THE EFFECTIVENESS OF MTRIZP PROGRAM ON CRITICAL THINKING AND PROBLEM SOLVING SKILLS AMONG SAUDI ARABIA'S GIFTED AND TALENTED STUDENTS

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UNIVERSITI SAINS MALAYSIA
2018
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by

ALATAWI ATALLAH MOHAMMED

Thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy

July 2018
DEDICATION

I dedicate this humble work to the springs of loyalty, affection and virtue, my mother and my brothers, to my loyal companion, my wife, who has always been there for me, to my dear children.

Atallah Alatawi
ACKNOWLEDGEMENT

Although this thesis represents an achievement that bears my name, it would not have been possible without help of others who I would to thank. First, and for most, I thank Allah (SWT) for all his blessings and guidance.

I would like to express my sincere thanks and deepest gratefulness to my supervisors main supervisor: Dr. Mohd Zuri bin Ghani and co-supervisor: Dr. Aswati Hamza for their supervision, encouragements, guidance, insightful criticism, and for all of their help during my research work and preparation for this thesis. I would also seize this opportunity to express my special thanks to the School of Educational Studies for all facilities and support to achieve this research.

Finally, I would like to extend my sincere appreciation and gratitude to the many people who helped make this work possible, for their inexhaustible love, understanding, sacrifice, prayers, confidence, and unlimited support. Words are inadequate to express my gratitude for their sacrifice, support, and patience. May Allah reward and bless them all.
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<tr>
<td>IQ</td>
<td>Intelligence Quotient</td>
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<td>KSA</td>
<td>Kingdom of Saudi Arabia</td>
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<td>MTRIZP</td>
<td>The Modified TRIZ theory-based Program</td>
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<td>PS</td>
<td>Problem Solving</td>
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<td>TRIZ</td>
<td>Theory of inventive problem solving. The acronym comes from the original Russian: Teoria Resheiqy Izibreatatelskikh Zadatch</td>
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ABSTRAK

THE EFFECTIVENESS OF MTRIZP PROGRAM ON CRITICAL THINKING AND PROBLEM SOLVING SKILLS AMONG SAUDI ARABIA'S GIFTED AND TALENTED STUDENTS

ABSTRACT

The purposes of this study were to construct a training program based on the TRIZ program and to measure its effects in enhancing critical thinking and problem solving of talented students. This study used a quasi-experimental method. A quasi-experimental approaches were used in the effectiveness of the MTRIZ Program on critical thinking skills and problem solving skills. The study sample in this research consisted of talented seventh, eighth, and ninth graders who attend the Tabuk center in Saudi Arabia. The total sample number was eighty students, whom were divided equally into two groups, control and experimental. The control group received the regular enrichment program that is adopted by the Ministry of Education in Saudi Arabia, whereas the experimental group received the MTRIZ Program. Two instruments were used, watson test, which assessed the students level of critical thinking skills and happener test, which assessed the students level of problem solving skills. These instruments were used to assess the students’ critical thinking skills and problem solving skills pre and post the application of the regular enrichment program or of MTRIZ Program. The data for this research were collected by using both qualitative (interview protocols with participating students) and quantitative (experimental) methodologies. The result of this study showed a significance difference in developing the critical thinking skills and problem solving skills of the talented students between the control and experimental groups (after intervention). The results also indicate that the talented critical thinking skills and problem solving skills
were significantly enhanced after the application of MTRIZ Program. Notably, class had an impact on the critical thinking; mother’s education had an impact for the children whom mothers have postgraduate education on the critical thinking; mother’s education had an impact for the children whom mothers have held university degree education on the problem solving. This study confirmed that critical thinking skills and problem solving skills can be enhanced through specialized programs, which target the development of critical thinking skills and problem solving skills.
CHAPTER 1

INTRODUCTION

1.1 Introduction

Human resource is more meaningful than other resources if it is properly prepared and invested in the development, expansion, and diversification of production. The most significant proof of the importance of human resource is the development achieved in Japan and South Korea; these achievements include but are not limited to the fields of technology and science; these countries are not rich in natural resource, but they achieved progress because of proper utilization of human resource investment, especially for gifted and talented students who have the potential to innovate, invent, find solutions, and generate new ideas (Al-Tawwab, 1986). The future and progress of nations in terms of scientific and technological development largely depend on the interest and welfare of gifted and talented students and in providing a suitable climate to launch their creative potential (Mouawad, 1989).

Proper care should be provided to the gifted to enable them to develop and prepare their abilities and aptitudes and to ensure that they do not wither and are not extinguished. The gifted usually represent an important human resource that exceeds the value of any other national human wealth. The development and investment on human resource are essential to the individual and any society that seeks to advance and construct (Clerk, 1981).

MTRIZP was chosen as the basis for this study because that TRIZ theory features special characteristics, which include Engineering foundations that focus on the development of techniques of the systems, and Creative methods for solving
technical, administrative, and pedagogical problems in addition to the Ability to solve contradictions for technological and non-technological problems (Altshuller (2002).

The importance of MTRIZP for this study that MTRIZP was designed to bypass and/or overthrow psychological learning barriers. It is utilizes methodologies that are used to address advanced problems, which require resourceful, creative applications, and it is efficient in analyzing expected outcomes and in selecting suitable means/processes to achieve desired outcomes. MTRIZP is effective in screening available resources and in choosing the appropriate resources and/or their adaptation to process requirements.

MTRIZP is important for gifted and talented student because MTRIZP consists of multiple methods for solving technical problems in such a way that the technical application is dependent on the cognitive framework, the principles of TRIZ can be taught to people to facilitate predictable inventions and to enhance creative thinking (TRIZ Journal, 2013). Altshuller et al, (2002). believed that invention is nothing more than the removal of technical contradiction with the assistance of a set of principles. He emphasized that one does not have to be born an inventor to be a good inventor (Lerner, 1991).

1.2 Background of the Study

The development of critical thinking is of particular interest to educators. Critical thinking includes five skills: (1) knowledge of assumptions, (2) reasoning, (3) discussion assessment, (4) inference, (5) and conclusion. Watson's critical thinking assessment is used as a metric for determining the level of critical thinking.
Education and psychology significantly contributed to our understanding of critical thinking processes and their elements. At present, education should be tailored according to the personal abilities of recipients. This approach matches education to thinking skills thereby facilitating its effectiveness.

Teaching approaches for gifted and talented students were given significant attention in the last few decades because the current curriculum does not provide them with elements that are appropriate to their development, cultivation of talents, and overall education. This scenario inspired many countries to include the category of gifted and talented students in the area of special education. This development was expanded to the establishment of specialized disciplines that focus on gifted and talented students in university systems. Thus, this group received improved cared because they were being trained by experts. Despite these advancements, education for gifted and talented students remains at its infancy. This field requires further studies to develop our understanding and ability to enrich the potential of this group.

Increasing interest in cultivating programs for talent and gifted students has been observed in the Arab world. Several areas of these programs are related to thinking processes that should be investigated to facilitate understanding of the methods that enrich the education of gifted and talented students. The present study aims to train gifted and talented students in Tabuk area. Training is centered on the development of critical thinking and problem solving skills.

According to a 1995 report of the Ministry of Education of the Kingdom of Saudi Arabia (KSA), educational policy in the KSA (1969: Article 57) includes general objectives to focus attention on the discovery and care of the gifted.
The policy confirms the importance of caring for outstanding individuals, identifying them, and constructing special programs to develop their talents. The policy also aims to create all means of scientific research that will help increase their abilities. Among the objectives related to the secondary stages are objectives that show the capabilities of students at this stage and direct them according to their potential (Al-Zahrani, 2001). Gifted and talented students are treasures of any society. They are the pioneers of thought, science, and art in all aspects of life of a state (Zehlouk, 2001).

Communities realized the importance of identifying individuals with high and distinguished potentials. They also realized the values of developing their capabilities and preparing leaders who are capable of raising their societies to prestigious cultural levels. The civilization attained by the Chinese Empire in 2200 BC in setting an accurate system for selecting gifted and talented students and providing them with appropriate programs are evidence of early efforts in this area (Abonyan and Al-Dhabyan, 1997).

Since the advent of Islam, Muslims nurture Muslim children with special capacities. According to Morsi (1992), Islam preceded modern practices in emphasizing the importance of genius, taking care of gifted and talented students, and highlighting their virtue in the social, economic, and cultural prosperity of their communities.

