Assessment of the Impact of the Saudi Aramco-Research Science Institute Programme in Terms of Fostering Higher-order Thinking Skills among Gifted Students at the High-school Level

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Corresponding author:
Amani K. Hamdan Alghamdi
Associate Professor of Curriculum
College of Education, Vice Dean
Curriculum and Pedagogy
Imam Abdulrahman Bin Faisal University
akhalghamdi@uod.edu.sa
Neama Abdulsalam. Co Author
Associate Professor
College of Education, Psychology
Imam Abdulrahman Bin Faisal University
naalnaser@uod.edu.sa

Abstract

The current study investigates the impact of the Saudi Aramco Research Science Initiative (SA-RSI) on the participating gifted and talented Saudi female students' acquisition of higher-order thinking skills. In this investigation, a particular emphasis is placed on the students' metacognitive skills, time-management skills, problem-solving skills and decision-making skills. This study also measures the participants' ability to engage in metacognitive thinking in terms of planning, self-monitoring and self-assessment. A scale was applied while measuring the students' acquisition of skills in time management, problem solving and decision-making. The researchers employed multiple training methods and strategies in order to stimulate and enhance the participants' abilities, especially in the areas of metacognitive thinking, problem solving, decision-making and time management. The study data indicate significant pre and post differences at the level of significance of 0.01 in the participants' mean scores pertaining to meta-cognitive thinking skills, problem-solving skills, decision-making skills and time-management skills.

Section one

1.1: Introduction

Over the last decade the education system of the Kingdom of Saudi Arabia (KSA) has experienced unprecedented development as a result of the implementation of a number of key initiatives by the Ministry of Education (MoE). Many of these initiatives involve an increased emphasis on fostering students' academic and life functionality skills, including their ability to think critically. One of the most prominent specific actions was the launch in 2008 of the King Abdulaziz and His Companions' Foundation for Giftedness and Creativity (2015) (also known as Mawhiba), which is "a national cultural

foundation that is honored to be presided over by the Custodian of the Two Holy Mosques who supervises it directly and continuously." According to the MoE, "Mawhiba's local summer programs constitute the first stations that enable gifted students to identify their potential abilities, to offer them the appropriate support to nurture and enhance their talent and to prepare them to have effective and distinctive participation in other events sponsored and presented by Mawhiba inside and outside the Kingdom" (The King Abdulaziz and His Companions' Foundation for Giftedness and Creativity, 2015). Dracup (2011) explains that Mahwhiba has two principal objectives: first, nurturing giftedness and creativity in students of both genders and, second, promoting the development of young gifted and creative leaders in the areas of science and technology.

The identification of students for Mawhiba depends on a combination of teacher recommendations, academic achievement, and scores on achievement tests. This methodology is closely aligned with trends on the international level. After the students have been chosen to participate in Mawhiba, they are invited to join the rigorous summer immersion program, which involves six weeks of intensive core research. The selection of students for this program is broadly consistent with Wininger et al. (2014), who explain that "Lohman's (2008) recommended approach to the identification of students for gifted education included four key sources of information: reasoning ability, standardized achievement tests, teacher ratings, and student interest" (p. 404).

Outside the scope of the Mawhiba program, more and more actions are being undertaken to advance gifted education in Saudi Arabia, as well as to promote critical thinking in general (see Abu Assi, 2012; Alqefari, 2010). Various experts have highlighted the fact that the MOE in 2000 established an independent unit called the General Administration for Gifted Students to assess and manage the education of gifted male students throughout the KSA (Alqefari, 2010); an equivalent unit for female students was launched two years thereafter (Dracup, 2011). The MOE's decision to establish these two units is a reflection of the fact that gifted-student programs are now open to both genders (Al Qarni, 2010). Moreover, as is explained in Dracup (2011), Saudi Arabia's 2009-2013 Development Plan articulated the objective of "Increasing the number of (male and female) students who benefit from 'giftedness and creativity' initiatives, to reach around 14,000 annually by the end of the Plan."

Alqefari (2010) emphasizes the fact that many Arab nations lack a gifted education policy and that Saudi Arabia's policy, while well intentioned, has a number of deficiencies that make it inaccessible to some students, namely the uneven targeting of geographical areas and a bias towards serving

students from upper-income families with a "patchy" approach complemented by selected curriculum modifications (p. 2). Al Qarni (2010) is in agreement with this perspective, pointing out that the MoE needs to improve the delivery of gifted education, especially in order to fulfill the legislative mandate that is now in operation. With respect to best practices, Al Qarni (2010) is in favour of formulating targeted curricula and then deploying approaches aimed at the distinctive requirements of gifted students, formulating strategies to accurately and efficiently identify and choose these students, and training supervisors and teachers in the distinctive methods of educating gifted students – all proposals that would necessitate sustained funding. Alqefari (2010) finds that, notwithstanding the fact that 200,000 gifted students were enrolled in Saudi schools in 2007, "the number of gifted students who receive the benefit of any specialist programmes in Saudi schools is much less than this number" (p. 19).

