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The Relationship between the University Students' Level of Metacognitive Thinking and their Ability to Solve Mathematical and Scientific Problems

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Abstract
The purpose of this study is to investigate the relationship between the university students' metacognition thinking and their ability to solve mathematical and scientific problems. 172 university students were involved in this study. The researchers employed two types of instruments: metacognition awareness inventory, and a mathematical & scientific problem solving test; which was constructed by the researchers. After the collection of data, the researchers ran a suitable statistical analysis. The study has concluded that Petra University students have a medium level of metacognitive thinking, and that the variables of sex, faculty, high school stream, and the current year in the university had no effect on their level of metacognitive thinking. The study has also shown that these students suffer from a lack of ability in solving mathematical and scientific problems; no significance correlation between the level of metacognitive thinking in the overall scale and the ability to solve mathematical and scientific problems. However, there was a significant correlation between a few factors of metacognitive thinking and the ability to solve mathematical problems, and these are: Procedural Knowledge, Evaluation, Fault Picking, and Managing Knowledge; as well as a significant correlation between Fault Picking and the ability to solve both mathematical and scientific problems.
Keywords: metacognitive thinking, problem solving.

1. Introduction
The process of solving problem is one of the most complex human behaviors, as it requires hiring high cognitive skills, as well as meta-skills. The process of solving problems is at the top of the learning hierarchies; therefore, an educational psychologist acknowledges the importance and necessity of cognitive processes to perform this operation (Gagne, 1970). According to many psychologists such as Sternberg (1985), the learner needs metacognition skills, in addition to cognitive components, to regulate and monitor the problem-solving process. These skills help the learner to define and identify the problem, choose the right strategy, monitor the effectiveness of the solution strategy, and organize the thinking process and the task of the solution (Davidson & Sternberg, 1998; Sternberg & Hedlund, 2002).

Cognition
A general term of thinking which can be described as the "mental process of knowing", which includes aspects like perception, judgment, reasoning, awareness, or anything that can be recognized through reasoning, intuition knowledge, and perception (Dawson, 2008).Thinking occurs in a variety of ways; the thinking process is meaningful and based on empirical data; which we call it 'perception'. Thinking can be to think of something tangible (as can be observed in concerned individuals), or to abstract real objects and properties. Thinking here is perception, perception is the mediator between the learner and the empirical world; perceived objects can be real objects, or ideas and abstractions (Noushad, 2007).

Metacognition
Flavell (1976) coins the term metacognition, where it was defined as the internalization of cognition, an understanding of cognition, means to control, organize and appropriately use it. (Wilson & Bai, 2010; Flavell, 1979; Reeve & Brown, 1985) assert that metacognitive thinking is to organize one's cognitive undertakings and activities in the process of learning. The term "metacognition" was associated with numerous terms, such as "thinking about thinking", "higher thinking skills", "learning process regulation", as well as other terms that are directly linked to the notion of cognitive learning (Zulkiply et al., 2008). Metacognitions could be called "second-order cognitions", requiring more engagement of executive functioning than first-order cognitions (Livingston, 2006; Fouché & Mark, 2011). The term metacognition refers to a student's knowledge about his or her process of cognition and the ability to control and monitor those processes as a function of feedback received via outcomes of learning (Gok, 2010).

Cognition and metacognition
The relationship between cognition and metacognition is a complex one; thus, it is difficult to separate the two; as metacognition draws on cognition. It is difficult for an individual to organize things in terms of metacognition without this action including cognitive activities; this is clear when it comes to setting and organizing steps for problem solving (Veenman et al., 2006). Metacognition can be thought of as consisting of one or more of the

following characteristics of the cognitive process: knowledge about, the monitoring of, and the control of the process **(**Serra & Metcalfe, 2009). If metacognition is understood as knowledge of "self-instructions" in order to control and organize one's performance in tasks, then it can be thought of as the vehicle of these "self-instructions" (Veenman et al., 2006).

(Hacker, et al., 1998) contrasts between different cognitive tasks; which include retrieving ideas one has learned in the past that could prove useful in solving the task or problem at hand, and beyond the task of knowledge, as well as to monitor and guide the problem-solving process (Noushad, 2007). In fact, and as mentioned earlier, metacognition draws on cognition. It is quite difficult to maintain acceptable and sufficient metacognitive knowledge of an individual's own competencies in a domain lacking sufficient (cognitive) domain-specific knowledge, like knowledge about related notions and theories in a given domain, for instance, or about substantial difficulties, about what is unrelated. When it comes to metacognitive skills, one cannot engage in planning without carrying out cognitive activities, such as generating problem-solving steps and putting those steps in appropriate order (Veenman et al., 2006; Swanson, 1990).