About 2%–5% of the population are considered outstanding, gifted, and talented. This percentage comprises scientists, thinkers, reformers, leaders, innovators, and inventors; since the ancient ages, humanity depended on these individuals for the progress of civilization because of their ideas of inventions, innovations, and reforms (Al-Qatiee et al., 2000).
1.2.1 General Information about KSA

The KSA is located in the Middle East in the Arabian Peninsula and has an area of about two million square meters with a population of about 29 million people. The main language of KSA is Arabic, and the major religion is Islam. The KSA is divided into 13 provinces. Tabuk occupies about 7% of the area of KSA and is located in the northwestern region of the country (Figure 2.1). Tabuk has a population of about 0.9 million people (Saudi Geological Survey, 2012). Tabuk City is the capital of Tabuk province.

The school education in KSA follows the traditional system, which is divided into elementary, middle, and secondary schools. The educational system involves gender-based segregation. The government announced that education is a top priority of the country. The government is eagerly involved in developing and adopting curricula and training teachers. In the past two years, the KSA adopted the curricula of McGraw-Hill for its science track. Thus far, the educational system employs rote learning (Aljughaiman & Grigorenko, 2013).

1.2.2 Gifted and Talented Students

Webster dictionary defines “gifted and talented student” as “whoever has the potential or the natural aptitude,” whereas the term “gifted” also refers to “whoever has the potential (or ability) or the natural aptitude.” This similarity refers to the use of two interchangeable terms used as synonyms (Merriam-Webster, 1979).

Arabic dictionaries show that the term “gifted and talented student” means “a characteristic that describes the individual that has an unusual high potential (or ability).” Until now, scholars did not specify the average IQ that describes this individual, but it is often set to 120 degrees or above. Mental level is usually related
to innovation or is used as a criterion in addition to some of the other characteristics of the individual (Al-Ashwal, 1987).

Arabic and English dictionaries agree that “talent” is the ability or the natural aptitude inherent in an individual. As far as educational and idiomatic aspects are concerned, identifying and defining the terms related to the concept of “talent” are difficult. These concepts are significantly detailed and unclear to use because of the multiple components of talent.

One of the most common definitions of “talent” is the provided by the Bureau of Education, which was adopted by the federal legislation of the gifted and talented student individuals in the United States in 1971. This adoption was known later as the definition of Maryland, which says that gifted or gifted and talented student children are those who are identified by the professionals and specialists. Such children have clear capabilities, and they have the ability for high achievement. They need special education programs and services more than those provided for normal students in normal programs in school to achieve their contributions to parents and the society at large. In addition to having high scores in their academic achievement, they stand out in one or more of the following capabilities; these capabilities include mental ability, specific academic readiness or aptitude, productive or creative thinking, ability of leadership, art or optical achievement, and mechanical ability (Al-Surour, 1998).

The fact that talent is a complex phenomenon and is not limited to the cognitive side must be considered. Talent is the power of memory and high achievement in the process of learning and thinking and similar processes. However, talent extends to the personality traits and emotional motivation. This broad direction
of the concept of “talent” can be observed in leading areas (leadership). Most of modern discussions focus on the need for gifted and talented student individuals that can exploit their talents and abilities in a distinct moral and desirable manner and not to exploit their talents. An example is to maximize their potential, gain personal wealth, and solve social problems such as poverty, environmental pollution, or unemployment (Al-Buhairi, 2002).

A gifted and talented student shows outstanding performance compared with those in his or her age group in one or more of the following dimensions: (a) high mental ability (IQ increases with one or two standard deviations), (b) high creative ability, (c) ability to achieve high academic level, (c) ability to do distinct skills (distinct talents, such as technical, mathematical, physical, or linguistic skills), (d) abilities of perseverance and commitment, high motivation, flexibility, and independence in thinking as the personal and mental attributes that distinguish the gifted and talented students from others (Al-Rousan, 1989).

1.2.2(a) Gifted and Talented Students In Saudi Arabia

In 1948, the KSA was the first country to establish a special section in training teachers of special education in several tracks, including academic achievement and innovation. Thus, Saudi Arabia can be considered as a nation that needs to ensure the establishment of an academic path at the undergraduate level to graduate special type of teachers to educate the gifted and gifted and talented students (Abdul–Jabbar, 2001).

The concern for the gifted and talented students basically started in the KSA in 1992 through the study of the draft program for the identification and care of the
gifted and talented students. This program was established in 1997 with the support and preparation of the King Abdul Aziz City for Science and Technology. The program was applied in the schools affiliated to the Ministry of Education. A public administration was also established in this regard to supervise the identification of the gifted and talented students in 2002. Among the most important objectives was to conduct the techniques and appropriate software to provide educational, psychological, and social care for the gifted and talented students (Al-Qatiee et al., 2000).

1.2.2(b) Centers of the Gifted and Talented Students in Saudi Arabia

The Center of the Gifted and Talented Students is an educational institution that operates in accordance with the prevailing social system in the KSA. This system works with a new thought and a new method. This system seeks to achieve the objectives of its education policy, particularly in the area of the gifted and talented students, through a range of programs and services geared to different age groups that wish to join the group. The center is run by a group of specialists and financed by private and public institutions. The center aims to discover and take care of the gifted and talented students in the various fields, age levels, and social groups. It also aims to satisfy their needs, provide necessary resources of care, and direct them toward the best investment. The talent center works to build a relationship between the gifted and talented students and different agencies and sectors with interest in this vein. Public management for taking care of the gifted and talented students in the Ministry of Education scientifically administers a number of talent centers across the KSA. These talent centers are connected to the departments of education in different regions and provinces. These centers opened in a number of cities including Riyadh,
Taif, Jeddah, Medina, Mecca, Dammam, Al-Ahsaa (Ministry of Education in the KSA, 2008).

These centers include activity groups with leaders, supervisors, mentors, and technicians of with greater experience and ability than those available in schools. Adequate budgets are allocated, and students are provided with additional time to perform activities through weekends, mid-year breaks, and summer vacations. The talent centers receive gifted and talented students nominated by schools, clubs and societies, and mosques. Tests are conducted to identify their talents in a scientific manner. Thereafter, the students are directed toward the appropriate educational activities, where they find care at a higher level than before (Al-Zahrani, 2000).

King Abdul Aziz City for Science and Technology is an institution created for science and technology. This institution solves the problems of society through scientific research based on objectivity and field experience concerning the importance of this issue. Two institutions are involved, namely, the Ministry of Education and the General Presidency for Girls' Education, and their responsibilities in this matter. A national project has been adopted for the development of education, including the program of identifying gifted and talented students and caring for them (Abu Nian, 1997).

The field of education in the KSA underwent significant development in the last 20 years. This development includes the spread, expansion, diversity, and upgrade of its programs, strengthening the potential of gifted and talented children, and providing care and attention to mentally retarded and handicapped children. Despite these developments, gifted and talented students do not receive adequate attention and care in terms of scientific efforts to identify them and provide them
with the educational programs appropriate for their care and learning. Given their talents and distinct abilities, this category should gain a significant degree of care and attention from the onset of childhood at home, at school, and the community because of the great payoff in the development and progress of society in return (Ministry of Education in the KSA, 2008).

Some signs of interest in this category started during the celebration in honor of academically talented students in the areas of education. They were given awards and material and moral support. Another sign is the establishment of awards of princes in some areas and the efforts of the General Presidency for Youth Care in encouraging talents in the arts and culture through clubs and art galleries. The International Award of King Faisal in the service of Islam and Islamic studies and Arabic literature, medicine, and science. This award emanated from King Faisal’s Charity Foundation. Such an award represents an important symbol of the extent to which the leaders of this country estimate scientific excellence at the level of senior scientists and thinkers and their recognition of distinct individuals in the fields of religion, literature, science, and medicine at the global level.

Paying attention to the talents and excellence from childhood is important when talents and abilities are potentially viable to grow and aptitudes are in need of care and encouragement. These talents evidently exist, and they are possibly realized when the children grow up and become capable of expressing themselves and their abilities in the progress and development of society. Many centers and activities are found in some developed countries that reflect this concern. Among these centers are Future Scientists and the Young Mathematicians, the Olympics of the Mind contest, and the award of the President of the United States for scientific excellence. Talent
starts with the beginning of life as a potential that can expand with the growth and
development of the individual in different stages of his or her life. Such a
development can be ensured by a good environment that allow talent and potential to
grow and flourish until it reaches the stage of achieving production and work. If it
does not find adequate care and an appropriate environment, talent diminishes,
disappears, and loses its usefulness for the individual and society. Talent and
excellence from childhood can be nurtured when abilities are potentially viable to
grow and aptitudes are in need of care and encouragement. These existing talents are
possibly realized when children grow up and become capable of expressing
themselves and their abilities in the progress and development of society (Alsharea,
2001).