The extant scholarly literature related to gifted Saudi students could be expanded through research and writing pertaining to support for instruction in science, technology, engineering and mathematics (i.e., the STEM disciplines). Even in the 1990s when the rudiments of KSA's policy for gifted education were being developed, concerns were being raised with respect to the need to identify and support students who are advanced in science, mathematics and technology (Al Qarni, 2010). The Mawhiba gifted-student program that eventually emerged from these early discussions seeks to respond to these concerns by fostering and increasing creativity, leadership, critical thinking and innovation as well as advanced skills in mathematics, science and information technology (IT) (Dracup, 2011).

Despite the many areas that require further development, it is nonetheless commendable that Saudi Arabia has taken the step of formulating and implementing a gifted education policy, including an organization specialized in identifying and supporting gifted and talented students. This study assesses the impact of the Saudi Aramco – Research Science Initiative (SA-RSI) summer immersion training program in terms of developing higher-order thinking skills – in particular with respect to the STEM disciplines – among gifted female students at the high-school level. This program is the outcome of a partnership between the Research Science Institute (RSI) of the Massachusetts Institute of Technology (MIT) and Mawhiba and it seeks to provide the RSI experience to the most promising students in the KSA (Sillman, 2015) with a view to encouraging them to pursue STEM careers. Gifted Saudi female students are worthy subjects of scholarly attention, as was emphasized by Alqefari (2010) when he asked whether "…the experiences of gifted male and female students were 'separate but equal'? Or do wider attitudes and expectations around gender and gender relations shape

practices, expectations and outcomes on the part of gifted students in Saudi Arabia?" (p. 228).

1.2: Scope, Objective and Research Question

1.2.1: Study Objective

This study's objective is to assess the effectiveness of the SA-RSI program's activities in terms of fostering higher-order thinking skills within gifted and talented female high-school students.

1.3: Research Question

This study's research question is as follows: in what ways and to what extent does the SA-RSI program develop gifted and talented female high-school students' higher-order thinking skills? Put another way, what if any differences in the pre- and post-measurements of the gifted and talented female high-school students' mean scores can be attributed to their participation in a program of activities associated with the acquisition and reinforcement of essential higher-order thinking skills, specifically meta-cognitive thinking, problem solving، decision making and time management? (See Appendix for definitions of the terms employed in this study.)

1.4: Study De-Limitation

This study's scope was restricted to the gifted and talented female high-school students who participated in the 2016 summer camp held at the College of Science of Imam Abdulrahman Bin Faisal University, which is located in Dammam in Saudi Arabia's Eastern Province. In addition to being held at and supervised by the College of Science, this program was supported by Saudi Aramco, Mawhiba and CEE/SRI. This site was selected for the study as it was the location of the most recent edition of Mawhiba. This particular group (i.e., gifted and talented female high-school students) was selected for the study because they comprise an under-researched population in Saudi Arabia.

Section Two

2.1: Literature Review

The literature review provided below has four main areas of focus: (a) a summary of the background and key elements of the Mawhiba SA-RSI program; (b) an overview of the effectiveness of the Mawhiba SA-RSI program; (c) an overview of the importance of creativity development over the course of the implementation of the SA-RSI programs; and (d) an assessment of the promotion of metacognition and time management. This literature review provides insight into the research question, which is focused on the degree to which the SA-RSI is able to promote higher-order thinking skills among gifted female high-school students, especially in the STEM disciplines.

2.2: Background and Key Elements of the Mawhiba SA-RSI Program

During the summer of 2015, the Center of Excellence in Education (CEE) marked the thirty-second anniversary of MIT's flagship Research Science Institute (RSI) and the eleventh anniversary of the partnership with Saudi Arabia's Mawhiba to deliver the RSI experience to the KSA's most promising students (Sillman, 2015). In 2005, the first cohort of Saudi high-school students attended MIT's RSI program in Cambridge, Massachusetts. A delegation of Saudi Arabia's brightest students has participated in this flagship program every year thereafter. Between 2011 and 2013, CEE, in collaboration with Mawhiba and Saudi Aramco, managed the Saudi Aramco – Research Science Institute (SA-RSI) program at King Abdullah University of Science and Technology (KAUST). Now led by KAUST, this successful program is in its sixth eighth summer. Alumni of both RSI and SA-RSI have proceeded to win many awards for their achievements inside and outside the KSA, including at Ibdaa (the Saudi Olympiad for Scientific Creativity) and at the International Science and Engineering Fair (ISEF) held in the United States. These individuals are currently enrolled in some of the most prestigious universities in the United Kingdom and the United States.

