predictors of learning is called contrastive model. Finally according to the eclectic model metacognitive skills in a specific way depend on intellectual abilities. More support for eclectic model was provided from studies of Veenman on learning, problem solving and studying texts in different areas

[10]. Finally many studies offered some observations about supporting eclectic model. Areas of research that concerns special intelligence is limited and stills the effects of multiple intelligence and special intelligence on the rate of applying metacognitive strategies. It is not specified that it the caused attachment of the two developed sets of and affective in learning the high level of cognition. What is concerned and processed in the current research is the effect of special intelligence on the rate of applying meta-cognitive strategies by students of virtual education of Tehran University. Special intelligence deals with high capacity of perception, creation and remaking as well as smart recognition of visual details and converting words to mental images, thinking images and having a strong sense of place and seeking directions for representing ideas visually and creating mental images [3]. Two main parts of special intelligence which are known and dealt with in tests of evaluating this type of intelligence are application of flexible strategies as connection between mental imaging and analytical thinking and also applying representing spatial-imaging in doing affaires [4]. As mentioned in the literature review in the recent years some studies were done regarding relationship between intelligence and metacognitive as predictors of learning that resulted in offering three models in this respect. Researchers offered observations for supporting eclectic model that according to it meta-cognitive skills depend on intelligence abilities in specific respects. Theoretical framework of this study for precise analysis of relationship between these two variables was offered about virtual students of Tehran University. Spatial intelligence in this framework is seen as independent variable that influences on dependent variable of applying meta-cognitive strategies. Relationship between these two variables and their components are offered in figure 1.
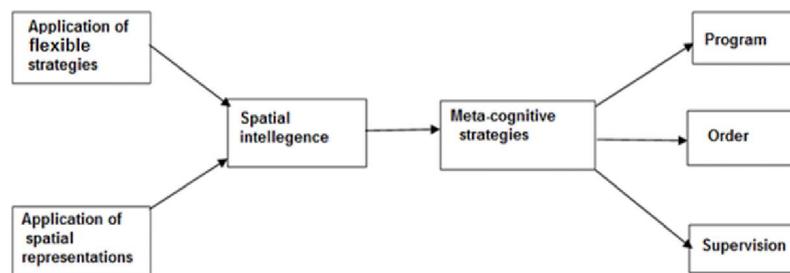
Figure 1: conceptual model of research

This research has one main and two secondary hypotheses as follow: The main research hypothesis indicates that "spatial intelligence has a significant effect on applying meta-cognitive strategies." Also, secondary hypotheses are:
1. Application of flexible strategies has a significant effect on applying metacognitive strategies.
2. Application of spatial-imaging representations has significant effect on applying metacognitive strategies.

Methods
With respect to nature and purpose this is an applied study and respecting method of data collection it is a descriptive and survey study. Population of this study includes

the entire educating students in the M.A. courses of E-Learning in the Tehran University. In this study to specify the size of samples, the Cochran formula was used and in 95% confidence and 5% of standard error, 130 samples were selected. For data collection a researcher made a questionnaire was used to measure spatial intelligence. This questionnaire is composed of four sections and 32 questions and to answer such questions the five scored Likert Scale was used. In the questionnaire of spatial intelligence the first section includes questions about demographic features of the respondents and the second section includes perception of respondents regarding each question and regarding multiple dimensions of spatial intelligence that ranged from 1 to 5 (this behavior totally corresponds to my behavior=5, it is strongly close to my behavior=3, it hardly corresponds my behavior=2, never corresponds my behavior=1) are set as the selecting criteria. In the stage of analyzing research findings, scores 1 and 2 are considered as weak quality, 3 as average quality, and scores of 4 and 5 are considered as good qualities.

To measure reliability the primary questionnaire was offered to 5 professors of the department of training sciences and according to their ideas necessary modifications were performed. For specifying stability of the questionnaire Cronbach's Alfa was applied using SPSS 20.0.

Cronbach's Alfa coefficient for the questionnaire of spatial intelligence was 84%. Reliability of the research instrument was promoted having applied modifying ideas of research committee, so that it could specify 75% variance of research variables.

To measure metacognition of students a questionnaire was used that previously was applied by Pintrich and Di Grout [11] to measure self-regulation learning. In the present research, according to the conceptual framework and related literature like Pintrich [12] questions were added to the questionnaire. Reliability of the present questionnaire was reported to be from 84 to 83%. Research data were achieved from responses of apprentices to the two questionnaires which were designed according to Likert's five degree scale and then the data were analyzed using Lisrel software 8.50 and SPSS 20.0, and according to coefficients and assumed structural relations the suggestive pattern of the study were specified. Criteria of study included taking part in the study and at least one year of participating in E-learning courses. Sampling was continued according to criteria of entering into study gradually until satisfying data. To consider ethical principles it was tried to preserve the secret of participants in the study and to maintain their results secretly, however prior to the study and data collection research purposes were described to participants.