Problem solving

A problem occurs when there is a gap between the individual and the desired objective; problem solving exists in numerous aspects in reality or games. It is also considered to be as a paradigm of complicated cognition that is unseparated from daily life practices (Gok, 2010). Thus, problem-solving does not only exist in the world of mathematics, but covers many events occur in the real-life experiences. It can be identified as the "knowledge and processes" that could steer and guide an individual's thinking process toward reaching a satisfying solution of a problem. Efficient mental model could make it possible for the problem solver to arrange and assemble information, control the strategies of solution, and aid in generalizing across problem (Mayer, 1998). The efficient problem-solver relies on the "nature and organization" of the knowledge available to him or her, which is why students who have a greater ability to reason are ahead of their peers and are more prone to be better students (Bransford et al., 1986).

In the process of problem-solving, the individual is required to use both his cognitive abilities and practical skills, which include metacognitive activities such as analyzing, synthesis and evaluation (Kafadar, 2012). Problem-solving requires three main conditions: the first is thinking about the problem and steering behavior toward the goal, then searching for a law or strategy that can help in reaching the desired goal, and finally to try these laws or strategies by putting them in action. In this phase, one must identify and set sub-goals in accordance with the type of the problem, then solving the problem and achieving the goal (Kafadar, 2012).

Metacognition in Problem Solving

Several researchers who have tackled this topic have emphasized relationships between metacognition and problem solving. The primary purpose of solving mathematical problems, as stated in the NCTM 2000 standards, does not provide students with the skills, and the development or enhance certain operations important to the learner, as far as what is important to enable students to think for themselves. The judgment on teaching skills and processes by solving the problem resides in judgment on these skills and their impact on operations expand students' thinking and improves their flexibility and independence of thinking (Desoete et al., 2001; Evans et al., 2003).

Metacognition includes one's knowing of how to recreate and analyze thoughts and ideas, and essentially the way to come up with conclusions based on their analysis, and finally how to apply what they have gained through learning practically. To solve a problem, students are obliged to understand the way their mind works and functions, and how they perform important cognitive tasks such as remembering, learning and problem solving (Noushad, 2007)**.**

Learners are able to define the problem, choose applicable solution strategies, monitor how effective this strategy solution is, and both recognize and act on constraints while solving the problem, all with the aid of metacognitive skills (Vaidya, 1999). Whether the problem in question is mathematical or scientific, it is still a phenomenon that requires a person to determine the strategy needed and make a decision for a solution, metacognition considered as an important key to success in problem solving (Özsoy & Ataman, 2009).

O'Neil & Schacter (1997) propose a model for problem solving, which includes these basic four elements: "content understanding; problem solving strategies; metacognition; and motivation", Content understanding and problem solving strategies are domain-specific; while metacognition and motivation are domain-independent constructs. (O'Neil & Schacter,1997; Wilson & Clarke 2004) highlight the critical role played by metacognitive thinking in both problem-solving and learning of mathematics. Additionally, there is a great confirmation by researchers that failing and succeeding in solving mathematical problems depends on the level of cognitive and metacognitive thinking and there are reports confirm that students who are facing problems in mathematics are not using a broad range of cognitive and metacognitive strategies in their approach to problem-solving (Wilson & Clarke, 2004). Researchers also points out that the process of control, as a metacognitive process, is one of the most critical metacognitive thinking behavior, which largely influences the process of decision making in problem-solving (Carlson & Bloom, 2005).

Based on many studies, Sternberg (1985) determines that "problem-solvers" not only need to have the useful cognitive components, but must also be capable of arranging and controlling these cognitive components in any problem solving task presented to them. These required meta-skills called meta- components (Mayer, 1998). These meta-skills previously mentioned (also known as metacognitive knowledge) include the knowledge of when to use, how to regulate, and how to monitor different skills on problem solving (Mayer, 1998). Many researchers claim that "everyday problem solving" calls for much more complicated processes of cognition than those required for solving and dealing with "well-structured problems" (which usually come in the shape of classical homework problems in textbooks); as well-structured problems call for the efficient use of metacognitive skills, and solving daily problems call for them even more (Lee, Teo & Bergin, 2009).

Researchers assert that the three components of metacognitive thinking that influence problem solving the most are the declarative, procedural & conditional knowledge (Carlson and Bloom, 2005). The importance of studying metacognitive thinking activities by the way students think lies in improving the students' education process (Livingston, 2006; Gok, 2010).

2. Study Questions

1. What is the university students' level of metacognitive thinking in the overall scale, and the scale's six factors?
2. Are there differences in the university students' level of metacognitive thinking based on the following variables: gender, specialization in high school streams (Scientific/Literary/IT/Others), faculty & year level?
3. What is the university students' ability level in solving mathematical and scientific problems?
4. Are there differences in the university student's ability in solving mathematical and scientific problems based on the following variables: gender, specialization in high school (Scientific/Literary/IT/Others), faculty & year level?
5. Is there a correlation between the university students' metacognition thinking and their ability to solve mathematical and scientific problems?

Operational Definitions

Metacognition: "Thinking about thinking". Metacognitive skills are defined as interrelated competencies for learning and thinking, and consist of many skills required for effective learning, critical thinking, reflective judgment, problem solving, and decision making (Dawson, 2008). These skills are measured according to the total scores obtained by the student in the (MAI) used in the study.