In 2015, the CEE (an organization affiliated with the Massachusetts Institute of Technology), in collaboration with Saudi Aramco, Imam Abdulrahman Bin Faisal University and Mawhiba, brought the RSI experience to the College of Science of Imam Abdulrahman Bin Faisal University. The second cohort of female high-school-student participants in the SA-RSI program came from all over the KSA to build their knowledge of and skills in research, develop new friendships and dream ambitious dreams. Among the subjects that they examined were the Markov decision process, alpha-globin gene mutations, medicinal plants and superconductive materials. In addition to partaking in a life-changing academic experience, the students enjoyed interacting on a social level, with plenty of late-night conversation, ice cream, table tennis, science poetry and Bulgarian dancing.

The young scholars' first week emphasized intensive STEM classes and seminars under the direction of distinguished professors. These classes and seminars highlighted current areas of research in biology, chemistry, physics, engineering and mathematics as well as the humanities. Moreover, the evening lecture series carried on throughout the summer. Among other benefits, these lectures enabled the students to interact in person with leaders in science and technology, including with Nobel laureates and technology entrepreneurs. At the end of the week, the research mentors provided the students with their preliminary assignments; this launched the students on the process of reading recent journal articles and advanced texts.

The central element of the RSI was a research internship that lasted between four and five weeks, an opportunity that enabled the students to

pursue individual projects under the guidance of respected researchers and scientists. The participants worked through their respective laboratory teams, engaged in guided research for "business hours plus." The combination of theory-oriented classes, applied sessions held in science labs, inspirational lectures provided by nationally and internationally recognized leaders, and outdoor cultural activities engaged the students in planning and managing multiple parallel and successive tasks within tight time constraints. Some activities involved experimentation, including the operation of microscopes and other types of scientific equipment, as well as the application of computer and programming skills. As the participants made progress on their personal research project they experienced substantial increases in their levels of self-confidence and independence.

The final week of the program required the students to develop and deliver an oral presentation and a written report on their individual research project, each produced at a level suitable for an academic conference. At the end of the final week, five presentations and five papers were given special commendation. Mawhiba's principle of creativity was respected in all aspects of the SA-RSI pedagogy and associated learning activities.

2.3: Overview of the Effectiveness of the Mawhiba SA-RSI Program

Only a small number of scholars have investigated the effectiveness of the Mawhiba SA-RSI program for gifted students in the KSA. A recent quantitative study undertaken by Alghamdi Hamdan and Abdul Salam Hassan (2016) investigated the benefits of this program in terms of helping to nurture critical-thinking skills among female students in Saudi Arabia. The study specifically focused on the participants in the 2016 summer Mawhiba program, which was held at a university located in Saudi Arabia's Eastern Province. In a forthcoming study, Alghamdi Hamdan and Abdul Salam Hassan emphasize that the students began to experience the enhancement of their capacity to think critically after the completion of the SA-RSI intensive program.

The ongoing growth in the number of studies focused on gifted-education initiatives in the KSA is occurring against the backdrop of Al Qarni's (2010) earlier finding that "only weak and limited studies were conducted to evaluate gifted programs in Saudi Arabia" (p. 13). This overall paucity of research studies underlines the need to continue assessing the impact of Mawhiba programs on students' learning, skills and knowledge.

The KSA's summer university programs have recently witnessed an increase the formation of partnerships aimed at engaging with and immersing gifted students, in part with a view to creating a basis for applying for public national and international awards. Organized each year by Mawhiba in 12 Saudi cities, these partnerships involve approximately 50 leading national and

international corporations, including Saudi Aramco (Tago, 2013). In addition to Saudi Aramco, some of the local organizations that are helping to support Mawhiba include King Abdulaziz City for Science and Technology, King Faisal Specialist Hospital and Research Center, and Interactive King Abdullah City for Atomic and Renewable Energy.