Results

In the present study after data collection and necessary information by questionnaires they were encoded entirely and then entered SPSS. To analyze such data and testing research hypotheses the method of structural equation modeling was used and hypotheses of this study were evaluated using Lisrel software.

Diagram of path coefficients: this diagram shows general relationship between latent and observable variables in this model.

Diagram 2 represents path analysis coefficients of the present study. Numbers on flashes represent related path analysis between variables that is achieved using Lisrel software. Circles represent variables and squires represent questions related to these variables.

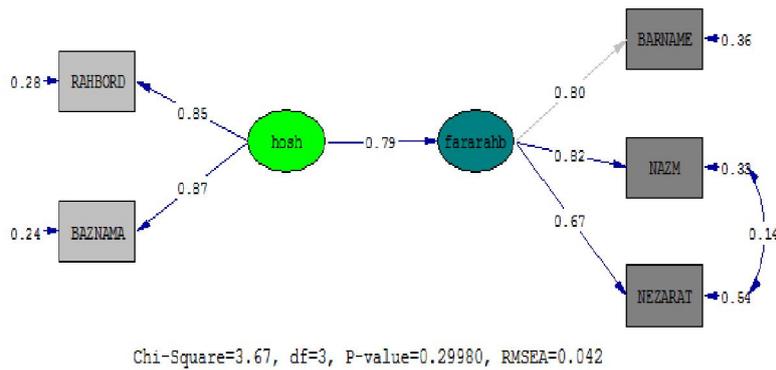Chi-Square=3.67, df=3, P-value=0.29980, RMSEA=0.042

Figure 2: diagram of path analysis in the standard state

As table 2 shows, for each unit increasing of spatial intelligence meta-cognitive strategies increases 0.79units, as well for one unit increasing of flexible strategies there is 0.81 unit of increasing in meta-cognitive strategies and finally for one unit increasing application of representation spatial-imaging metacognitive strategies increases 0.80%.
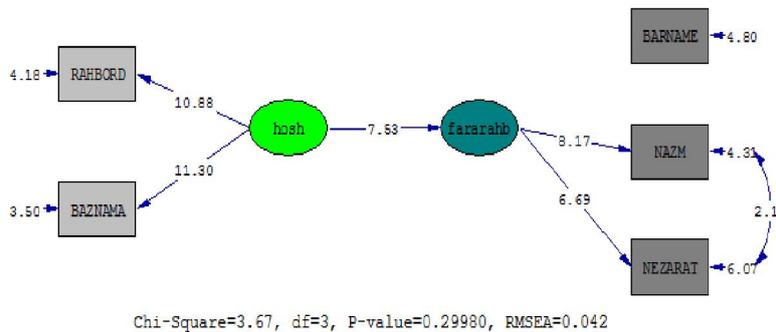

Chi-Square=3.67, df=3, P-value=0.29980, RMSEA=0.042

Figure 3: diagram of path analysis

Table 1: summery of testing hypotheses

Main hypothesis	Standard coefficient	p-value	Result
Spatial intelligence has a significant effect on applying meta-cognitive strategies.	0.79	0.007	Approved
Secondary hypotheses	**Standard coefficient**	**p-value**	**Result**
Application of flexible strategies has a significant effect on applying meta-cognitive strategies.	0.85	0.008	Approved
Application of spatial-imaging representations has significant effect on applying metacognitive strategies.	0.87	0.00ャ	Approved

Testing the main hypothesis: Spatial intelligence has a significant effect on applying meta-cognitive strategies. Result of table 1 shows that the p-value of testing this hypothesis is 0.007 and regarding the significant level of 0.05 it is significant. This issue represents approval and significance of the stated issue statistically. Therefore, this hypothesis was approved and with 95% confident we claim that spatial intelligence has a positive and significant impact on applying meta-cognitive strategies.

Testing the first secondary hypothesis: Application of flexible strategies has a significant effect on applying meta-cognitive strategies. Result of table 1 shows that

the p-value of testing this hypothesis is 0.008 and regarding the significant level of 0.05 it is significant. This issue represents the approval and significance of the stated issue statistically. Therefore, this hypothesis was approved and with 95% confident we claim application of flexible strategies has a positive and significant impact on applying meta-cognitive strategies.

Testing the second secondary hypothesis: Application of spatial-imaging representations has significant effect on applying meta-cognitive strategies. Result of table 1 shows that the p-value of testing this hypothesis is 0.003 and regarding the significant level of 0.05 it is significant. This issue represents approval and significance of the stated issue statistically. Therefore, this hypothesis was approved and with 95% confident we claim Application of spatial-imaging representations has a positive and significant impact on applying meta-cognitive strategies.