Problem solving: is defined as a cognitive process directed toward achieving a goal when there is no solution method is clear to the problem solver, and it has four key Characteristics: first, problem solving is cognitive, second, it is a process, third, it is directed and. Finally, it is related to the person. (Mayer & Wittrock, 1996). It is, also, measured according to the total scores obtained by the student in the mathematical and scientific problem solving test used in the study.

Limitation of the study

This study was limited to students at the University of Petra, in addition to that the findings of it are determined by the characteristics of the two scales used, and the scales' ability to differentiate between students' level of metacognitive thinking, and students' ability level in solving mathematical and scientific problems.

3. Methododology

Sample of the study

(172) Students from Petra University in Jordan enrolled in the first semester of the academic year 2013/2014 participated in the study. Among participants, (48) were male students with a percentage of (27.9%), and (124) were female students with a percentage of (72.1%). The participants were studying in a variety of academic faculties, including arts and sciences (98), administrative & financial (39), pharmacy and medical sciences (10), information technology (11), architecture and design (12), and other faculties (2). There were (50) of them specialized in scientific stream in high school, (44) of them in the literary stream, (63) in IT stream and (15) of them in other streams.

Instruments (Tools of Data Collection)

To collect data, researchers used two instruments **(**Metacognition Awareness Survey (MAI), Mathematical and Scientific Problem Solving Test).

1- Metacognition Awareness Inventory (MAI)

To determine levels of student's metacognitive thinking skills, the researchers used the Metacognition Awareness Inventory (MAI) developed by Schraw and Dennison (Schraw & Dennison ,1994). It consists of eight factors assessed by (52) items. These items were graded on a five-point Likert scale (1 means almost never; 2 means seldom; 3 means sometimes; 4 means frequently; 5 means almost always).

The scale represents two main components of metacognitive thinking, which are Knowledge and Regulation.

The first component "Knowledge" is classified into three main factors: Declarative Knowledge, which consists of knowledge of the self and knowledge of strategies; Procedural Knowledge, which is the knowledge of how to use strategies; and finally Conditional Knowledge, which is composed of knowing when and why to use these strategies. "Regulation", on the other hand is classified into five factors: Planning, which includes setting goals; Organizing, which is organizing information; Monitoring, which deals with the person learning and assessing strategies; Debugging, which deals with the strategies chosen for mending mistakes; and finally Evaluation, which is to analyze accomplishments and the strategies' efficiency after learning has been accomplished

These eight factors measure the following dimensions of Metacognition: Explanatory Knowledge, Procedural Knowledge, Conditional Knowledge, Planning, Monitoring, Evaluation, Fault picking, and Managing Knowledge.

Validity and Reliability of the Instrument: The researchers translated the instrument (MAI) for metacognitive thinking into Arabic. Additionally, the Researchers had the translation reviewed by a group of professional reviewers to ensure it is suitable for the Jordanian culture although it already possesses great validity and reliability in its original format. The reliability coefficient (Cronbach Alpha) has been calculated using a sample group of 50 students, The reliability value for (MAI) scale as a whole was (0.952), the reliability coefficient values for the eight factors are shown in Table(1).

able 1. Reliability Coefficient values for the metacognition eight factors

	Explanatory Knowledge	Procedural Knowledge	Conditional Knowledge	Planning	Monitoring	Evaluation	Fault	Managing Knowledge
No. of items	7	4	6	7	8	6	5	9
reliability coefficient	0.704	0.692	0.84	0.83	0.88	0.81	0.81	0.88

The range for average score that a respondent obtains in the Metacognition Awareness Inventory is between 52 and 260. The level of metacognition is categorized as low for scores 52 to 121, for percentage of (20% - 46.5%), moderate for scores 122 to 191 for percentage of (46.6% - 73.5%) and high for scores 192 to 260, for percentage of (73. 6% - 100%).

2**- Mathematical and Scientific Problem Solving Test (MPS&SPS) test**

A scale has been designed to measure the student's ability to solve mathematical and scientific problems; the test includes (28) problems, (13) of them are mathematical problems and (15) of them are scientific ones. The mathematical problems covers a range of basic mathematical knowledge, such as calculation, numbers, algebra, mathematical patterns, modeling, mathematical representation, and geometry; while scientific problems include features problems in chemistry, physics, geology, biology, and ecology. The scale has also been reviewed by a number of specialists in mathematics and science, and has been modified accordance to their suggestions and feedback. Their overall approval of the scale is proof of its consistency. The reliability coefficient (Cronbach Alpha) has been calculated using a sample group of 50 students (pilot group). The reliability value for the test as a whole was reached (0.74), which is acceptable for scientific research.

4. Results & Discussion

The present study focuses on examining the relationship between metacognition thinking and student's ability to solve mathematical and scientific problems. It also compares metacognition thinking and mathematical and scientific problem solving in university students across academic year, gender, faculties & specialization in high school (Scientific / Literacy/ IT / Other streams).