1.2.2(c ) Saudi Experience Concerning the Care of Gifted and Talented Students

The next subsections describe the many stages of development of care for gifted and
talented students (Ministry of Education in the KSA, 2008).

First Stage

From 1990–1996, official efforts were provided by King Abdul Aziz City for
Science and Technology, the Ministry of Education, and the General Presidency for
Girls' Education. These reports facilitated the establishment of a research program
that starts by identifying gifted and talented students and taking care of them in
different educational levels. A national research project emerged, namely,
“Identification and care program for the gifted and talented students.” This project
resulted in the preparation of standards in intelligence and creativity. This project
included the preparation of two experimental programs in science and mathematics
as prototypes for gifted and talented student programs in the KSA.

Second Stage

The second stage involves the identification of gifted and talented students: This program was founded according to the minutes of the meeting headed by the Minister of Education, the Vice President of King Abdulaziz City for Science and Technology, and a research team (Alsharea, 2001). The project was adopted and applied in schools affiliated with the Ministry of Education by providing all potential human and technical resources needed for implementation. A working group was assigned, which was headed by Abdulnafee Al Sharee and the membership of the research team who implemented the program and provided detailed account of its establishment according to Ministerial Decree No. 877 dated 8/9/1996. Another program was inaugurated to address the needs of gifted and talented female students in the General Presidency for Girls' Education in 1997. Actual work started in the second semester of academic year 1998.

Third Stage

This stage involved the establishment of public administration for gifted and talented students. In the pursuit of the ministry to expand the programs of the gifted and talented students, a need emerged to create a public administration for gifted and talented students. This organization represented the educational system that would implement the policy of the KSA in taking care of gifted and talented students and achieving the objectives of the Ministry of Knowledge. A public administration was established to supervise the process of identifying gifted and talented students according to Ministerial Decree No. 58054 dated 6/6/2002.
Fourth Stage

This stage involved the establishment of a management system for gifted and talented female students. A department for gifted and talented female student care was established on 02/05/2001 as a result of the expansion of care programs for gifted and talented female students. On 25/5/2002, this management was linked to His Excellency the Deputy Minister of Education for Girls.

Fifth Stage

The fifth stage involved the unification of efforts in taking care of gifted and talented students: To unify the policies and business strategies in caring for gifted and talented students in the KSA, the decision of His Excellency, the Minister of Education, No. 373373 dated 24/6/2002 was issued. This decision assigned the responsibilities of the general management to take care of gifted and talented students regardless of gender.

1.2.3 Programs Offered by the Ministry of Education for Talented Students

First: acceleration of child transfer to upper levels

Second: administration of classes and private groups

Third: educational enrichment in regular classrooms

The Program for talented care in science and mathematics includes the following (Alsharea, 2001):

1 - Enrichment Program in Science
a) Specialized departments were established in the Ministry of Education and general directorates to work on the education of talented female students

b) Use of talented student-detection (identification) tools after circulation in the KSA

c) Study and discussion of the most appropriate methods for talented students in all disciplines

d) Development and monitoring of the implementation of programs in all disciplines for talented students in the KSA

e) Establishment of a highly specialized center for talented students in science and mathematics supervised by the Department of Awareness at King Abdul Aziz City of Science and Technology to provide summer programs for talented students in science and mathematics at the secondary level

f) Incorporation of educational enrichment activities to the science curriculum at all educational levels for boys and girls to be performed only by talented students already identified by detection tests applied in the Saudi environment

g) Establishment of a specialized center for talented students in science for boys in each educational department. This center provides programs in the evening or during weekends or summer vacations or a combination of them. In large cities such as Riyadh, more than one center are established to facilitate transportation and the geographical distribution of students.

h) Development of research skills among science teachers through training courses

i) The need for one or more subjects in the curriculum of educational training in the colleges of education and teachers' colleges in the KSA. These curricula
focus on introducing talented students to future teachers in terms of their characteristics to detect these subjects and how to take care of them.

2- Enrichment Program in Mathematics

a) Teaching advanced topics in mathematics that focus on solving usual and unusual issues

b) Using computers in teaching talented students by teaching programming and taking advantage of the mathematical programs in addition to providing an opportunity for students to access information databases and link all data to the information taught in the classroom

c) Providing a learning environment that contains necessary educational tools to link the abstract material to the scientific aspect

d) Choosing an appropriate time for students to enroll in such programs when they are exhausted after attending their usual school courses in the morning

e) Taking advantage of existing programs in some of the developed countries in this area but considering the suitability of the educational environment in the KSA

1.3 Problem Statement

The increasing worldwide diversity calls for creative and complex thinkers. Given the current speed of information discovery, the quantity of available information is estimated to double every 10–18 months (Murgatroyd, 2010); this rapid growth of information requires emerging adults to recall information from their academic experiences and continually incorporate new ideas into knowledge they already know. As the complexity of society increases, the types of problems that students
will face after schooling will become increasingly complex, which will result in increased demand for proficient (Noykes, Schunn, & Chi, 2010) and creative thinkers (Sternberg & Lubart, 1996). A number of theorists (Romer, 1994) also believe that economy will be driven by creative and innovative products and solutions that respond to critical societal needs.

Schools are at the heart of educational systems. However, most students obviously lack important thinking skills. Clement (1979) highlighted the educational challenges encountered by schools: “We should be teaching students how to think. Instead, we are teaching them what to think.” Norman (1981) also expressed his dissatisfaction with the educational system: “It is strange that we expect students to learn, yet seldom teach them anything about learning.” Given the differences in abilities and potentials of students, an ideal school system should undertake learning that matches the abilities of students (Knight & Becker, 2000). Unfortunately, most schools still lack appropriate procedures for identifying talented students (Malik & Balda, 2006; Winebrenner, 2000).

Substantial research has been conducted to identify the characteristics of gifted students, whereas other research focused on pedagogical practices in the education of gifted children (Garni, & Abdullah, 2012; Abunayyan, 1994; Reis & Renzulli, 2009; Renzulli, Smith, & Reis, 1982; Silverman & Baska, 1993; VanTassel-Baska et al., 2009). Despite the availability of these studies, the majority of gifted students throughout the world spend most of their time in regular classrooms (Hyatt, 2000; Maajeeny 1990). The National Association for Gifted Children in the US (2011) published its 2010–2011 annual report entitled “State of the Nation in Gifted Education.” The report showed that gifted students spend the majority of their time in regular classrooms and they receive instruction from
teachers who are not trained to meet their needs. The majority, if not all, of gifted students in Saudi Arabia spend most of their time in mainstream classrooms (Al Qarni, 2010; Maajeeny, 1990). The downside of this situation is the tendency of gifted students to easily and quickly complete mainstream tasks and problems (Winebrenner, 2009); they also frequently become bored (Cohn, 2003) and frustrated (Delisle & Galbraith, 2002). Subsequently, they may lose interest and ultimately underachieve. In addition to the adverse effect on the academic process, the lack of special attention for unidentified talented students may leave negative implications on the self-esteem and motivation of talented students (Knight & Becker, 2000).

Gardner (2004) suggested that gifted students must be provided with different instructions that can match their unique abilities to enable them to overcome the risk factors of academic achievement and motivation.

Given the explosion of information technology and the shift from an industrial society to a knowledge society, the attitude or disposition to think critically has become as important as other skills (Halpern, 2003; Pascarella & Terenzini, 1991), such as professional acquisition of knowledge and lifelong learning (Tiwari, Lai, So & Yuen, 2006). Understanding the nature of critical thinking and how it can be acquired could help educational institutions instill such skills in their educational strategies and hence become effective and efficient. Critical thinking is an important skill in the category of talented students because it is through the development of critical thinking skills that talented students are driven for academic and social success.

Critical thinking is a high-order type of thinking. Critical thinking is a non-algorithmic, complex mode of thinking that often generates multiple solutions. Low-level taxonomy under Bloom’s classification, such as knowledge, can be considered
low-order thinking skills, whereas high-level taxonomy, such as analysis, synthesis, and evaluation, can be considered high-order thinking skills. The combination of multiple elements of critical thinking forms other skills including, but not limited to, problem solving, inferring, estimating, predicting, generalizing, and creative thinking. This finding suggests that problem solving is preceded by critical thinking.

