The Relationship of Fluid Intelligence Level with Higher-order Thinking Skills in Work and Energy among Sixth-grade Students in Jordan

Fadel Ali Abdallah Obeidat[1] & Salmiza Saleh[1,*]

[1]School of Educationsl Studies, Universiti Sains Malaysia, Malaysia

*Correspondence: School of Educational Studies, Universiti Sains Malaysia, Malaysia. E-mail: fadelobeidat@yahoo.com

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Abstract

This study aims to investigate the relationship between levels of fluid intelligence and higher-order thinking skills according to Bloom's three levels classification (analysis, evaluation, creation) among sixth grade students in Jordan in the subject of work and energy as one of the science book topics for the first semester of the academic year 2021-2022.

For this purpose, a test for higher-order thinking skills was designed on the subject of work and energy, consisting of 17 paragraphs of the type of essay questions and multiple-choice in the 3 areas of higher-order thinking skills (analysis, evaluation, creation). The standard Raven test of fluid intelligence with its 5 levels was also applied to the students.

After conducting the statistical analysis, the results of the study revealed: (1) a decrease in the level of higher-order thinking skills to less than the average (analysis, evaluation, and creation, respectively); and (2) a positive correlation between the students' fluid intelligence and their scores in the higher-order thinking skills test. Therefore, the study recommended including activities that take into account fluid intelligence in the curricula to improve students' performance in higher-order thinking skills.

Keywords: fluid intelligence, higher order thinking skills, work and energy

1. Introduction

One important goal of science education is to enhance students' higher-order thinking skills (HOTS) (Abdel Salam, 2009; Widiawati, Joyoatmojo, & Sudiyanto, 2018). These high-level skills are reflected in the first three levels of Bloom's Taxonomy: Analysis, Evaluation, and Creativity. Whereas lower thinking skills are reflected in the three lower levels of Bloom's classification: remembering, understanding, and applying (Higgins, 2017; Merta Dhewa, Rosidin, Abdurrahman, & Suyatna, 2017; Suprapto, Priyono, & Basri, 2017). HOTS requires students to be active and positive, which will necessarily be reflected in their academic achievement (Conklin, 2011). Moreover, some researchers believe that higher-order thinking skills include learning complex judgment skills, such as critical thinking, reflective thinking, creative thinking, and problem-solving (Ismail, Salleh, Zakaria, & Harun, 2017).

Cattell and Horn defined the fluid intelligence as a student’s ability to identify the underlying rules or concepts in novel problem-solving domains (Geary, Berch, & Koepke, 2019). Fluid intelligence is usually measured by taking tests that include deduction and inductive reasoning, which reflect an individual's ability to think, solve complex problems based on logical reasoning and reach conclusions in an important way (Ali & Ara, 2017). So, fluid intelligence is an indicator of academic performance (Ren, Schweizer, Wang, & Xu, 2015).

In science education, in general, and physics, in particular, fluid intelligence skills are used more often when solving serious problems in many educational situations. For example, solving a motion problem, such as finding final velocity from time data, acceleration, and initial velocity based on the equation of motion, so is an indication of crystallized intelligence. But if the question is changed and acceleration is subtracted from the initial and final velocity and time data, then this is a solution to a new problem that requires logical thinking, it is an indication of fluid intelligence. Spatial reasoning associated with vectors and graphs is also a good indicator of fluid intelligence, which enhances conceptual understanding and higher-order thinking skills. (Shekoyan, Armendariz, Tremberger, & Cheung, 2017). Therefore, fluid intelligence is positively correlated with the extent to which students acquire higher-order thinking skills. Preusse, Van-Der, Deshpande, Krueger, and Wartenburger (2011) indicates that people with a high level of fluid intelligence do better on thinking tasks.

1.1 Problem Statement

Although thinking skills, in general, and creative thinking, in particular, are form the outlines of science curricula at the primary stage in Jordan (Al Qararah, 2014), the conceptual assimilation of science in general and physics in particular at this stage requires the development of higher-order thinking skills that include analysis, deduction and solving Problems and linking variables together (Harahsheh, 2017). However, the results of the national test for quality control of education at the primary level (including the sixth grade) indicated low levels of skill acquisition related to higher-order thinking skills (Jordanian Ministry of Education, 2007). Oliemat (2019) also asserts that students in Jordan have weaknesses in dealing with higher order thinking skills when faced with mechanical physics problems and phenomena, including motion, force, and mechanical energy.