Matches are made between students enrolled in these programs on the one hand and professors of mathematics, biology, physics and chemistry on the other hand, all of whom are based at the College of Science of Imam Abdulrahman Bin Faisal University (formerly known as the University of Dammam). Participants are given exposure to a blend of theory and hands-on research supplemented by extracurricular activities designed to stimulate the development of higher-order thinking skills. Each year these programs are attracting more and more participating organizations and students. For instance, one organizer highlighted the fact that, between 2014 and 2015, the number of student participants expended by 13 percent. Yet, it appears that few rigorous studies have been undertaken on these intensive programs, including with regard to the benefits received by the participating students. One of the exceptions is the study of Alghamdi Hamdan and Abdul Salam Hassan (2016) in which evidence is provided for the Mawhiba program's ability to enhance gifted female students' critical thinking skills.

2.4: Promotion of Metacognition and Time Management

The SA-RSI program employed multiple pedagogical strategies to maximize its effectiveness in fostering essential cognitive skills. One of these strategies involved the division of the most talented participants into distinct teams working under the supervision and guidance of highly respected professors whose areas of specialization are related to the teams' respective areas of focus. The students then had a superior foundation for personal decision-making pertaining to their topics and areas of interest. Each participant developed a detailed schedule to help her to finish all of the elements involved in developing and writing a scientific paper. The professors promoted dialogue and interaction among the participants and between the participants and the professors. These mentors also assisted in the search for and in the detailed assessment of published studies and other scientific writing pertaining to each student's area or areas of focus.

Small groups helped to provide valuable guidance facilitating the development of essential research skills; each of these groups was comprised of three participants working under the mentorship and direction of one member of the teaching team. The intention was for this guidance, in combination with an active style of learning and the requirement for the participants to organize, plan and present ideas in a systematic manner, to

make a substantial contribution to the acquisition of higher-order thinking skills. These various activities promoted the development of the participants' metacognitive skills, including the planning, monitoring and self-evaluation abilities, as well as the disciplined search for answers to the practical and theoretical problems that they encountered in the laboratory. Beyond undertaking the scientific research and the writing required to prepare a scientific paper for publication in a scientific magazine or journal, each student rose to the responsibility of developing a comprehensive presentation pertaining to her research topic and conclusions.

The program's full week of intensive lectures on theoretical matters provided the participants with a strong basis for their subsequent scientific research. Further, these lectures brought to the students' attention multiple knowledge sources that could act as points of reference. The participants greatly increased their ability to engage in dialogue, to assess and critique the results of earlier studies, to search for solutions to challenges that could emerge during the research process, to suggest ad articulate alternatives, and to determine the validity of the experimentation. These elements were all aimed at helping the students to acquire and enhance skills required for making appropriate decisions related to the various problems that they might experience in the laboratory or in the process of performing a theoretical analysis.

An individual's capacity to make informed decisions largely is a function of his or her higher-order thinking skills and of his or her level of access to reliable information pertaining to his or her research goals. Informed decision-making also necessitates the capacity to assess in a systematic manner the range of alternatives and all of the stages of the research process while taking into account the available data. Beyond developing their abilities in these areas, the SA-RSI participants were exposed to some of the major phenomena that can undermine with informed decision-making; these include the tendency to work too quickly and/or to hesitate and the interference with objectivity that can flow from flattery and from elevated emotions.

Gifted education experts are regularly looking beyond the importance of creativity, personal interest and cognitive ability (skills and knowledge) to explore the role played by individuals' meta-cognition and time management, including the extent to which they impact students' development of higher-order thinking skills. Broadly speaking, gifted students engage more metacognitive techniques while learning than non-gifted students (Borland, 2008). One of the key goals of Mawhiba is to promote creativity and assist participants in the identification of their potential areas of strength. These programs foster participants' ability to use their talents to participate in and *contribute to the world in an effective and distinctive manner. According to Lee et al. (2012), metacognition helps gifted students to be "highly adaptive and creative individuals who are able to assume epistemic agency and learn intentionally" (p. 22).*

It is essential to make a clear distinction between cognition and metacognition. Cognition pertains to an individual's knowledge acquisition by means of thought, experience and the five senses. Conversely, metacognition (with meta referring "awareness beyond") pertains to an individual's consciousness and perceptions of his or her own thinking (Downing at al., 2009). Metacognition is a particularly effective predictor of learning success. Metacognition "involves knowing how to reflect and analyse thought, how to draw conclusions from that analysis, and how to put what has been learned into practice. [In this way, students learn to] understand how their mind functions" (Downing et al., 2009, p. 610). According to Veenman et al. (2005), "metacognitive skills have their own virtue in learning, partly independent of intellectual ability" (p. 206).