Critical thinking also affects the acquisition and retrieval of knowledge because concepts are acquired through abstractions. Moreover, principles connect these concepts, which result in the establishment of a network of knowledge. New concepts must fit into the existing cognitive structure. Such an accommodation will not be possible without critical thinking. When a problem occurs, it must be analyzed critically before it can be solved by asking the following questions: What is the problem?, What is the given information? Critical thinking is continually involved in problem solving.

Problem solving involves a skill required in all aspects of daily life. Most people make daily plans, make business decisions, and manage their budgets. These activities require logical thinking and problem solving skills (Wedemann, 1995). Problem solving is an important life skill that involves a range of processes including analyzing, interpreting, reasoning, predicting, evaluating, and reflecting (Anderson, 2009).

Problem solving has many definitions. The following definitions encompass most of these definitions. For Polya (1973), a pioneer in problem solving, “solving a problem means of finding a way out of a difficulty, a way around an obstacle, attaining an aim that was not immediately understandable.” According to Green and Gilhooly (2005), “problem solving in all its manifestations is an activity that
structures everyday life in a meaningful way and that problem solving draws together different components of cognition.” Annable (2006) stressed the importance of problem solving and pointed out that problem solving skills are potentially manifested in developing students’ responsibility and increasing their motivation for learning and its retention. In addition, problem solving strategies are effective in collaborative learning settings (Annable, 2006).

Educational systems at present continually struggle to engage students in critical thinking and problem solving activities (Tempelaar, 2006), but students seldom use critical thinking skills to solve complex, real-world problems (Bartlett, 2002; Rippen, Booth, Bowie, & Jordan, 2002). Existing studies show gifted students cannot develop their potential on their own (Fiedler, Lange, & Winebrenner, 2002; Winebrenner, 2000, 2009). To unleash their potential, they must receive adequate training from qualified teachers. Çetinkaya (2014) confirmed such connection by using a problem solving program administered to talented students. Çetinkaya’s research indicated that problem solving is directly linked to creative thinking skills. Therefore, institutional programs should be developed that target the development of critical thinking and problem solving. These programs can bridge the gap in the education of talented students and in providing them with means to excel.

Talented students should be taught how to think critically to foster their development. Critical thinking training should be included in programs that target talented students; this can only happen, however, if professional programs in these disciplines evolve accordingly by not only teaching content but also teaching processes of how to think (Ahuna et al, 2014; Cabrera & Colosi, 2009). Critical thinking training can help talented students practice rigorous thinking, evaluate ideas
and concepts, and understand the underlying nature of things. Training in critical thinking can sculpt the personalities of talented students and empower them to face difficult, real-life problems. Critical thinking training for talented students can also boost their self-confidence and self-dependency. Such a training can also enrich the cultural and ideological rationale of students. Critical thinking training can lead students to apply methodologies in evaluating and comparing ideas and concepts before accepting them. Thus, it can reduce the likelihood that students will accept false logic or an unsupported idea or concept. Another benefit of critical thinking training is reduced arrogance and tendency to underestimate others or to undermine new ideas and concepts. Critical thinking can strengthen the abilities of talented students to identify contradictions and logical fallacies (Al-Sukary, 2010).

Educational systems in many countries are continuously realizing the importance of fostering high-level thinking skills, which are directly linked to high abilities in reasoning, evaluation, analysis, and conclusion (Al-Sharafi, 2005). These abilities are also necessary in enhancing the specific talent of each student (Astleitner, 2002). The inclusion of critical thinking training can stimulate and advance the mental abilities and skills of these students (Al – Rafei, 2012). However, this success is contingent on educational support and on the specific environment that can affect the customization of critical thinking exercises and activities. Moreover, the inclusion of critical thinking training into these programs should emphasize the excitement and dynamicity of critical thinking (Halpern, 1998).

According to Harnadek, Anita (1976), every student can exercise critical thinking if he or she receives appropriate and adequate training (Jarwan, 2002; Bahjat, 2005; Abrami., 2008). The author arrived at this conclusion because the application of critical thinking can lead to strong and deep cognitive content and
facilitate the ability to dynamically utilize such a skill (Al-Hamory & Al-Wahr, 1998).

The emphasis on the importance of fostering talented students was also evident in conferences held in many countries. In 2000, Connecticut University held “Teaching and Learning Enrichment for Fostering Talented Students.” In 2005, the conference on “Fostering Talented Students is an Arabic Priority in the Globalizing Era” was held in Amman, Jordan. The Jeddah/Saudi Arabia Fourth Annual Regional Scientific Conference entitled “Fostering Talented Students-Pedagogy for the Future,” which was held in 2005, was focused on fostering talented students. The conference addressed the importance of teaching and enhancing the different types of thinking including critical thinking. Based on the consensus on the importance of advancing thinking skills, the conferences recommended the vital importance of research in understanding and developing programs that address teaching and learning of thinking, particularly critical thinking (Al – Rafei, 2012).

Existing research data and the recommendations of conferences on advancing the teaching and learning of talented students suggest the importance of critical thinking skills of talented students. The value of critical thinking is attributed to personal and societal benefits. The present study was conducted to address the scarcity of research to advance the critical thinking abilities of talented students in Arab countries in general and in Saudi Arabia in particular. In this study, we attempt to shed light on advancing research on critical thinking. The present study followed the developments achieved in developed countries that have placed the advancement of thinking skills at the top of their agenda and social priorities. Despite the consensus on the importance of teaching critical thinking skills, this subject is still taught within the context of other disciplines. Thus, the present study focuses on
teaching critical thinking skills in an interdisciplinary approach. This study aims to teach critical thinking skills in a broad context to help talented students apply their acquired knowledge and skills in real-life situations. This study is of crucial importance to the Saudi Arabian society because it focuses on the interdisciplinary approach of teaching critical thinking to talented students.

One of the most recognized theories in the world is TRIZ. TRIZ has been constantly evolving since its inception; a yearly conference addresses the continuous development of TRIZ theory (www.aiTRIZ.org). Altshuller (1984) conceptualized this theory by identifying and codifying principles that enabled people to invent; these principles are the basic, universal drives for creative thinking. According to Altshuller (1999), these principles can be taught to people to facilitate predictable inventions and to enhance creative thinking (TRIZ Journal, 2013). Altshuller et al., (2002). believed that invention is nothing more than the removal of technical contradiction with the assistance of a set of principles. He emphasized that one does not have to be born an inventor to be a good inventor (Lerner, 1991).

When used in isolation, TRIZ principles can be used as part of brainstorming to create ideas and solutions. However, the philosophy of TRIZ is focused on problem solving effort in areas that are likely to be successful instead of generating large quantities of ideas (TRIZ Journal, 2013). The proponent criticized the trial-and-error method, which is normally used to make discoveries. The definite roadmap and concise target of TRIZ principles makes this theory an attractive model for implementing the development of thinking processes, particularly in the area of critical thinking and problem solving. TRIZ theory was originally modeled for technical problems, but it can serve as the foundation for non-technical and educational purposes given its flexibility and universality.
Bowyer (2008) confirmed the effectiveness of TRIZ principles in solving non-technical problems by non-specialized individuals. Bowyer’s research supported the argument that TRIZ principles can improve certain aspects of critical thinking abilities of an individual. Therefore, TRIZ principles can improve the problem solving ability of participants because critical thinking processes precede problem solving. In addition, the dynamicity of TRIZ principles allows them to be an effective and efficient tool for training and in conducting group problem-solving exercises.

A growing interest in talented students has been observed in Arab societies, and serious steps have been taken to identify talented students in an attempt to provide them with necessary care (Aljughaiman & Grigorenko, 2013). However, educational policy toward gifted students, which was initiated in 1969 (Ministers No. 779 dated 26/11/1969), directed the educational system to identify and care for talented students within the framework of public programs (Public Management, 2001).