Since students' fluid intelligence level may influence the extent to which higher-order thinking skills are acquired, the Lee and Therriault (2013) study suggested that fluid intelligence may play an important role in creative thinking as a high-level cognitive process. Moreover, Ali and Ara (2017) and Ren et al. (2015) indicated that fluid intelligence is an indicator of academic achievement or performance. On the other hand, Habibollah, Abdullah, Tengku, and Jamaluddin (2010) showed that the effect of fluid intelligence on achievement for gender variables (male or female) was not shown. Concerning the contradiction in the relationship between fluid intelligence, student achievement, and the development of their thinking skills, researchers in Jordan did not find any studies that examine the relationship between the level of fluid intelligence and the extent of male and female students possess higher-order thinking skills in physics.

Therefore, this study aims at examining the relationship between the level of fluid intelligence among sixth-grade males and females' students in Jordan and their acquisition of higher-order thinking skills in work and energy. Thus, the questions leading this study were the following:

1**-** What is the level of higher-order thinking skills of work and energy for the sixth-grade students?

2- Is there any statistically significant relationship between the level of fluid intelligence phases and the level of higher-order thinking skills domains in work and energy among the sixth-grade students?

1.2 Literature Review

Fluid Intelligence:

Raymond Cattell assumed in his theory that intelligence is dichotomous: fluid intelligence, which is expressed by the factor (GF), and crystallized intelligence, which is expressed by the factor (GC). Thus, he opposes Spearman's idea that intelligence is unified, which is expressed in the general factor (Vinney, 2019). Table.1 shows the difference between fluid intelligence and crystallized intelligence from several aspects (Preusse et al., 2011; Qousha, 2000).

Academic achievement in educational subjects is closely related to the way we deal with certain educational context, as learners' performance may vary based on the method of teaching manipulated by their teachers in class. While in other educational situations, it requires students to use more logical thinking, especially in mathematics and physics According to Cattell's Fluid Intelligence theory, incorporating fluid intelligence into the teaching process is a positive predictor of increased academic achievement and learning effectiveness (Furnham & Monsen, 2009; Kyrychenko, 2018; Ren et al., 2015; Sanginabadi, 2020; Soares, Lemos, Primi, & Almeida, 2015).

It can be significantly predicted that students' performance, when faced with standard and real problems, students with high fluid intelligence do better on thinking tasks than those with average fluid intelligence (Preusse et al., 2011; Xin & Zhang, 2009).

Fluid intelligence (Gf) is defined as the use of intentional mental processes to solve new problems (i.e., tasks that cannot be performed as a function of simple memorization or routine), such mental processes include drawing inferences, concept formation, categorization, hypothesis creation, and testing, identification of relationships, understanding implications, problem-solving, induction, and information transformation (Primi, Ferrão, & Almeida, 2010). GF is related to tasks that require analytical abilities such as: analyzing patterns, folding and cutting paper, understanding the complex relationships between variables in new situations, classifying and comparing, matrices and sequences, spherical geometry, and solving complex problems (Qousha, 2000).

Table 1. Difference between Fluid Intelligence and Crystallized Intelligence

Field	Fluid Intelligence	Crystallized Intelligence
Genetic influences	Stronger	weaker
Social and intellectual experiences	Less influential	Higher impact
Increase in age	It deteriorates with age, peaks at age 14, and then begins to decline.	It increases with age, as it is mainly related to the experience gained
Cultural influences	Less influential	Higher impact
Associated skills	Inductive reasoning, spatial reasoning, non-phrasal and conceptual skills, induction, deduction, understanding relationships between ideas, understanding and realizing concepts, and integrating them mentally.	Explanation abilities, verbal skills (such as vocabulary and general information), accumulative acquired knowledge
Problem-solving	Solve new or emerging problems, or problems that were not previously learned	Solve previously learned problems or solve similar ones