Metacognition entails (a) consciousness of one's own thinking and thought processes; (b) self-regulation and self-monitoring of one's own cognitive processes; and (c) application of cognitive heuristics. Metacognition is essential for effective task management and problem solving (from a time and cost perspective) (Chew, 2016; Downing et al., 2009; Lee et al., 2012). After all, "whilst cognition focuses on solving the problem, metacognition focuses on the process of problem solving" (Downing et al., 2009, p. 611). Moreover, the "core of being metacognitive is taking a step back and observing one's thinking.… What is the problem to be solved? What should I do? How am I doing? How well did I do? What can I do differently and better next time?" (Wilson & Conyers, 2016, p. 1). Individuals who ask themselves these questions more often are likely to have richer metacognition.

Metacognition has two principal components. The first component is comprised of individuals' awareness and understanding of their own cognition, including of the ways in which they acquire skills and knowledge. The second component is comprised of their internal regulation of their thought processes through such activities as the organization, evaluation and monitoring of those processes (Lee et al., 2012). Time management is an element of the regulatory component, and it includes the capacity to strategize, plan and manage the time that one has available for the completion of one's tasks and projects. Various studies have demonstrated that techniques for using metacognition can improve the performance of students by strengthening their self-regulation of time (Imani et al., 2013).

Gifted, high-performing students are in an especially strong position to benefit from learning how to implement metacognitive and cognitive methodologies, especially strategies for time management (Wilson & Conyers, 2016). In order to refine and use their gifts and talents to resolve abstract and complex problems within and across disciplines (including the STEM

disciplines), deep learning of this kind includes advanced metacognition levels (related to planning, objective determination, monitoring and assessment) (Heacox & Cash, 2014). This type of deep learning involves a particular requirement for learners to "possess exceptional time management skills" (Heacox & Cash, 2014, p. 79).

Gifted learners are able to employ effective time management to acquire a distinctive perspective on metacognition and self-regulation (specifically with respect to the ways in which their brain functions and the measures that they can use to approach problem solving creatively and critically) (Heacox & Cash, 2014). Individuals acquire the ability to manage their time in part by determining the elements that are involved in any particular project or activity, and then by adjusting and readjusting based on their performance (Elliott et al., 2014). Of particular relevance in this regard is the caution of Elliott et al. that gifted "young people who don't have to put effort into their work to earn high grades won't understand the time needed in order to do a job that would be acceptable in the work environment" (p. 153). Gifted individuals who learn how to manage their time while they are still students (such as the participants in the Mawhiba program) are in a much stronger position to achieve success after they graduate, especially in STEM-related fields.

Section Three

3.1: Methodology and Procedures

The study involved a quasi-experimental research design based on a single group of participants who were subjected to pre and post tests. It aimed at ascertaining and understanding the degree to which the SA-RSI summer training program is effective (the independent variable) at fostering gifted and talented female high-school students' capacity to acquire higher-order thinking skills (the dependent variables) (see Appendix).

3.2: Study Sample

The study's scope was comprised of all of the gifted and talented female high-school students residing in the Eastern Province of Saudi Arabia; from this overall sample 100 individuals were selected. These 100 individuals were the province's most outstanding participants in the Scholastic Aptitude Test (SAT), an examination that is annually administered by the KSA's National Center for Measurement and Evaluation. The 100 participants were chosen based on the following criteria: scholastic achievement (average of 95 percent or above); the highest level of percentile; and nomination by teachers and educational departments. The two samples are explained below.

- ***Exploratory sample: The sample rationing tool was comprised of 32 gifted female high-school students from Saudi Arabia's Eastern Province. These students' ages were between 15 and 17 years and they had an average age of 16.21 years with a standard deviation of 0.75.***

- ***Principal sample: This was comprised of 42 gifted female high-school students from Saudi Arabia's Eastern Province. These students' ages were between 15 and 17 years and they had an average age of 16.23 years with a standard deviation of 0.74. All of the individuals in this sample participated in the six-week Mawhiba SA-RSI program held in 2016.***

3.3: Instruments

The researchers employed four instruments to collect this study's data.

3.3.1 Pilot: Before these instruments were applied, they were pilot tested on 32 gifted and talented high-school students from Saudi Arabia's Eastern Province. These students' ages were between 15 and 17 years and they had an average age of 16.21 years with a standard deviation of 0.75.