The education of gifted students has emerged as a strong and noticeable subject in many countries including the KSA. The policy of education in the KSA recognized the special needs of the gifted group and the necessity for developing them. To provide gifted students with the streams of culture and the appropriate expertise, KSA decided to construct special programs and curricula. The policy also concentrated on providing the gifted with tools for scientific research to invest in their talents and abilities. KSA’s efforts in identifying and caring for gifted students are substantial, important steps in driving the prosperity of the country. The main objectives of the educational policy in KSA are to identify gifted students and to provide them with opportunity and different potentials. Through this policy, the
country hopes that the talents of students are well cared for within the framework of public programs (Al-Mousa, 1999). The ability to think is a distinct feature of human beings. The quality of our thinking distinguishes us from other members of our own species. Critical thinking facilitates our improvement and progress. Not all natural thinking process leads to excellence. Scriven, M. and Paul, R. (2003) suggest the cultivation of critical thinking to prevent bias, distortion, partiality, uninformation, and prejudice. This study examined enthusiasm on the development of critical thinking in education. Teaching critical thinking skills have gained considerable attention in educational research. Glaser's (1941) seminal work reported that training programs have beneficial effects on different aspects of critical thinking elements. MacBride and Bonnette (1995) also reported that training and education can foster critical thinking in at-risk groups. In his comment on Atkinson’s (1997) article, Davidson (1998) maintained that critical thinking should be introduced even if it is considered a culture-specific trait.

These discussions display the importance of the integration of critical thinking and problem solving into the educational system in general and in the enrichment programs for talented students in particular. The present study aims to use the principles of MTRIZP to develop the critical thinking and problem solving skills of talented students in Saudi Arabia. MTRIZP is flexible, dynamic, systematic, and versatile. Most importantly, it targets critical thinking and problem solving. The researcher selected 10 principles of the TRIZ program. The selection of these principles were based on their ease of adaption and suitability to create a training program, namely, MTRIZP. This program aims to develop the creative thinking and problem solving skills of talented students in Tabuk, KSA. The following TRIZ principles were selected: (1) segmentation, (2) extraction, (3) merging, (4) inversion,
(5) self-service, (6) changing color and transparency, (7) nesting, (8) universality, (9) blessing in disguise, and (10) copying. MTRIZP will present and explain each of the selected TRIZ principles to talented students in Tabuk. MTRIZP will further elucidate each of the selected TRIZ principles by providing talented student with hands-on examples and discussions of sample problems. At this stage, the students will work collaboratively with their trainer to follow and assess each stage of the process. After providing adequate training to each of the selected TRIZ principles, MTRIZP will present a problem to the students, which they will work on within their assigned groups.

The focus of MTRIZP is to equip talented students with critical thinking skills that will motivate them to explore and resolve problems. Throughout the process of critical thinking and problem solving, the talented student will employ a myriad of skills that will transform them into dynamic, creative self-learners. Existing research supports the premise that traditional methods of pedagogy, such as lecture and memorization, do not lead to long-term knowledge or the ability to apply this knowledge to new situations (Celuch & Slama, 1999; Daz-Iefebvre, 2004; Kang & Howren, 2004). On the one hand, lecture and rote memorization do not promote critical thinking and its application to new problems. On the other hand, instructional strategies that employ the high-order thinking skills of students lead to improved critical thinking skills (Duplass & Ziedler, 2002; Hemming, 2000; Wong, 2007).

Assessments should emphasize the ability of students to identify their strengths and weaknesses thereby facilitating their advancement (Ennis, 1993). By presenting students with case problems, MTRIZP diverts from memory recall (Schafersman, 1991) and limited assessments. In this manner, MTRIZP not only
trains students on critical thinking and problem solving, but also directs them in evaluating and balancing multiple solutions and leads to their collaborative work ethics. The learning, processing, evaluating, and collaborative nature of MTRIZP will raise the self-confidence and the engagement of talented students.

1.4 Objectives of the study

The main objective of this study is to develop the critical thinking and problem solving skills of gifted and talented students in Saudi Arabia. To achieve the general objective, the following specific objectives were drawn:

1. To examine any significant difference in the critical thinking and problem-solving skills of participants between the experimental and control groups on pre-test
2. To examine any significant effect of the application of MTRIZP on critical thinking and problem solving skills of gifted and talented students
3. To examine effect according to age, birth order, class, father’s education, and mother’s education on critical thinking after applying MTRIZP on gifted and talented students
4. To examine effect according to age, birth order, class, father’s education, and mother’s education on problem solving after applying MTRIZP for gifted and talented students
5. To describe the respondents’ perspective of students and teachers on MTRIZP
1.5 Research questions

The following research questions were derived from the research objectives:

1. Is there a significant difference in participants’ critical thinking and problem-solving skills between the experimental and control groups on pre-test?

2. Is there any significant effect of the application of MTRIZP on the critical thinking and problem solving skills among gifted and talented students?

3. Is there effect according to age, birth order, class, father’s education, and mother’s education on critical thinking skills after applying the MTRIZ program to gifted and talented students?

4. Is there effect according to age, birth order, class, father’s education, and mother’s education on problem-solving skills after applying the MTRIZ program to gifted and talented students?

5. What is the respondents’ perspective of the MTRIZ program?

1.6 Hypotheses

$H_{01}$: No significant difference was found in the critical thinking and problem solving skills between the participants in the experimental and control groups on pre-test.

$H_{02}$: No significant effect was found from the application of MTRIZP on critical thinking and problem solving skills of gifted and talented students.
$H_03$: No significant effect according to age, birth order, class, father’s education, and mother’s education on critical thinking skills after applying the MTRIZ program to gifted and talented students.

$H_04$: No significant effect according to age, birth order, class, father’s education, and mother’s education on problem solving skills after applying the MTRIZ program to gifted and talented students.

1.7 Significance of the Study

This study will be conducted on gifted and talented students in Tabuk, KSA. The purpose of this study is to closely interact with gifted and talented Saudi students and gain insights on the overall and particular components of the thinking processes of gifted and talented students. The study is designed to ensure that the experimental and control groups are composed of gifted and talented students. The program will be administered to the experimental group. Thus, the results of this study will show the effectiveness of MTRIZP on the development of thinking skills of the experimental group. The application of MTRIZP will be particularly significant in determining the effect of the enrichment program of the development of problem solving skills and critical thinking abilities. Such knowledge can give insights into the design and development of further enrichment programs for gifted and talented students.

A major, indirect goal of this study is to increase the motivation and activism of gifted and talented students in their own learning and in general academic processes. Such direction can promote the involvement of gifted and talented students in the outward expansion of their interests and involvement in the society.
The category of gifted and talented students will most likely take on important professions in society. Therefore, such groups of people should be well prepared and trained to ensure their benefits to society.

Some demographics (age, birth order, class, father’s education, and mother’s education) have been studied in this research, so as to provide useful scientific information to researchers, talented teachers and decision-makers so that they can employ them and apply them in the field of gifted care also to take care of these variables when teaching a program.

1.8 Conceptual Framework

The foundation of this study is the TRIZ theory. TRIZ contains 40 principles, which represent a systematic process that can be used to accomplish a special thinking process that promotes innovativeness. The researcher chose 10 principles from the 40 TRIZ principles to use in his study. The selected principles were chosen for their ease and suitability for designing a training program (MTRIZP). MTRIZP design contains

Activities for development of critical thinking skills and problem solving skills. The TRIZ principles used in MTRIZP are: (1) segmentation, (2) extraction, (3) merging, (4) inversion, (5) self-service, (6) change of color and transparency, (7) nesting, (8) universality, (9) blessing in disguise, and (10) copying.

After designing the program, MTRIZP was introduced to several education and talent experts and they were asked to evaluate it. After receiving feedback, MTRIZP was resigned to incorporate the comments, viewpoints, and corrections of the evaluators. After evaluation, the validity of MTRIZP was verified through a pilot study.
In each of the MTRIZP sessions, one of the selected TRIZ principles is presented and discussed thoroughly. The understanding of students of the TRIZ principles is then reinforced using case studies of general, real-life problems. After thorough training, students work collaboratively (in groups of five members each) to generate multiple, alternative solutions to a given problem. At the later stages, the groups present their findings. The findings of all groups are critiqued and examined from different aspects through class discussions. The logistics of MTRIZP are consistent with those of MTRIZP. The principles of MTRIZP support critical thinking skills, which in turn are directly linked to problem solving abilities. The critical thinking skills that will be assessed in MTRIZP are: (a) assumptions, (b) interpretations, (c) discussions assessment, (d) deduction, and (e) inference. The problem solving skills that will be assessed in MTRIZP are: (a) problem identification, (b) outlining of the problem, (c) construction of alternatives, (d) making decisions, (e) and assessments. The two tests that will be used to evaluate MTRIZP are Watson’s Critical Thinking Assessment and Heppner’s Problem Solving Assessment.