To answer the first question that tackles the level of metacognitive thinking of students based on the overall scale and its eight factors, the researchers have calculated the mean, standard deviation and percentage of the student's scores for each of the factors in the Metacognition Awareness Inventory. The results are shown in Table (2).

Table 2. Means, Std. deviations and percentages of the scores on each factor of metacognitive thinking

	No of Items	Mean	Std. Deviation	Minimum	Maximum	%
Explanatory Knowledge	7	25.27	5.76	9	35	72.2
Procedural Knowledge	4	14.09	3.58	4	20	70
Conditional Knowledge	6	21.18	5.348	6	30	70.6
Planning	7	24.38	6.20	7	35	69.7
Monitoring	8	28.80	7.30	8	40	71.99
Evaluation	6	20.95	5.37	6	30	69.8
Fault	5	18.02	4.76	5	25	72
Managing Knowledge	9	32.40	8.26	9	45	71.98
Metacognition(overall)	52	185.09	40.75	54	260	71.2

The Table above shows that the means for the student scores on eight factors of metacognitive thinking scale varied between 14 and 32 scores, and percentages between 69.7% and 72.2%. The percentages of eight factors in descending order are shown below:

Explanatory Knowledge (72.2%), Fault picking (72%), Monitoring (71.99%), Managing Knowledge (71.98%), Conditional Knowledge (70.6%), Procedural Knowledge (70%), Evaluation (69.8%) and Planning (69.7%).

The student's level of metacognition thinking was found to be moderate, mean (185), SD (40.75), with a percentage of 71.2%. Results indicate that the majority of respondents were in moderate level category of metacognition. It is noted in Table (2) that mean of the student's score on the Metacognition Awareness Inventory reached 185, with a percentage of 71.2%, and this result does not go in accordance with what has been obtained by (Al-Hamouri & Abu Mokh, 2011), nor with (Aljarah and Obeidat, 2011) which showed that the level of metacognitive thinking among Yarmouk University students was relatively high. This difference in metacognitive thinking level can be explained by that the students in this sample had somewhat low high school scores compared to students in public universities; which could account for the lower level of metacognitive skills in university students in private universities, which is not in the same levels as those who have been enrolled in public universities. It is critical to point out that Metacognition Awareness Inventory, whether used in this study or similar studies in a Jordanian context, are self-reporting instruments; and therefore, do not accurately reflect the real level of metacognitive thinking; thus, students are given the chance to reflect how many metacognitive skills they have acquired through these instruments, but not how they practice them or put them into use in the educational process or in problem solving, and whether they use them properly. On the other hand, the result of this study is consistent with previous studies when it comes to the results obtained through the eight factors. Results of this study are consistent with the results of some previous studies regarding the level of metacognitive thinking through the eight factors such as (Yunus & Ali, 2008) which showed high metacognitive thinking levels in the following factors: Debugging, Managing & Conditional knowledge in comparison with Procedural knowledge, Monitoring, Planning & Declarative Knowledge. It also is consistent with the study conducted by (Aljarah and Obeidat, 2011), which showed that the level of metacognitive thinking of the students was higher in the information processing, organizing information, knowledge consequently. While the results of these studies showed a weakness among students in the skills of organization and planning.

Second question: Are there differences in the university students' level of metacognitive thinking based on the following variables: gender, specialization in high school (Scientific / Literacy/ IT / Other streams), faculty & year level?

The researchers have first calculated the mean and standard deviation values of the students' scores in the different factors of metacognition, and on the overall test, categorized according to their gender. Table (3) shows these findings.

Table 3. Means and Std. deviations values of the students' scores in the different factors of metacognitive thinking scale and on the overall scale according to gender.

Scale-Factors	sex	N	Mean	Std. Deviation	t	Sig. (2-ailed)
Explanatory Knowledge	male	48	25.69	5.717	0.585	0.559
	female	124	25.11	5.799	0.589	0.557
Procedural Knowledge	male	48	13.92	3.619	-0.401	0.689
	female	124	14.16	3.574	-0.399	0.691
Conditional Knowledge	male	48	21.52	5.120	0.519	0.604
	female	124	21.05	5.443	0.533	0.595
Planning	male	48	25.21	5.649	1.087	0.279
	female	124	24.06	6.387	1.147	0.254
Monitoring	male	48	30.06	7.039	1.419	0.158
	female	124	28.31	7.370	1.448	0.151
Evaluation	male	48	20.73	4.988	-0.340	0.734
	female	124	21.04	5.524	-0.356	0.723
Fault	male	48	17.40	4.495	-1.066	0.288
	female	124	18.26	4.852	-1.103	0.273
Managing Knowledge	male	48	32.85	8.166	0.452	0.652
	female	124	32.22	8.319	0.456	0.649
Metacognition (overall)	male	48	187.38	39.089	0.456	0.649
	female	124	184.21	41.491	0.468	0.641

Table (3) indicates that the means for male students were higher than the means of female students on the scale as a whole and on the following five factors: Explanatory Knowledge, Conditional Knowledge, Planning, Monitoring and Managing Knowledge.