In science and physics teaching, in particular, fluid intelligence skills are used more when solving serious problems in many educational situations and are a prerequisite for a positive understanding of physics, with higher-order thinking skills such as critical thinking skills. For example, solving a moving question similar to a previous one, such as finding final velocity from time data, acceleration, and initial velocity based on the equation of motion, so this is an indication of crystallized intelligence. However, if the question is changed and the acceleration is requested from the data of the initial and last velocities and time, then this is a solution to a new problem that requires logical reasoning, then this is an indication of fluid intelligence. Spatial reasoning associated with vectors and graphs is a good predictor of fluid intelligence, which enhances conceptual understanding and higher-order thinking skills (Shekoyan et al., 2017).

Primi et al. (2010) verified the relationship between fluid intelligence and differences between individuals, as this relationship was tested using multi-level growth curve modeling applied to data that measured improvement between individuals in mathematical achievement tests. The study sample consisted of 166 students (88 boys and 78 girls), and their ages ranged between 11 to 14 years, and the test results (M = 12.3, SD = 0.64). These individuals underwent four mathematical tests, which were vertically equal through element response theory, at the beginning and end of the seventh and eighth grades. The cognitive abilities studied were numerical reasoning, abstract thinking, verbal reasoning, and spatial reasoning (according to the measurement of the differential thinking test). The general cognitive factor was closely related to the criteria for baseline (intersection) and rate of change (slope). A high level of intelligence was associated with higher initial scores, as well as a sharp rise in mathematics scores over the two years. Liquid Intelligence is associated with faster math learning consistent with the definition of intelligence as the ability to learn.

The study of Xin and Zhang (2009) explored whether first and second-order cognitive holding power perceived by children in mathematical classrooms, fluid intelligence, and mathematical achievement predicted their performance on standard problems and especially realistic problems. A sample of 119 Chinese 4–6th graders were administered the word problem test, the cognitive holding power questionnaire, and Raven's standard progressive matrices. Results showed that: (1) children's fluid intelligence and general mathematical achievement significantly predicted their performance on both realistic and standard problems, however, second-order cognitive holding power predicted their performance on realistic problems but not standard problems; (2) the relationship between first-order cognitive holding power and children's correct answers to realistic problems was mediated by second-order cognitive holding power; (3) children's performance on standard problems was significantly better than that on realistic problems and children's performance on both types of problems improved with their grades

Preusse et al. (2011) illustrate the brain's associations with high fluid intelligence using geometric scalar reasoning as a model that measures this ability purely without the need for additional contextual knowledge, as do, for example, verbal tasks. Hence, the study collected a sample of two identical groups of healthy young participants who did not differ in psychometric or demographic characteristics except for their fluid intelligence measured using the Raven test (RAPM). The sample consisted of two subgroups: an experimental group with a high level of fluid intelligence and a control group with a medium level. Approximately 4 months before the first experimental session, a Liquid

Intelligence Scale test was administered to 120 students from 11th grade in Berlin, Germany. Students with higher IQ learned more flexibility with the demands of the Analog and Geometric Thinking task than on average fluid IQ. The research also showed that the relationship between brain activation and fluid intelligence is not one-way. Instead, the frontal and parietal brain regions are differentially modulated by fluid intelligence when participants perform the analogous geometric reasoning task.

Liu, Alvarado-Urbina, and Hannum (2020) extensively investigated the relationship between intelligence and creativity. While previous studies focused mainly on the relationship between intelligence and creative achievement or the creative process, the current study examined the relationship between intelligence and creative aptitude. It measured participants 'creative competence with the Williams' creative aptitude and fluid intelligence test using Raven's advanced progressive matrices. The study showed that the Gf was positively associated with the creative ability of curiosity and imagination. Further analyzes showed that Gf has an indirect effect on the creative competence of curiosity and imagination through the experience-openness personality measured by the modified NEO personality inventory. These results indicate that openness to experience plays a significant role in the process by which Gf may influence creative competence.