The targets of this study is the talented students in Tabuk, KSA. The drive for designing a MTRIZP originated from the need of talented students in KSA for programs to help them excel in their talents and promote an outward expansion of their abilities and motivation.

MTRIZP consists of multiple training sessions designed to be administered in three months in a talent center in Tabuk. MTRIZP will be administered to male students in middle school (seventh, eighth, and ninth grades). This experimental
study uses a control group in parallel with the experimental group. The experimental group will be administered with MTRIZP, whereas the control group will follow the regular talent program designed by the Ministry of Education in KSA, which is offered through the Tabuk Talent Center.

Figure 1.2. Conceptual framework of the study
1.9 Operational Definitions

1.9.1 Gifted and Talented Students

A student who possesses a stronger sense of willingness, exceptional ability, or outstanding performance than his or her peers in one or more areas estimated by the community, especially in the areas of mental superiority, innovative thinking, academic achievement, and special skills and abilities, requires special education that cannot be provided by a school that offers ordinary curricula. This goal cannot be achieved unless a teacher has special skills to invest in a student's potential (Rayni, 2001).

Operational definition: in this study the gifted and talented students refers to the students in the seventh, eighth, and ninth grades in Talented Tabuk Center, identified by Talented Tabuk Center.

1.9.2 Critical Thinking

Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action (Paul, Elder, and Bartell, 1997).

Operational definition: The total score obtained by the student in the test by Watson(1998) for critical thinking, which reflects the sum of the scores in the dimensions of the scale.
1.9.3 Problem Solving

This process uses cognitive problem solving skills, such as reasoning and heuristics, to search through the problem space (Newell & Simon, 1972). Therefore, problem solving skill is a conscious and cognitive thinking action that a student can learn and use to solve complex problems.

Operational definition: The total score obtained by the student in the test by Happner (1982) for problem solving skill, which reflects the sum of the scores in the dimensions of the scale.

1.9.4 TRIZ Program (Algorithm for Inventive Problem Solving)

This program is an analytical tool that incorporates the most basic concepts of TRIZ into a system of problem solving. This program is composed of a sequence of procedures for defining the problem and deriving proposed solutions (Abu-Jado 2005).

Operational definition: The program which develop by Altchuller (1926).

1.9.5 MTRIZP

MTRIZP is a program developed by the researcher to improve critical thinking and solving problem skills. The training program in this study was based on theory. This study used 10 principles in MTRIZP, namely, Extraction, preliminary, blessing, copying, discarding, segmentation, nesting, inversion, color changes, and phase transitions.
Operational definition: Program developed by the researcher according to TRIZ Program in this study.

1.10 Limitations of the Study

The limitations of this study are the following.

This study uses MTRIZP to examine the effect of developing the level of critical thinking and problem solving of gifted and talented students. The duration of this experiment is 10 weeks, which cover 20 lessons. The study is limited to gifted and talented students in the seventh, eighth, and ninth grades in Tabuk City. The selected sample will be divided into two groups. The control group will be taught by the normal program of teaching, whereas the experimental group will be taught by MTRIZP. Each lesson will last for 45 minutes. Therefore, the findings of this study might not be applicable to other situations that do not lie within the limitations of this study.

1.11 Conclusion

This chapter provides the introduction, background information and statement of the problem, objectives, hypothesis, research questions, and definitions. This chapter also discusses the rational, significance, and limitations of the study. Lastly, it elicits the conceptual framework of the study.
CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This section discusses the existing body of research on the effect of MTRIZP on the
critical thinking and problem solving skills of gifted and talented students in Saudi
Arabia. This section is organized into areas, such as critical thinking, problem
solving of gifted and talented students, and theoretical frameworks.

2.2 Talented and Gifted Students

The many characteristics described by researchers are evidence of giftedness. For
instance, gifted students may exhibit advanced comprehension, deep curiosity, thirst
for knowledge, heightened sensitivity toward others, capacity for understanding an
extraordinary quantity of information, persistence, early insight into social issues,
musical gifts, dancing abilities, and enhanced academic abilities (Garni, & Abdullah,
2012; Catron & Wingenbach, 1986; Clark, 2002; Davis & Rimm, 2004; Gagné,
2004c; Gardner, 2004; Tannenbaum, 1997). By understanding such specific
characteristics of gifted students, teachers and administrators can provide appropriate
definitions and identification procedures for their schools (Manning, 2006;
Sumreungwong, 2003) as well as influence their attitudes toward the gifted child.

Gifted students differ in their cognitive abilities, motivation, personalities,
self-sufficiency or independence, conscientiousness, emotional control, perseverance
and learning styles (Clark, 2002; Gagné, 2004c; Grigorenko & Sternberg, 1997;
Renzulli, 2002b; Winebrenner, 2000). Hence, future teachers should be equipped
with adequate knowledge on the diverse characteristics of the gifted to ensure that they can nurture the gifted’s individualities. Understanding the gifted student’s characteristics will help in providing them with an appropriate education that will meet their specific needs (Garni, & Abdullah, 2012; Davis & Rimm, 2004).

The range of characteristics exhibited by gifted children is extensive. According to Winebrenner (2000), gifted students differ in five ways from other students in terms of learning. First, they learn new concepts quickly. Second, they remember previous experiences that can enable them to review lessons they have been studying. Third, they perceive concepts and ideas at a level more complex and abstract than those of their classmates. Fourth, they become frustrated when they are asked to shift from a topic they find interesting to other learning tasks before they master the entire topic. Finally, they have heightened powers of concentration.

These characteristics can affect a future teacher’s beliefs and attitudes toward meeting the individual needs of gifted students (Sumreungwong, 2003). These characteristics should be understood by future teachers to enable them to provide gifted students with appropriate education.

There are many factors that have a relationship to the effect on the gifted. This study examined some demographic factors such as age, birth order, class, father’s education, and mother’s education.

In an exploratory study, Alqefari (2010) focused on the factors of talented student in Saudi Arabia. Most parents (85%) of gifted students who responded to the questionnaires appeared to have higher education qualifications; their fathers being more educated than their mothers.
This difference can be explained by the Saudi social law requiring the father to be more responsible for the financial support of the family. According to Islamic social law, a father should support and spend money on his family, even if the mother has more money. Further, a majority of parents of gifted students work for the government, in professions and many were teachers (Alqefari, 2010).

The research results also showed that more than half of the students had two brothers and two sisters. Over half of the gifted students in the sample were either first or second born. This could indicate that most families are concerned about these children more than the others, concerned about their support and how much time they give them although no specific reasons can be attributed to this (Alqefari, 2010).

The researcher study this factors to provide useful scientific information to researchers, talented teachers and decision-makers so that they can employ them and apply them in the field of gifted care also to take care of these variables when teaching a program.

If we want to trace the problems and obstacles faced by talented students, we can attribute these problems to the following sources that interact with the talented and form his character (Habib, 2000); these problems obstruct their natural growth, cause either frustration or failure, or affect their talents and creativity:

1) Personal problems related to the talented individual

a) A talented child may suffer from psychological problems that lead him to poor psychological and social adjustment. A talented person is characterized by high motivation toward learning. He or she has a desire to search and explore knowledge. He or she thinks of everything that is happening around him or her. When a child goes through painful experiences, especially in the early stages of
life, or when the environment fails to satisfy their needs, they become frustrated and worried. This situation turns their life into internal psychological conflicts that harm and diminish their creativity. In this case, they should either accept this fact or abandon these creative activities. This scenario happens in all age levels of the child. In all cases, the loss is significant for the individual and for society when individual contributions and serious achievements are lost.

b) The talented students sometimes choose tracks of study or types of professions that are unfamiliar or interfere with the wishes of the family or the parents who feel that they are not commensurate with their social status. In such a case, the parents stand in the face of their children and prevent them from attending this type of study or profession. This situation causes the talented to retreat, become frustrated, and fail.

2) Problems related to the domestic environment

a) The talented face problems or obstacles directly from parents, brothers, or sisters. The most important of these obstacles is the family’s indifference to the child’s mental or technical talents such that they neglect their activities thereby causing their unwillingness to exercise them, their indifference and the failure of providing them with material and moral potentials regardless of simplicity. Thus, the family may bury the talent in its infancy. Talented children often withdraw and abandon their talents and the practice of their hobbies in cases of repeated failures, especially in early stages, as well as in instances of fear and threat by their parents. This scenario may be attributed to the fact that the talented have effusive emotions and social sensitivity (Habib, 2000).
b) The family may follow wrong methods in the processes of education and socialization. For example, they do not accept the child and his talents and consider him to be mischievous. Thus, the family utters verbal phrases that are unacceptable or make fun of his ambitions. Other patterns of socialization are also wrong, such as when the family exaggerates in the launch of expressions of thanks and praise for their son or daughter and when giving them excessive affection and pampering, which result in vanity and a sense of arrogance.

c) Among the mistakes that parents make is teaching their children misconceptions and stereotypes in thinking, such as promoting only one solution to a problem with all other alternative solutions being wrong. The spirit of creativity is suppressed among children who can discover solutions and other alternatives unfamiliar to adults and parents. According to Siewert (1998), the mental functions of the talented can be collapsed in inappropriate homes (Habib, 2000).