To determine if the differences between the means of female and male students are statistically significant, the researchers have calculated the t-values, which are shown in Table (3). It can be noted from Table (3) that there is no statistically significant difference between male and female students in the sub-dimension of the metacognitive thinking scale, and the overall scale itself.

The results of this study show that there is no statistically significant difference between the means of male and female students in the level of metacognitive thinking, which is consistent with previous studies such as (Zulkiply et al., 2008; Abu-Alia & Alwaher, 2001; Al-Hamouri & Abu Mokh, 2011), and which also showed that there is no significant differences based on sex in the eight metacognition factors; however, these results oppose the findings of (Sabatin, 2006), which showed that some differences exist based on gender in the evaluation factor in favor of males, and planning, in favor of females, which could be due to the difference in age groups (Sabatin, 2006). The current findings were inconsistent with those of (Aljarah & Obeidat, 2011), as they showed statistically significant differences based on the variable of sex in metacognitive thinking, in favor of females; our findings are also inconsistent with those of (Yunus & Ali, 2008) which showed that female students have a higher level of metacognitive thinking compared to male students on the eight scale factors, but this is not significant except in the aspect of debugging, or what could be called "Fault Picking". The differences in the findings of the current study could be due to the variation of age groups, as well as the social environment, which could affect what experiences individuals may have acquired and the way they learn, which calls for further research.

For the purpose of investigating the impact of high school Stream, the researchers have first calculated the mean and standard deviation values of the students' scores in the different factors of metacognition, and on the test overall for the sample who were enrolled in one of these streams during high School: Scientific, Literary, IT and Others. ANOVA test was used to find out if there were statistically significant differences between the means of student' score attributed to specialization in high school. Table (4) demonstrates these findings. It can be noted from Table (4) that differences between means values of students' score are insignificant.

Table 4. Mean and Std. deviations values of the students' scores of metacognitive thinking scale based on Student's graduated stream in high school

Scale-Factors	Scientific-Stream N=50		Literary-Stream N=44		I.T N=63		Others N=15		F	sig
	M	SD	M	SD	M	SD	M	SD		
Explanatory Knowledge	3.67	0.99	3.73	0.92	3.61	1.03	3.40	0.93	0.45	0.72
Procedural Knowledge	3.60	1.07	3.64	1.07	3.48	1.06	3.27	0.86	0.56	0.64
Conditional Knowledge	3.47	3.48	3.63	0.89	3.37	0.99	3.00	1.2	1.76	0.16
Planning	3.43	1.00	3.34	0.87	3.51	1.05	3.47	0.69	0.26	0.85
Monitoring	3.69	0.89	3.66	0.95	3.68	1.10	3.4	0.89	0.40	0.75
Evaluation	3.43	0.95	3.69	1.10	3.46	1.10	3.23	0.84	0.88	0.45
Fault	3.79	1.06	3.70	1.05	3.53	1.21	3.4	1.00	0.77	0.51
Managing Knowledge	3.73	1.09	3.73	1.09	3.82	1.06	3.54	1.20	0.60	0.62
Metacognition (overall)	3.62	0.78	3.61	0.69	3.52	0.87	3.39	0.78	0.46	0.71

As for the effect of Faculty on overall metacognitive thinking, and its eight factors, the researchers have calculated the mean and standard deviation of the participants' scores in different faculties. ANOVA test was used to find out if there were statistically significant differences between the means of student' score attributed to faculties. Table (5) shows these findings.

Table (5) shows the differences in the means values of student's scores on overall metacognitive thinking scale, and its eight factors based on the faculty, it can be noted from this Table that the differences are statistically insignificant.

As for the effect of the current university year students have reached on metacognitive skills, the researcher has calculated the mean and standard deviation for the participants scores based on how many years they have spent at the university (1-4 years). ANOVA test was used to find out if there were statistically significant differences between the means of student' score according to their year level. Table (6) demonstrates this data.

Table 5. Means and Std. deviations for the scores of metacognitive thinking scale based on student's university faculty

Scale Factors	Pharmacy N = 10		Architecture and Design N = 12		Administrative & Financial N=39		IT N=11		Art & Sciences N=97		Others N=2		F	Sig
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD		
Explanatory Knowledge	4.05	0.72	3.42	0.93	3.82	0.91	3.45	0.85	3.56	1.04	4.5	0.71	1.29	0.27
Procedural Knowledge	3.25	0.72	3.79	1.66	3.77	1.01	3.14	0.78	3.47	1.07	4.25	1.06	1.21	0.31
Conditional Knowledge	3.45	0.9	3.25	1.06	3.67	1.03	2.77	0.93	3.42	0.9	3.75	1.77	1.67	0.15
Planning	3.3	0.9	3.54	1.16	3.5	0.84	3.18	0.81	3.44	1	3.75	1.77	0.3	0.91
Monitoring	3.75	0.7	3.63	0.91	3.94	0.84	3.18	0.87	3.6	0.99	3	0.71	1.59	0.17
Evaluation	3.5	0.7	3.25	1.23	3.58	1.02	3.27	0.9	3.53	1.06	2.25	1.06	0.88	0.5
Fault	3.75	0.6	3.38	1.11	3.86	0.97	3.68	0.98	3.55	1.21	4.25	1.06	0.71	0.62
Managing Knowledge	3.65	0.9	3.75	1.23	3.79	1.07	3.32	1.08	3.69	1.14	2.25	1.77	0.98	0.43
Metacognition (overall)	3.64	0.5	3.45	0.66	3.74	0.69	3.31	0.65	3.53	0.87	3.37	0.54	0.75	0.59