When a model benefits an appropriate theoretical background, in the next stage appropriation of this model and data of researcher was gathered. Hence, some of the goodness fit tests for data of this research and model were used to analyze this appropriation. To specify goodness fit indexes there are different factors which are represented in table 2. According to the result of table 2 we can say that the research model had a good fitness from data of the real world.

Table 2: amount of fitting indexes

Row	Fitting index	Acceptable amount	Amount of model	Result of fitting
1	X^2/df	Less than 2 excellent Less than 3 proper	0.122	Excellent
2	RMSEA	Less than 0.06 excellent Less than 0.08 proper	0.042	Excellent
3	NNF1	More than 0.9	0.99	Proper
4	AGFI	More than 0.9	0.94	Proper
5	GFI	More than 0.9	0.99	Proper

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Conclusion

The Purpose of this study was to analyze the effect of spatial intelligence on the rate of applying meta-cognitive strategies. The findings showed that spatial intelligence has a positive and significant effect on applying meta-cognitive strategies. Several studies in line with this study were introduced and reported significant differences in applied meta-cognitive strategies among smart and ordinary students including studies of Cheng [13], Hana and Shoor [14], Shoor and Davar [15], Zimmerman and Martinez-Pons Veenman [16]. On the other hand Allen, Gutkin and Bruning [17] acquired a low correlation between Weksler's scores of intelligence and metacognitive scores by asking participants about their activities of problem solving. While other studies showed that meta-cognition is to some extent independent from intelligence. For example Maksud [18] and Stevenson [19] specifically stated that trivially metacognition is related to fluid intelligence and they provided some observations for supporting eclectic model that according to it metacognitive skills depend on intelligent abilities in specific areas.

In line with specifying the stated findings and in relation to secondary hypotheses we can say that spatial intelligence refers to high capacity for understanding and creating, rebuilding and smart recognition of visual details and also the ability of changing terms to mental images, thinking about images and strong sense of place and seeking orientations and shortly representing ideas visually and creating mental imaginations [3]. Two main aspects of spatial intelligence that are known in measurement tests of this type of intelligence and dealt with are application of flexible

strategies as connection between mental imagination and analytical thinking as well as applying representing spatial imagining in doing affaires [20].

Result of testing the first and secondary hypothesis indicates that application of flexible strategies has a positive and significant effect on applying metacognitive strategies. Result of the study by Colom et al [21] represents overlapping spatial intelligence, attention and speed of processing information that is in line with the result of present study. Specifically and in relation to applied studies concerning spatial intelligence, Bunner et al, studied active memory, spatial intelligence and their relationship to problem-solving skills [22]. Result of their study represented a positive and significant relationship that is in line with the result of present study.

Also, respecting the second secondary hypothesis, applying representation of spatial imagining has a positive and significant effect on applying metacognitive strategies. Result of study by Prokysek et al, showed that application of spatial imagining causes better results in educating students who have a lower level of spatial intelligence. These findings are in line with result of present study [23].

Malekian et al., studied the effect of using complementary educational images in the rate of learner's spatial intelligence and consequently they found a positive and significant relationship between research components [4]. The two significant approaches exist regarding educating spatial intelligence and seeking skills in the two key components, one is that this type of education is processed in the classroom and the other is that learners who are encouraged about learning in a space outside class giving sufficient opportunities for experiencing space and performance in the realm of spatial intelligence skills in home and outside environment [24]. In addition, researchers found that learning in the realm of spatial intelligence can be reinforced by technology and affective education [25]. Providing a tool box for educating such skills commonly by teachers and theorists of this area can provides the empty space for curriculums to fill the learning skills of spatial intelligence [26]. Stating this point is necessary that though studies showed technologies and new methods have high impact on increasing spatial intelligence, but having this type of intelligence requires applying them [20]. In this way the first thing is to inform teachers and instructors from spatial intelligence and then affecting on their activities to include educations which reinforce spatial reasoning. As spatial intelligence is an unknown concept for teachers, many areas which have natural opportunities for spatial learning will be ruined, and as spatial intelligence is not a subject to be educated in school then it is not possible to offer courses to extend them. To the extent that teachers became familiar with this concept and adjust their teaching methods so that include the content related to educating spatial intelligence, it is possible to examine the effect of this content on the increase of student's spatial intelligence. When we found that teachers realized the issue regarding the way they do their educations accordingly, we can do studies in this respect to see how concepts are done by them and to whom they are transferred to students and by designing the organized contents learners spatial intelligence should be reinforced.

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