Ng, Fong, and Soon (2010) employed the Fluid Intelligence Test (FIT) as a competency test to assess fluid intelligence before students participate in problem-based learning (PBL) via ICT within the global learning community. The study included items to assess students' creative/critical thinking, logical reasoning, and reasoning skills. FIT is designed to explore whether students' higher-order thinking (HOT) skills in these aspects are enhanced after they participate in improved PBL. Analysis of the data showed that FIT was effective in differentiating students with different proficiency levels. A recommendation was made to conduct more research activities with more adaptation of the validated items to include assessment of students' fluid intelligence before implementation of the syllabus to provide conceptual/procedural knowledge.

Qatami and Qatami (1996) investigated the degree of intelligence and achievement motivation on the method of solving the problem among the outstanding male students in Amman schools in Jordan for the years 1990-1991, and the sample of the study included (538) students representing ages (12, 13, 14) years. For this purpose, the developed Raven scale was used on a sample of Jordanian students, and the achievement motivation test on achievement assignments and the level of problem-solving thinking, which was based on its construction on the Burns ford curve that the researcher built, made sure of its validity and stability. The results of the study indicated that the overall IQ scores are one of the factors most capable of explaining the variation in solving the problem, both randomly and structured, while the degree of interpretation of the other factors included in the study is low.

It is noted from the above that there are few studies that dealt with the relationship between fluid intelligence and learning in general and learning physics in particular. In Jordan, this study is almost the first of its kind - as far as the researcher knows - which deals with the relationship of fluid intelligence with learning science in Jordan. Also, most studies linked fluid intelligence with academic achievement, while this study examined the relationship between fluid intelligence and higher-order thinking skills in science and physics subjects in particular.

Higher Order Thinking Skills (HOTS):

The concept of higher-order thinking skill (HOTS) is a fundamental shift in evaluation reform that aims at promoting thinking skills in learners and taking them away from rote learning. Higher-level mental abilities of the learners such as to analyze, interpret, reason out, synthesize or evaluate the given information are likely to enable them to transfer learning to totally different situations (Ramos, Dolipas, & Villamor, 2013).

Thus, educators define higher-order thinking skills by the extent to which the learner uses mental operations to face the challenges he faces. For example, Onosko and Newmann,(1994) referred to in Yee et al. (2015) defined HOTS as the potential use of the mind to deal with new challenges because HOTS can challenge an individual to interpret, analyze or manipulate information (Yee et al., 2015). HOTS enables students to overcome the challenges of having too much information in the current information explosion era, and it needs limited processing time (Phillips, 2004).

Supeno, Astutik, Bektiarso, Lesmono, and Nuraini (2019) defined higher order thinking skills as the ability to think not just recall, restate, or recite but it reaches several dimensions of knowledge, including metacognitive dimensions. So, students with higher-order thinking skills will have the ability to relate different concepts, interpret, solve problems, communicate, reason, and make the right decisions.

Simply put, the skills categorized at levels of analysis and use in new situations are higher-order thinking skills, thinking skills that are activated when individuals encounter unfamiliar problems, doubts, questions, and dilemmas. In such situations, students can use not only a memorized solution but a combination of critical, logical, reflective, metacognitive, and creative thinking to develop a creative strategy for solving it (King, Goodson, & Rohani, 2011).

Although HOTS is originally based on lower-order thinking skills (LOTS) such as discrimination, simple application, analysis, and cognitive strategies, its application products are more complex including interpretations, decisions, performance, and solutions that are valid not only in the context provided by the teacher but also real-life situations that students can familiarize themselves with it (Nguyễn & Nguyễn, 2017).

Some educators believe that HOTS is divided into two parts: critical thinking skills, which include (knowledge of assumptions, interpretation, and evaluation of arguments), and creative thinking skills in both convergent and divergent aspects, and include three basic skills: fluency, originality, and flexibility (Abiola, 2022; Al- Qeyam & Alnajjar, 2020; Al-Mashqabah, 2019; Al-Zahrani, 2018; Yunus, 2022).