Table 6. Means and Std. deviations for the scores of metacognitive thinking scale based on student's year-level

Scale Factors	First-Year N=78		Second-year N=36		Third-year N=26		Fourth-year N=32		F	Sig
	M	SD	M	SD	M	SD	M	SD		
Explanatory Knowledge	3.67	1.02	3.35	0.96	3.62	0.80	3.91	0.98	1.94	0.18
Procedural Knowledge	3.67	1.14	3.21	0.94	3.33	0.83	3.74	1.18	2.28	0.08
Conditional Knowledge	3.38	0.93	3.32	1.05	3.48	0.94	3.63	0.96	0.68	0.57
Planning	3.44	1.03	3.18	0.94	3.62	0.85	3.58	0.89	1.40	0.24
Monitoring	3.67	1.04	3.42	0.82	3.69	0.91	3.84	0.78	1.24	0.30
Evaluation	3.51	1.09	3.83	0.76	3.38	1.15	3.38	1.15	1.44	0.23
Fault	3.80	1.20	3.43	1.09	3.54	0.88	3.55	1.03	1.14	0.34
Managing Knowledge	3.81	1.08	3.56	1.25	3.63	1.16	3.50	1.01	0.81	0.50
Metacognition (overall)	3.62	0.87	3.38	0.78	3.56	0.61	3.63	0.78	0.84	0.48

It can be seen from Table (6) that all calculated F-values are statistically insignificant; thus, no differences have been found among students based on university year. These findings are consistent with a study (Zulkiply et al., 2008; Al-Hamouri & Abu Mokh, 2011; Abu- Alia & Alwaher, 2001), on other hand study (Sabatin, 2006) argues that the school class level has an effect on the level of metacognitive thinking; favoring higher school classes, which could be due to the differences in the characteristics of study sample in this study which was held on samples of university students, whilst the study by (Sabatin, 2006) focused on samples of school students. These findings are also inconsistent with those (Aljarah & Obeidat, 2011) in terms of the effect of university major, favoring humanities major students in the dimension of managing knowledge.

Third question: What is the university students' ability level in solving mathematical and scientific problems?

The researchers have calculated the mean and standard deviation values and the percentage of students' scores in the test as a whole, and on the mathematical and scientific problem-solving tests. Table (7) shows these findings.

Table 7. Means, Std. deviations and Percentages for the scores of mathematical & scientific problem solving test

	No of items	N	Minimum	Maximum	Mean	Std. Deviation	%
MPS test	13	172	0.0	9.0	4.06	1.98	31.2%
SPS test	15	172	0.0	13.0	5.42	2.57	33.6%
(MPS&SPS) test	28	172	0.0	19.0	9.48	3.63	33.9%

Table (7) shows the mean scores of the students on the mathematical problem solving test, which reached 4.06, with a percentage of 31.2%; as well as the mean scores of students on the scientific problem solving test which reached 5.42 with a percentage of 33.6%; and finally the mean scores of both tests which reached 9.48 with a percentage of 33.9%. This shows that students clearly lack the necessary skills of solving mathematical and scientific problems.

Forth question: Are there differences in the university student's ability in solving mathematical and scientific problems based on the following variables: gender, specialization in high school (Scientific / Literary / IT stream,

and Others), faculty & year level?
The mean, standard deviation, and percentage values of the participants' scores (male and female) have been calculated and are shown in Table (8).

Table 8. Means, Std. deviations and Percentages for mathematical & scientific problem solving test based on sex

	sex	N	Mean	Std. Deviation	t	Sig
MPS test	male	48	3.542	1.8561	-2.149	0.697
	female	124	4.258	1.9995	-2.221	
SPS test	male	48	5.292	2.6171	-4.03	0.491
	female	124	5.468	2.5549	-3.98	
(MPS&SPS) test	male	48	8.833	3.4784	-1.452	0.742
	female	124	9.726	3.6678	-1.486	

Table (8) shows that the mean values of female students in overall test and in the mathematical problem test were higher than those of males. To see if these findings were statistically significant, the researchers calculated the (t) values which are also shown in Table (8). The final result indicates that these values were not statistically significant.
To investigate the impact of specialization in high school (Scientific/Literary/IT stream/ Others) on the student ability of solving mathematical and scientific problems, the researchers have calculated the mean and standard deviation values. ANOVA test was used to find out if there were statistically significant differences between the means of student' score according to specialization in high school. Table (9) shows these findings.