3) Problems and difficulties related to the school environment

The school environment contains multiple variables and various media that play an important role in the development of creativity and honing the talent in children if they have been properly exploited for the benefit of the child. By contrast, it can be a source of problems for the talented, which may interrupt their growth and limit their talents and creativity. The most important problems are the following:

a) Many problems emerge in the classroom between talented students and their teachers because the talented often look for individuality that distinguishes them from their peers. They might increase their questions about the issues and the subjects they study or solutions that they might need to address.
Alternatively, they might present solutions and proofs different and unfamiliar to their teachers or ask difficult and complex questions. Teachers and coaches might feel irritated and suppress them or ridicule their ideas and opinions. They may call them mischievous or retarded and provoke chaos in the classroom. The American paper “Pronidence” published in 1992 published a document stating that the parents of talented children in one of the cities have protested against the manner in which their talented children are treated. This protest was presented to the City Council by the secretary of the Association of Talented and Creative Children accusing public schools of putting innovative students in the same classroom with mentally retarded ones. They are treated as mentally retarded because of the behavioral problems that occur (Habib, 2000, p.85). The talented and creative are placed in a class with mentally retarded children.

b) What is the state of the talented in developing and underdeveloped countries?

c) Talented children do not tend to memorize. They favor other methods of learning, such as exploratory education. They also search for information and facts on their own through self-learning. They also depend on patterns of thinking based on observation and inference, analysis, and evaluation, which are high levels of thinking. They often feel bored when teachers use traditional methods of teaching based on the methods of indoctrination and stereotypical thinking. A traditional school climate, lack of potentials in the school, and lack of school activities, hinder their normal and natural growth. These activities include sports, music, and art activities, as well as fieldtrips and visits.
2.3 Critical Thinking

Critical thinking is one of the thinking patterns a learner uses to differentiate between correct and false arguments. Critical thinking is an important educational issue. Critical thinking is a key feature used to achieve progress and success in the 21st century (Huitt, 1998). Critical thinking is knowledge that solves problems efficiently and facilitates decision making (Ajwa and al-Banna, 2000). Mere possession of critical thinking among students is not enough. Students should also know how to use this ability and apply it to all aspects of their knowledge and feelings. Critical thinking enables students to become self-observers of events around them thereby allowing them to make use of this ability in all manners of life (Norris, 1985).

Developing critical thinking skills has become a legitimate and civilized necessities. Critical thinking should be developed because it facilitates the achievement of self-interest in the learner and provides general social benefit (Rafii, 2012). The ability to think critically is not common among students. Most students who are subject to critical thinking tests do not obtain good grades (Norris, 1985). A number of studies, such as Al Djaafarh and Kharabsheh (2007), indicated the low total scores achieved by outstanding students in critical thinking. Alhaddabi (2012) asserted that self-learning is not enough to earn this skill because individuals need to undergo special training programs with the help of experts (Yasrh, 2010). Some studies, such as Sabri and Al-Hazmi (2013) and Azza Abdasameea (2013), recommended studies that delved into Therese Theory principles on critical thinking, such as Mahmoud and Anzi (2009) and Al-Anzi (2007).
2.3.1 Definition of Critical Thinking

Critical thinking skills include: (1) knowledge of assumptions, (2) reasoning, (3) discussion assessment, (4) inference, (5) and conclusion. Watson critical thinking assessment is used as a metric for the level of critical thinking. Jarwan (1999) defines critical thinking as a composite thinking connected with an unlimited number of behavioral issues in a wide range of situations; critical thinking is interconnected to other principles, such as logic, problem solving, learning, and knowledge theory. Katamy (2004) mentioned that critical thinking is an anticipative, logical thinking based on an individual’s beliefs or performance. Bahjat (2005) perceived critical thinking as the analysis of a problem, its components, and its assessment to formulate and determine new ideas and new tasks that enable a student to make a decision pertaining to complicated, technical, and dynamic aspects of living or working situations.

Abo Hatab (1972) defined critical thinking as an assessment operation that formulates the final, commanding thinking process, which concludes the collection of the memory, understanding, and inference. Watson and Glacier (1980) defined critical thinking as a continuous attempt to assess the facts or opinions in light of supporting evidence, which is directly based on facts or opinions instead of arriving at conclusions. Watson’s definition of critical thinking is the awareness of logical analysis, which evaluates the different pieces of evidence, attainment of accurate results, assessment of the results, and the subjective evaluation of discussions. Abd Al-Majeed and Hindam (1988) defined critical thinking as the form of thinking required in situations that demand scientific and social judgments or thinking required during the evacuation of discussions or supportive evidence of a subject.
2.3.2 Critical Thinking Skills

Critical thinking requires the following skills: (1) accuracy in observing events, (2) objectivity, (3) evaluation of topics and cases (Katamy, 2004).

A myriad of theoretical guidelines are used in studying critical thinking and its dimension. They can be summarized as: (a) differentiation between facts that can be supported by evidence and claims with strong leads; (b) differentiation between facts and assumptions and inferences that are connected or unconnected to the event; (c) ability to evaluate the degree of validity of a statement or an event; (d) identification of the claims, reasons, and inconspicuous assertions; (e) identification of unstated assumptions; (f) identification of erroneous information; (g) objectivity; (h) identification of uncoordinated thinking or assumption; (i) ability to evaluate the strength of evidence or claim; (j) ability to make a decision and formulate a good base for its execution; and (k) prediction of the solution or decision consequences (Jarwan, 1999; Milhim, 2001; Katamy, 2004).

As mentioned by Jarwan (1999), Udall and Daniels described the three categories of thinking skills:

1. Inference thinking skills
2. Evaluation thinking skills
3. Inductive thinking skills

According to Abo Jalalah (2007), the most popular schemes for organizing critical thinking abilities are: problem solving, comprehension of assumptions, and problem evaluation. Bahjat (2005) identified the mental practices involved in critical thinking, namely, assembly, analysis, evaluation, and conclusion.
2.3.3 Metrics of Critical Thinking

Several metrics can be used to evaluate and express the level of critical thinking competency. These metrics are used as guidelines that should be considered and carefully employed in the assessment of thinking process in general and critical thinking in particular. Below is a summary of the most employed metrics and some of the basic questions that can be asked within each metric.

2.3.3.1 Clarity

Clarity is one of the most important critical thinking skills because it can be considered as the leading metric among the other critical thinking metrics. The clarity metric is concerned with the ability to formulate comprehensible, expressible ideas. Ideas should be expressed in clear statements. Lack of clarity can lead to the inability to understand the statements and determining their meanings. Ideas cannot be evaluated. Some of the suitable questions include the following. Can you clarify the topic by providing a more detailed topic? Can you give examples? Can you present the idea in a clearer style? What do you mean by it?

2.3.3.2 Truthfulness

Truthfulness describes the content reliability of the information or its sources. Some of the suitable questions include the following. Is that really true? What is the source of this information? How can you validate the truthfulness of such statement? How can we find the source of this information?
2.3.3.2 Accuracy

Accuracy in critical thinking means the appropriate portrayal of the topic or idea with the least number of errors. Some of the suitable questions include the following. Can the idea be outlined in a simpler form? Can you give more details?

2.3.3.3 Association

Association describes the connection between the question, evidence, an issue, and the discussed topic. Some of the suitable questions include the following. Can this question or idea clarify or explain the problem? Do these questions or ideas contain a supportive or contradicting evidence? Is there an interaction or a link among the pieces of evidence?

2.3.3.4 Depth

Depth represents the deviation of being superficial in dealing with the problem. The topic portrays the complexity and challenges of the problem. Some of the suitable questions include: Can you further divide the ideas into more units? What are the inferences that are present in the given evidence? What information can you read between the lines?