Developed by Abdul Salam Hassan (2015), the time-management skills scale was one of the main instruments. The researchers implemented this scale's psychometric characteristics and, employing validity criteria and measures of reliability, the researchers applied the alpha method. For the exploratory sample (n = 32) of gifted and talented female high-school students, the value of the reliability alpha coefficient was 0.95.

3.4: Validity and Reliability of instrument: The researchers also implemented Abdul Salam Hassan's (2015) metacognitive thinking skills scale and used factor validity and alpha reliability to determine the psychometric characteristics of this scale. For the whole, the alpha coefficient was 0.89 while, for the dimensions, the alpha coefficients were 0.77 for self-monitoring, 0.65 for self-assessment and 0.756 for planning.

Further, the researchers implemented the problem-solving scale, also developed by Abdul Salam Hassan (2015) using criterion-related validity (concurrent validity). In order to determine its degree of reliability, the researchers used the alpha method; the reliability alpha coefficient was valued at 0.76 for the exploratory sample (n = 32) of gifted and talented female high-school students.

Finally, we implemented the decision making scale, which was also developed by Abdul Salam Hassan (2015) using criteria validity. In order to determine its degree of reliability, the researchers employed the alpha method; the reliability alpha coefficient was valued at 0.82 for the sample (n = 32).

3.5: Statistical Means: Data Collection and Analysis

Prior to the start of the 2016 edition of the six-week Mawhiba SA-RSI program, all 42 of the participants in the sample employed the four instruments, thus generating the pre-program data. After the program was finished, the procedure was repeated for all of the participants, thus generating the post-program data. A t-test was employed to identify any

significant deviations between the students' mean scores in the two measurements (pre and post tests).

Section Four

4.1. Results and Discussions

The research findings indicate that the SA-RSI program was effective in terms of promoting the development of some of the most important life, cognitive and academic skills (including metacognitive thinking skills and time-management skills) within gifted and talented Saudi female high-school students.

The results highlight the efficacy of the SA-RSI program and its demonstrably beneficial effect in terms of promoting higher-order thinking skills, especially in the areas of metacognitive thinking, time management, problem solving and decision making. These abilities were all found to be statistically significant: metacognitive thinking was measured as 0.93, time management was measured as 0.91, problem solving was measured as 0.97 and decision making was measured as 0.964.

4.1.1: results of the first aim and hypothesis: With respect to time management, statistically significant differences were found to exist between the pre- and post-test mean scores (t=2.237), and this value was significant at 0.03. The Mawhiba program had a considerable impact on the development of time-management skills (Eta squared = 0.143), and this confirms the efficacy of the program for fostering time-management skills among gifted female high-school students (see Table 3). For this instrument, the Cronbach's alpha was 0.95, a result that confirms a high degree of reliability (See Appendix for Tables 1 and 2.)

					Post		Pre		
					s.d	M	s.d	M	
Large	0.143	0.03	30	2.237	19.31	90.70	17.76	86.09	Time Management

Table 3 T Test (pre – post) in time management skills (N=42)

4.1.2: results of the second aim and hypothesis: As discussed above, metacognition encompasses individuals' consciousness of and ability to reflect on their own thinking, and it has been found to be an effective predictor of learning achievement (Downing et al., 2009; Veenman et al., 2005). The measure of metacognition used in this study included planning, self-monitoring and self-assessment. While self-assessment was not found to be statistically significant, self-monitoring and planning were found to be

significant at the 0.01 and 0.001 levels respectively – notwithstanding the closeness of the mean scores for each of them (see Table 4). Furthermore, it is important to remember that this instrument's Cronbach's alpha was very high, at 0.089, and the values varied for each sub-dimension (see Table 4). Self-assessment was the least reliable dimension at 0.650, and generated insignificant results.

Table 4: Values of the reliability coefficients for metacognitive thinking using Cronbach's alpha

Dimension	*Reliability coefficient values (Alpha)*
Self-monitoring	*0.777*
Planning	*0.756*
Self-assessment	*0.650*
Metacognitive thinking	*0.890*

4.2. Discussion

The current study's results are congruent with the results of Alghamdi Hamdan and Abdul Salam Hassan (2016), specifically with their finding that the Mawhiba SA-RSI program effectively promoted essential elements of higher-order thinking and, in particular, critical thinking. Alghamdi Hamdan and Abdul Salam Hassan (2016) is the first study that examined the efficacy of the condensed SA-RSI science summer program with respect to the development of Saudi female students' cognitive abilities. The current study contributes to this emerging literature by confirming that the Mawhiba SA-RSI program builds capacity in terms of problem solving and decision making and in terms of time management and metacognition. The expansive effect size and the exceptionally high mean scores underline the success of this program among female students who are focused on the STEM disciplines. These results are of particular importance because gifted and talented female STEM students have not been adequately researched in Saudi Arabia, and because government decision-makers and educators have been encouraged to challenge the long-held view that male and female gifted students are "separate but equal" (Alqefari, 2010, p. 228).