The concept of HOT thinking is derived from Bloom's classification of the cognitive domain that was introduced in 1956 (Forehand, 2010). Based on this classification, the cognitive domain includes knowledge and the development of intellectual skills, and this includes recall or recognition of facts and patterns Procedural and specific concepts that develop intellectual capabilities and skills. There are six main classes (levels) of cognitive processes, ranging from the simplest to the most complex. Bloom classifies intellectual behavior into six levels of reasoning: knowledge, understanding, application, analysis, synthesis, and evaluation (Saido, Siraj, Nordin, & Al_Amedy, 2015).

Al-Sabahi and Krishan (2011), referred to in Al-Manadi (2016), confirm that higher-order thinking skills are the advanced mental skills in Bloom's highest classification, and are represented by analysis, synthesis, and evaluation. Which express creativity, composition skills, and critical thinking (such as the skills of discrimination, proposing solutions, and defining the problem).

Schraw and Robinson (2011) referred to in Merta Dhewa et al. (2017) classify bloom's thinking skill into two categories that are Lower Order Thinking Skills which consists of knowledge, understanding, and application. Higher Order Thinking Skills consist of analysis, evaluation, and creation. Description and the keyword of each category can be seen in the table (2).

In preparing the higher-order thinking skills test, the researcher will rely on the skills of analysis, evaluation, and creation referred to in Bloom's Taxonomy.

Table 2. Description and Key Word of Bloom’s Taxonomy

Type of Thinking Skills	CATEGORY	Keywords
Lower Order Thinking Skills (LOTS)	Remembering: can the student recall or remember the information?	Mention the definition, imitate the pronunciation, state the structure, pronounce, repeat, state.
	Understanding: Can the students explain the concept, principle, law, or procedure?	Classify, describe, explain the identification, place, report, explain, translate, paraphrase.
	Applying: Can students apply their understanding in a new situation?	Choosing, demonstrating, acting, using, illustrating, interpreting, arranging schedule, making a sketch, solving a problem, writing.
Higher Order Thinking Skills (HOTS)	Analyzing: can students classify the sections based on their difference and similarity?	Examining, comparing, contrasting, distinguishing, doing discrimination, separating, test, doing an experiment, asking.
	Evaluating: can students state either good or bad towards a phenomenon or certain object?	Giving argumentation, defending, stating, choosing, giving support, giving assessment, doing an evaluation.
	Creating: can students create a thing or opinion?	Assemble, change, build, create, design, establish, formulate, write.

Saido et al. (2015) demonstrated that higher-order thinking skills in science need improvement, and in physics specifically. Ramos et al. (2013) identified the relationship between students' HOTS and academic performance in physics, The results showed that male and female students have approximately the same level of HOTS. However, for the relationship between HOTS and students' gender, there is no certainty which one is better. King, Wood, and Mines (1990) indicated that males may outperform females on tests of critical thinking skills at the university level, while Ahmad and Duskri (2018) indicated that female students' critical thinking skills were slightly better than males' skills, especially in related to math problems.

The study of Ramos et al. (2013) determined the relationship between higher-order thinking skills (HOTS) of students and the academic performance in physics. The research was conducted at Benguet State University during the school year 2010-2011 and respondents were students enrolled in Physics. Results show that 49.5% of female students have an average HOTS level on analysis while 54.4% of male students have a below-average level. In comparison, almost 50% of both male and female students have below-average levels while more than half of male and female students have an average level on inference. Almost half of the male students and female students have an average level of HOTS on evaluation. Male and female students have a similar level of HOTS in all four areas. Moreover, the HOTS level on analysis, comparison, and evaluation significantly influences the physics performance of male students while the HOTS level on analysis, inference, and evaluation significantly influences the physics performance of female students.

Supeno et al. (2019) believed that students with high-level thinking skills would have the ability to relate different concepts, interpret, solve problems, communicate, reason logically, and make the right decisions. HOTS must be identified through research and the results are expected to be used as a reference for designing instructional strategies appropriate to students' characteristics. In this study, higher-order thinking skills are determined by measuring problem-solving ability, communication skills, and reasoning. The results showed that the students' ability to solve well-structured problems is satisfactory but the ability to solve unstructured problems needs to be developed. As for communication skills, students are still not accustomed to expressing their ideas in scientific writing. As for thinking skills, students can think about some aspects, but in general it is still not satisfactory. Therefore, it is necessary to develop an instructional design appropriate to physics and to follow the characteristics of students to teach higher-order thinking skills.