Table 9. Means and Std. deviations for the scores of mathematical & scientific problem solving test based on student's graduated stream in high school

Scale-Factors	Scientific-Stream N=50		Literary-Stream N=44		I.T N=63		Others N=15		F	sig
	M	SD	M	SD	M	SD	M	SD		
MPS test	4.48	2.06	3.69	1.84	3.99	1.90	4.07	2.34	1.32	0.27
SPS test	5.82	2.69	5.37	2.41	5.13	2.65	5.47	0.30	0.68	0.56
(MPS&SPS) test	10.30	3.74	9.05	3.61	9.11	3.45	9.53	3.91	1.29	0.28

Table (9) shows that the mean values of the students who graduated from Scientific Stream, in mathematical and scientific problem solving test were higher than those in other streams.
To investigate whether the faculty in which the students in the sample were enrolled had any effect on their abilities in solving mathematical and scientific problems, the researchers have calculated the mean and standard deviation values of the sample, ANOVA test was used to find out if there were statistically significant differences between the means according to student's faculty. The finding can be seen in Table (10).

Table (10). Means and Std. deviations for the scores of mathematical & scientific problem solving test based on student's faculty

	Pharmacy N=10		Architecture and Design N=12		Administrative & Financial N=39		IT N=11		Arts & Sciences N=98		others N=2		F	sig
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD		
MPS test	4.50	2.12	5.75	1.66	3.67	1.92	4.18	2.52	3.94	1.89	4.50	2.12	2.34	0.04
SPS test	5.90	1.73	6.08	3.26	5.54	2.71	5.45	2.07	5.22	2.58	6.00	1.41	0.37	0.87
(MPS&SPS) test	10.4	1.98	11.83	4.06	9.20	3.87	9.64	3.78	9.16	3.45	10.5	0.71	1.39	0.23

Table (10) shows that Architecture and Design students have scored the highest means in the mathematical problem solving test, scientific problem solving test, and the test overall. Moreover, it shows statistically significant differences between the students' mean scores in the mathematical problem solving test based on the students' majors, as Architecture and Design students scored the highest.
To investigate the effect of the level of academic year at the university on the student ability to solve mathematical and scientific problems, means and standard deviation values for the sample were calculated. ANOVA test was used to find out if there were statistically significant differences between the means of student' scores according to the level of academic year. Table (11) shows the results.

Table 11. Means and Std. deviations for the scores of mathematical & scientific problem solving test based on year-level

	First-Year N=78		Second-year N=36		Third-year N=26		Fourth-year N=32			
	M	SD	M	SD	M	SD	M	SD	F	Sig
MPS test	3.86	1.93	4.33	1.93	4.3	1.93	3.96	2.14	0.69	0.56
SPS test	5.44	2.27	5.67	2.90	3.07	3.20	5.38	2.57	0.27	0.85
(MPS&SPS) test	9.3	3.35	10.0	3.63	9.04	4.63	9.04	4.2	0.47	0.70

The Tables above (9, 10, 11) present the F-values of the differences in the students' mean values in the mathematical and scientific problem solving tests based on specialization in high school, university faculty, and university study year; all of these findings are statistically insignificant, except the finding related to the students' ability to solve mathematical problems which corresponds to their major in university, which means that neither specialization in high school nor university study year had an impact on the students' level in solving mathematical problems, scientific problems, or mathematical and scientific problems combined.
Fifth question: Is there a correlation between the university students' metacognition thinking and their ability to solve mathematical and scientific problems?
To answer this question, the researchers have calculated these different correlation coefficients, which are presented in Table (12).

Table 12. The correlation coefficients between the students' metacognitive thinking & their ability to solve mathematical and scientific problems

		MPS test	SPS test	(MPS&SPS) test
Metacognition	Pearson Correlation	0.136	0.032	0.097
	Sig. (2-tailed)	0.075	0.675	0.205

Table (12) shows a correlation of 0.097 in the level of metacognitive thinking and the ability to solve scientific and mathematical problems, which is insignificant; additionally, the correlation coefficient of the level of metacognitive thinking and the ability to solve mathematical problems reached 0.136, which is also statistically insignificant. The correlation coefficient of the level of metacognitive thinking and the ability to solve scientific problems reached 0.032, which is insignificant, These findings are consistent with (Coutinho, 2006) who notes that metacognitive thinking is not helpful for students who are fulfilling the tasks of problem solving, as students who had a higher level of metacognitive thinking did not score any better than those who had a lower level of metacognitive thinking. This result is unexpected, since it is rather expected that the performance of students in problem solving should increase if the level of metacognitive increases as well, as those with higher levels of metacognitive thinking would be thought to use their metacognitive strategies in problem solving. This could be because the problems were too hard for students to solve, even if they were aware of metacognitive thinking strategies, but have not decided to use them in problem solving. This sheds light on the importance of implementing cognitive strategies in teaching, which gives an implication for further studies on the importance of educational programs and how to motivate students to develop and use these cognitive strategies in problem solving. (Pennequin et al. , 2010) have emphasized the importance of practice on using metacognitive thinking strategies in improving the students' abilities in solving spoken mathematical problems, as their study has concluded the important of practicing metacognitive thinking strategies in developing metacognitive thinking skills in various aspects, as well as developing the ability to solve spoken mathematical problems. This emphasizes the fact that possessing and being aware of metacognitive thinking skills is just as important as putting these skills into use in the educational process and problem solving in general, and solving mathematical and scientific problems specifically.
The findings of this study that show no correlation between metacognitive thinking and the ability to solve scientific and mathematical problems is inconsistent with (Yunus & Ali, 2006) who assert that there is, in fact, a strong correlation between metacognitive thinking skills and achievement in math through solving mathematical problems, as well as the existence of a strong correlation with achievement in general.
In order to specify the aspects in which metacognitive thinking is related to the ability to solve problems, the researcher has calculated the correlation coefficients for each of the various factors of metacognitive thinking and solving mathematical and scientific problems, which are shown in Table (13).