Section five

5.1. Conclusion and Recommendation

5.1.1 Conclusion

Consistent with Alghamdi Hamdan and Abdul Salam Hassan (2016), the findings of the current study confirm the effectiveness of the SA-RSI program's underlying pedagogy. Over the course of the intensive six-week program, the gifted and talented female high-school students were exposed to critical readings of relevant literature, research protocols, experimentation, analysis, problem solving, critical evaluation, synthesis and writing

conventions – elements that covered the full range of higher-order thinking skills. In this regard it is important to acknowledge that the KSA's development strategy includes an increase the number of students who are exposed to initiatives to capitalize on their talent, giftedness and creativity (Dracup, 2011). The results of the current study underscore the foresight and wisdom of this objective – an objective that can be achieved at least in part through the expansion of the scope of the SA-RSI program. More importantly, it is evident that both male and female STEM students are in a particularly strong position to benefit from metacognitive and time-management skills (Elliott et al., 2014; Heacox & Cash, 2014) – a fact that was confirmed by the experience of the participants in the 2016 edition of this program.

A perhaps surprising finding of the current study is that self-assessment is not statistically significant. This is an important element of metacognition that involves students assessing their own learning and, in the process, becoming more aware of the need to correct "faulty metacognition, which in turn should contribute to more successful self-regulated learning" (Chew, 2016). The leaders and designers of the SA-RSI program should closely examine the degree to which and the ways in which curricula foster self-assessment. In addition, other scholars need to examine any disparities that might exist between male and female gifted learners' self-assessment in order to determine the degree to which and the ways in which the SA-RSI program might need to be adjusted to take into account any gender-based differences (see Alqefari, 2010).

5.1.2. Recommendation: Highly trained scientists and world-renowned STEM leaders played the main role in delivering the program. The impact of the SA-RSI program can be further expanded through the direct involvement of other types of educators. For instance, Al Qarni (2010) believes that the KSA Ministry of Education should comprehensively train the teachers and supervisors of gifted and talented students, an initiative that would necessitate long-term funding. The authors of the current study believe that teachers at the public-school level should be trained in the use and implementation of the SA-RSI program's strategies and activities. As Wilson and Conyers (2016) emphasize, the formulation and delivery of higher-order-thinking curricula constitute a challenging project; this requires a long-term financial and policy commitment from the relevant governments. Saudi Arabia's clear policy aimed at female gifted students since 2002 (Dracup, 2011) has increased the urgency of delivering sufficient teacher training.

In order to address the common view of the KSA's approach to gifted education – as being, according to Al Qarni (2010), inconsistent and undermined by an incomplete strategy, inadequate modifications to curricula and weak sharing of information – various decision-makers have sought to base future programs on key elements of the Mawhiba SA-RSI program (Sillman, 2015). Moreover, there exists considerable scope for the King Abdulaziz and His Companions' Foundation for Giftedness and Creativity

(2015) to continue to strive to promote young, gifted and talented leaders in the STEM disciplines (Dracup, 2011). The results of the current study underline the fact that the SA-RSI program is an important step towards the development and implementation of an initiative covering all of Saudi Arabia.

It is important to acknowledge that there continue to be only a small number of gifted students who have the opportunity to participate in any kind of specialized program in Saudi schools (Al Qarni, 2010; Alqefari, 2010). According to Al Qarni (2010), an appropriate response would be to formulate curricula that are suitable for gifted students and then to implement these curricula across the KSA. An exceptional pedagogical model for this kind of development is the Mawhiba SA-RSI program itself. After all, this program has been confirmed as being highly effective for developing gifted and talented Saudi female STEM students into more creative, more independent and more productive higher-order thinkers.