Hassan, Mustapha, Yusuff, and Mansor (2017) explained that teaching HOTS has challenges, and it should be emphasized in the curriculum as one of the 21st skills, therefore they conducted a study aimed at identifying the need and willingness of teachers to develop HOTS in science teaching in primary schools. The primary analysis was conducted based on interviews with sixth-grade science teachers in six elementary schools. The results showed that teachers' willingness to implement and knowledge does not meet the needs of students, and it seems that teachers do not have the necessary skills to integrate the elements of higher-order thinking skills in science teaching, as they faced problems related to constructing HOTS questions. The interview data also showed that teachers need guidance materials in this area. As for the students, they had difficulty understanding the HOTS questions.

Saido et al. (2015) evaluated the level of HOTS among seventh-grade students in the Kurdistan region of Iraq. The HOTS test was developed based on Bloom's Cognitive Domain Taxonomy and consists of 20 multiple-choice questions. The test was distributed to a random sample of 418 students. The overall results revealed that the majority of the seventh grade students were at the lowest level of thinking skills = 278 (79.7%). The level of male students was lower than the level of female students. However, there were no significant differences between the students' HOTS level and their gender ($p > 0.05$). Based on students' higher-order thinking skills results, the study provided evidence that nearly all students need to improve their HOTS, especially analytical and assessment skills and creation in science.

By reviewing previous studies, it becomes clear that there is a weakness in higher-order thinking skills in physics among students in general, with some differences in their areas according to Bloom's classification of higher-order thinking skills. There are few studies that investigate the relationship between fluid intelligence and HOTS skills in work and energy, and there are hardly any studies in Jordan that address this relationship.

2. Methodology

This study is an analytical correlational study that attempts to explore the relationship between fluid intelligence level with higher-order thinking skills level of work and energy subject among the sixth-grade students in Jordan.

The population of this study comprises of all male and female sixth-grade students enrolled in Bani Kenanah directorate of education(Irbid, Jordan) during the first semester of the academic year 2021-2022. The total number of the population of the study is 2350 male and female students in 22 governmental schools. They are in the age group ranging from 11.5–12.5 years. They are also homogenous in terms of their nationality, first language (Arabic), exposure to English as a foreign language, educational system, and cultural background.

The sample of the study consisted of 332 sixth-grade male and female students. They were distributed according to their gender variable as shown in table 3.

Table 3. Frequencies and Percentages of the Distribution of the Sample Subjects According to Their Gender Variable

Gender	Frequencies	Percentages
Male	164	49.40%
Female	168	50.60%
Total	332	100.00%

Table (1) shows that Males were (164) with percentage (49.40%), while (Females) were 168 with percentage (50.60%).

The present researcher used two instruments:

1- Fluid intelligence Test (FIT) to assess students' fluid intelligence levels by using Standerd Raven's progressive matrices (RPM) which consisted of 60 items distributed equaly into 5 phases.

2- Higher Order Thinking Skills Test: (HOTST) to measure the higher order thinking skills for the sixth-grade students. To achieve the reliability of this test, the researcher chose a pilot sample consisting of (32) students. The researcher administrated the test on them. The researcher applied the Kuder-Richardson 20 method. The reliability of the test phases ranged between (0.86 – 0.92) and (0.90) for the whole test.

HOTST was built into the (Work and Energy) content from the sixth-grade science course in Jordan to measure higher-order thinking skills according to Bloom's Taxonomy (Analysis, evaluation, and Creation) with 17 items distributed in multiple choice and essay questions.

To insure the its validity , the higher order thinking skills test was given to a jury of university professors to elicit their views as to the approriateness of the test. Then the test modified according to their recommendations.

The Study Variables:

The Independent Variable is Fluid intelligence level among the sixth-grade students in Jordan. hereas the dependent variable is higher-order thinking skills level among the sixth-grade students in Jordan.