Table 13. Correlation coefficients for each of the various factors of students' metacognitive thinking & their ability to solve mathematical and scientific problems

		SPS test	MPS test	(MPS&SPS) test
Explanatory Knowledge	Pearson Correlation	-0.028	0.025	-0.007
	Sig. (2-tailed)	0.712	0.748	0.932
Procedural Knowledge	Pearson Correlation	-0.051	0.175*	0.060
	Sig. (2-tailed)	0.508	0.022	0.437
Conditional Knowledge	Pearson Correlation	0.024	0.072	0.056
	Sig. (2-tailed)	0.751	0.349	0.462
Planning	Pearson Correlation	0.017	0.072	0.051
	Sig. (2-tailed)	0.828	0.348	0.505
Monitoring	Pearson Correlation	0.029	0.104	0.077
	Sig. (2-tailed)	0.703	0.175	0.313
Evaluation	Pearson Correlation	0.043	0.153*	0.114
	Sig. (2-tailed)	0.571	0.046	0.136
Fault	Pearson Correlation	0.106	0.175*	0.171*
	Sig. (2-tailed)	0.165	0.022	0.025
Managing Knowledge	Pearson Correlation	0.057	0.187*	0.143
	Sig. (2-tailed)	0.455	0.014	0.062
Metacognition(overall)	Pearson Correlation	0.032	0.136	0.097
	Sig. (2-tailed)	0.675	0.075	0.205

The findings in the Table (13) indicate a significant correlation ($\alpha < 0.5$) between solving mathematical problems and the following metacognitive thinking factors: Procedural Knowledge factor, in which the correlation coefficient reached 0.175; Evaluation factor, in which the correlation coefficient reached 0.153; Fault factor, in which the correlation coefficient reached 0.175; and finally Managing Knowledge factor, in which the correlation coefficient reached 0.187. Moreover, a significant correlation exists between the Fault factor in metacognitive thinking and the ability to solve both mathematical and scientific problems, which reached 0.171.
These findings indicate that students are aware of how to use metacognitive thinking strategies, as well as how to evaluate these strategies and their own personal education process, in addition to the ability to use the necessary strategies to fix mistakes during problem solving. These findings also reflect a weakness in students during problem solving, in the way they understand themselves and the nature of strategies used, as well as the difficulty in deciding when and why to use a certain strategy, and a lack in the ability of organizing information The existence of a correlation between solving scientific and mathematical problems, and the Fault Picking factor only shows the students' inability to comprehend different metacognitive thinking factors except for Fault Picking strategies that help fix mistakes.
These findings are quite unexpected considering the nature of the correlation between metacognitive thinking skills and the ability to solve mathematical problems, which could be due to that the problems chosen for this study were difficult, or due to the low scores in high School which is evident in the results and percentage of those who passed the General Education Certificate, as well as the students' weakness reflected in the international TIMMS tests in those two fields (Mullis et al., 2012; Martin et al., 2012). These findings can be explained further by hypothesizing that students do possess high metacognitive thinking skills but do not put these skills into use in problem solving, which is consistent with (Coutinho, 2006; Abu- Alia & Alwaher, 2001; Al-Hamouri & Abu Mokh, 2011). Finally, it is critical to point out that the nature of problems chosen for the scientific and mathematical problem solving scale were decision-making problems; thus, problem solving steps and strategies were not tackled in this study.

5. Recommendation

The following is a list of recommendations that, one believes, if implemented would contribute positively to enhance the relationships between metacognition thinking and problem solving:

1- Paying more attention for the development of metacognitive thinking skills in all academic years and in all disciplines at university.
2- Infusing educational courses that deal with metacognition thinking skills.
3- Encouraging instructors to develop thinking skills of the students by placing specific strategies to develop thinking and embedded in the various courses.
4- Conducting training courses on metacognition thinking skills for the instructors and students alike.
5- Enhancing the student's ability to solve mathematical and scientific problems and to enrich students' understanding of these problems, and instill these problem solving skills in student interest and awareness of

regarding these skills

6- Further studies should be conducted in the areas of metacognition thinking, mathematical and scientific problems solving and the relationship between the two.

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