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تقييم أثر البرنامج السعودي البحثي لأرامكو على تنمية مهارات التفكير العليا بين طالبات المدارس الثانوية الموهوبين

الكلمات المفتاحية: الموهبة في المملكة العربية السعودية ، الطالبات ، الموهبة ا

أماني خالد حمدان الغامدي

أستاذ مشارك في المناهج

كلية التربية ، وكيل الكلية

المناهج وطرق التدريس

جامعة الإمام عبدالرحمن بن فيصل

نعمة عبد السلام. المؤلف المشارك

أستاذ مشارك

كلية التربية ، علم النفس

جامعة الإمام عبدالرحمن بن فيصل

تسعى هذه الدراسة إلى دراسة تأثير مبادرة العلوم البحثية أرامكو السعودية (SA-RSI) على تطوير مهارات التفكير العليا للطلبة السعوديات المشاركين - وخاصة مهارات التفكير وراء المعرفي ومهارات حل المشكلات وصنع القرار المهارات ومهارات إدارة الوقت. وتسعى

هذه الدراسة أيضًا إلى قياس مستوى مهارات التفكير ما وراء المعرفي لدى الطلاب فيما يتعلق بثلاثة مجالات أساسية: التخطيط ، والمراقبة الذاتية ، والتقييم الذاتي. تم تنفيذ مقياس تطوير إدارة الوقت وحل المشكلات ومهارات اتخاذ القرار كما تم توظيف استراتيجيات وطرق تدريبية متعددة بهدف تحفيز قدرات الطلاب وتوسيعها ، خاصة فيما يتعلق بمهارات التفكير وراء المعرفي ومهارات اتخاذ القرار ومهارات إدارة الوقت ، وكذلك من حيث القدرة على حل المشكلات. أظهرت النتائج وجود فروق ذات دلالة إحصائية عند مستوى دلالة ٠.٠١ بين ما قبل وبعد القياس في متوسط درجات الطلاب من حيث مهارات التفكير الإدراكي المعرفي ومهارات اتخاذ القرار ومهارات إدارة الوقت ، وكذلك من حيث القدرة على حل المشكلات.

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Appendix

Higher-order thinking skills

These skills encompass the complex combination of cognitive skills that an individual employs in his or her daily life. They include metacognitive thinking skills, problem-solving skills and decision-making skills.

Metacognitive thinking skills

As explained by Abdul Salam Hassan (2004), metacognitive thinking skills (MCTS) encompass an individual's capacity to describe his or her own thinking and to monitor his or her own performance while performing various tasks. These skills also encompass an individual's capacity to formulate detailed plans to complete the tasks that have been entrusted to him or her as well as his or her capacity for self-monitoring and self-regulation. In the current study, MCTS are examined with an emphasis on three basic skills (planning, self-monitoring and self-evaluation).

Problem-solving skills

One perspective on problem solving is that it is a higher-order cognitive process that engages individuals in the control and application of other skills. Problem-solving skills fall within two main categories: personal problem solving and mathematical problem solving. According to Jarwan (2014), problem solving is the process of developing a solution to a problem.

Decision-making skills

The current study defines decision-making skills as the skills that are necessary to analyze multiple alternatives and to select the best one in accordance with specific criteria with a view to solving a specific problem or dealing with a specific situation.

Time-management skills

As explained by Abdul Salam Hassan (2015), time-management skills engage individuals in the positive use of time in order to complete multiple concurrent and/or successive tasks. These skills include "setting goals, planning, organization, evaluation and taking advantage of free time." The degree to which an individual has developed these skills can be ascertained based on his or her demonstrated capacity for self-regulation and self-monitoring, and based on his or her academic and work-related outcomes.

Reflection on the Development of the Participants' Cognitive Skills

Table 1

Variable	Measurement				t	df	Sig.(2-tailed)	(η2)	Effect size
	Pre		Post						
	Mean	Std. deviation	Mean	Std. deviation					
Metacognitive thinking skills	**99.95**	**11.85**	**104.85**	**11.45**	**3.88**	**41**	**0.00**	**0.93**	Large

Table 2

Variable	Measurement				t	df	Sig.(2-tailed)	(η2)	Effect size
	Pre		Post						
	Mean	Std. deviation	Mean	Std. deviation					
Time-management skills	**81.14**	**5.67**	**83.30**	**5.90**	**3.18**	**41**	**0.03**	**0.91**	Large

Table 3

Variable	Measurement				t	df	Sig.(2-tailed)	(η2)	Effect size
	Pre		Post						
	Mean	Std. deviation	Mean	Std. deviation					
Problem-solving skills	**14.30**	**2.58**	**16.90**	**3.09**	**5.98**	**41**	**0.00**	**0.97**	Large

Table 4

Variable	Measurement				t	df	Sig.(2-tailed)	(η^2)	Effect size
	Pre		Post						
	Mean	Std. deviation	Mean	Std. deviation					
Decision-making skills	**50.07**	**5.68**	**52.83**	**5.06**	**5.25**	**41**	**0.00**	**0.964**	Large