Data Analysis:

Statistical Package for the Social Sciences: SPSS software was used to test the questions of this study. The data were analyzed by using the following statistics:

1. Descriptive statistics: such as the means, standard deviation, frequencies, and percentages were used.

2. Pearson Correlation Coefficient's.

3. Results and Discussion

The following section is describing the results of the descriptive statistics. After collecting collected the necessary data via the study two instruments: "fluid intelligence test and higher order thinking skills test". The results were concluded and presented according to the study questions:

Results Related to the first Question: What is the level of higher-order thinking skills for the sixth-grade students?

To answer this question, the researcher computed the descriptive statistics (Means and Standard Deviations) of the students' grades on the higher-order thinking skills test, the results were shown in table (4).

Table 4. Means and Standard Deviations of the Students' Grades on the Higher-order Thinking Skills

#	The Domains	# Of Items	Mean	Std. Deviation	Percent	Rank
1	Analysis	8	4.21	1.84	52.63%	1
2	Evaluation	3	1.17	0.89	39.00%	2
3	Creation	6	2.19	1.05	36.50%	3
	Higher-order thinking skills	17	7.57	2.81	44.53%	=

It is clear from the table 3 that the performance of students on the HOTS test is less than the average in all areas (analysis, evaluation, and innovation), and this is consistent with the studies of Ramos et al. (2013); Saido et al. (2015).

Table (3) shows the first domain (Analysis) ranked firstly with mean (4.21), and standard deviations (1.84). The second domain (Evaluation) ranked secondly with mean (1.17), and standard deviations (0.89). While the third domain (Creation) ranked finally with mean (2.19), and standard deviations (1.05). The grand mean of the students' grades on the higher-order thinking skills test was (7.57), and standard deviations (2.81). This may be due to the fact that innovation skills are located at the top of Bloom's pyramid and require elements to be combined together and organized to form a functionally coherent unit, which leads to production, construction, design, planning, ...while the evaluation stage requires skills higher than analysis and less than innovation (Conklin, 2011; Shawqi, 2018).

Results Related to the 2nd Question: is there any significant statistical relationship between the level of fluid intelligence phases and the level of higher-order thinking skills domains among the sixth-grade students?

To answer this question, the researcher computed the Pearson correlation coefficients of the study subjects' grades on the two tests. The results were shown in table (5).

Table 5. Pearson Correlation Coefficients of the Study Subjects' Grades on the Two Tests

Tests	Higher-order thinking skills			
	Analysis	Evaluation	Creation	HOTS
Phase I	0.682**	0.716**	0.734**	0.762**
Phase II	0.628**	0.640**	0.676**	0.738**
Phase III	0.784**	0.599**	0.689**	0.689**
Phase IV	0.440**	0.402**	0.599**	0.631**
Phase V	0.457**	0.460**	0.784**	0.790**
Fluid intelligence test	0.758**	0.728**	0.688**	0.812**

**Significant at ($\alpha \leq 0.01$).

Table (4) shows that there are positive correlation coefficients between the level of fluid intelligence phases and the level of higher-order thinking skills domains which ranged between (0.402 – 0.812).

This is consistent with the effect of fluid intelligence on academic performance and students' abilities to think at a higher level, as in the studies of Primi et al. (2010); Xin and Zhang (2009); Preusse et al. (2011). The results of this study in the field of the relationship between fluid intelligence and creativity agree with (Liu et al., 2020; Ng et al., 2010; Zahran, 2020).

This positive correlation may be between levels of fluid intelligence and students' practice of higher-order thinking skills because fluid intelligence skills require students to include conclusions, concept formation, classification, hypothesis creation and testing, identifying relationships, understanding implications, solving new problems, induction and transferring information (Primi et al., 2010). Which requires analytical abilities of students and making judgments in a systematic way (evaluation) and to a higher degree invention, design or rebuilding to reach new product (creation) (Qousha, 2000).

It is noted there is an absence of studies that investigate the relationship between fluid intelligence at the five levels according to Raven's classification and the three domains of higher-order thinking skills (analysis, evaluation, and innovation). Therefore, the researcher recommends including the skills that are compatible with fluid intelligence in the school curricula, especially in the work and energy unit, in order to enhance higher-order thinking skills among students in Jordan.

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