2.3.3.5 Breadth

Breadth means the comprehensive covering of all aspects of the problem. Some of the suitable questions include: Is there an area that is not applicable to what is presented? Is there another method for solving the problem?
2.3.3.6 Significance

Significance pertains to the identification of the importance and influence of the presented topic. Some of the suitable questions include: Do these ideas represent the most significant aspect of the topic? What are the central main and tangential ideas in the topic?

2.3.3.7 Logic

Logic is the assessment of the systematic and sequential streaming of ideas to portray a clear meaning or plausible result. Some of the suitable questions include: Is this idea or solution logical? Can you identify a contradiction between the ideas? Do these premises lead to such results?

In summary, critical thinking metrics should be applied beyond their theoretical boundaries. Moreover, they should be integrated and used in the individual’s thinking processes and in his or her lifestyle. Critical thinking metrics should be employed as an integrated, active unit (Nosich, 2006).

2.3.4 Basic Elements of the Critical Thinking Process

The critical thinking process depends on five basic elements. The success of the critical thinking process depends on the use of all of the five elements, and the process will not proceed in the absence of one or more element, as the five elements are tightly linked with one another. The five elements of critical thinking are listed as follows.
2.3.4.1 Basic Knowledge

Basic knowledge describes the collection of information, abilities, morals, and experiences of an individual, which he or she believes to be factual. Basic knowledge is necessary to drive contradictions.

2.3.4.2 External Events

External events are the stimuli for sensing contradictions. They can have various degrees of ambiguity and composition. The influence of the external events vary depending on the individual’s level of the critical thinking and his or her basic knowledge.

2.3.4.3 Personal Outlook

Personal outlook describes the influence of the basic knowledge on the personality of the individual. Personal outlook is unique for every individual and it forms the utilities by which the individual interacts and responds with the external events.

2.3.4.4 Sense of Contradiction

Recognizing the lack of understanding or discomfort in dealing with a topic causes the individual to seek knowledge in an attempt to increase the understanding or relive the discomfort. Sense of contradiction is highly influenced by personal outlook and is considered as a central, variable player for all thinking processes.
2.3.4.5 Resolving Contradiction

Resolving contradiction includes all elements of critical thinking, in which the individual attempts to resolve the contradiction using various steps and tools. Thus, resolving contradiction is the central element in critical thinking (Al-Sayed, 1995).

These findings demonstrate that critical thinking depends on five basic elements. The existence and collaborations of all the elements are crucial to the critical thinking process. Basic knowledge is important to realize contradiction, whereas external events are stimuli for sensing contradictions. Personal outlook directly influences the ability and degree of sensing contradictions. The momentum for building the sense of contradiction results in directing the individual to resolve the contradiction.

![Figure 2.2. Five elements of critical thinking](image)

2.3.5 Steps of Critical Thinking

Critical thinking is applied through six sequential steps.
2.3.5.1 First Step: Motivation

Motivation includes the following commands: (1) desire for enhancing knowledge, (2) acquaintance of thinking processes, (3) awareness of thinking stimuli, (4) investment of time and effort, (5) curiosity, (6) objectivity, and (7) personal skills. Motivation is the driving force for seeking knowledge and understanding of events by asking questions and a high level of curiosity.

2.3.5.2 Second Step: Pursuing Information

Pursuing information is considered an outcome for basic knowledge and previous experiences, which enable the individual to resolve contractions. Pursuing information requires several activities: (1) attention, (2) knowledge of principles, (3) identifying contradictions, and (4) ability to use resources.

2.3.5.3 Third Step: Associating Information

Associating information is the employment of definite information and includes the following commands: (1) compiling data, (2) sorting of information, (3) logical inference, (4) setting of premises, (5) asking questions to identify a weak area, (6) setting procedures and application of principles to resolve contradictions, (7) creative thinking to identify classical and innovative relations in the data.

2.3.5.4 Fourth Step: Assessment

Assessment is established by three tracks: (1) temporary solution to the contradiction, (2) assessment of the outcome and its association to the contradiction, (3) acceptance of the solution after self-validation of the outcome.
2.3.5.5 Fifth Step: Presentation

In this step, the individual announces his or her solution, receives criticism, and then modifies the solution based on the given input and new information.

2.3.5.6 Sixth Step: Integration

Integration occurs at the end of the activity. This step involves the integration of basic knowledge with new and modified information. The individual may respond by “I understand,” which signifies his or her satisfaction with the acquired information. The individual stays satisfied until he or she faces a new contradiction, a time in which the creative thinking process is reinitiated by employing the first step of critical thinking.

2.3.6 Enhancing Critical Thinking

In the last few decades, psychologists and education experts started focusing on critical thinking, which is viewed as an important educational principle. Critical thinking promises a proactive advancement of knowledge and assures that individuals seek their highest thinking potential, which can be applied for positive interactions with their environment. Most educational studies indicate that good thinking skills cannot be acquired through traditional learning processes such as memorizing and recalling of the information. In other words, critical thinking is a process that does not develop without intervention because it is not a natural outcome of experience (Al-Mane’a, 1996).

Critical thinking skills are life skills needed by all individuals in society. Many applied research projects that focused on the enhancement of critical thinking
skills indicated that critical thinking skills can provide the following benefits: (1) result in better and deeper understanding of the knowledge by the learners, (2) lead to emphasizing independent thinking, (3) decrease the student’s self-centering, (4) increase the student’s optimism, (5) promote research and eagerness to learn, (6) refusal to accept unsupported arguments or information that has not been inspected, (7) strengthen the ability to debate, (8) enhance the value of school experiences and encourage teachers to be more proactive, (9) increase the ability of students to solve their problems and make necessary decisions, and (10) result in an overall increase in the student’s self-confidence and self-respect.

In summary, critical thinking skills are important and essential in our fast-changing world. Critical thinking skills can promote proactive involvement in society and can provide students with experiences that can acclimate them to the necessities of life. Critical thinking skills can assist students in pursuing long-term success by preparing well-rounded citizens who can make good, free choices and decisions. The preceding reasons show that critical thinking has great value and that education experts should give it the importance that it deserves.

2.3.7 Characteristics of a Critical Thinker

According to Jarwan (1999) and Katamy (2004), the main characteristics of a critical thinker include: (1) open to new ideas, (2) argues in an unfamiliar topic, (3) seeks more information, (4) constantly inquires about unreasonable and unclear issues, (5) attempts to separate emotional and logical thinking, (6) able to make a decision or change his or her stand with arising evidence, (7) gives attention to all aspects of the issue, (8) attempts to avoid common errors in his or her analysis, (9) uses and relies
on dependable scientific resources and is careful in referencing them, (10) very selective in his or her vocabulary and other means of expression, and (11) stays connected to the central point of the topic.

2.3.8 Previous Studies on Critical Thinking

Critical thinking is one of the most important educational issues because it is an essential feature for achieving advancement and success in the twenty-first century (Al-Hadaby, 2012). In addition to this importance, critical thinking is viewed as a knowledge base that can lead to processes of solving problems efficiently and making proper decisions (Ajwah & Al-Bana’a, 2000).

In considering these issues, the development of critical thinking and training individuals have become an inevitable necessity and a legitimate civilized demand. The need for the development of critical thinking is important because it is useful to the learners and society (Al – Rafei, 2012). However, students’ possession of abilities to perform critical thinking is not sufficient because they should know how to use these abilities and how to apply them to their knowledge and emotions. These abilities enable a student to observe his or her own thoughts thereby translating his or her critical abilities into behavior inside and outside of school (Norris, 1985). A plethora of research examined the development of critical thinking in association with other variables. Some of these studies are reviewed below.

Salah (2016) investigated the extent of the effectiveness of an intervention program based on the development of critical thinking skills. Salah employed this intervention program to 64 male and female seventh grade students. The critical thinking skills of students in the experimental was extensively improved. This
finding was evident in the delayed test given to the students in the experimental group. Salah (2016) examined the effect of using Web Quest in developing critical thinking skills by teaching science. The study employed a quasi-experimental research design to 20 sixth grade students. The study revealed statistically significant differences in the skills of critical thinking, especially in the delayed test.

To examine the effectiveness of de Bone in the development of critical thinking skills among gifted students in secondary schools, Abdulhameed (2015) used Cognitive Research Trust 3 (CORT3), which was proposed by Edward de Bone. The sample included two groups of students (control and experimental) who were homogeneous in age, intelligence, and critical thinking skills. Each group consisted of 25 gifted students whose ages were between 16 and 17 years. The instrument used in the study was adopted from Watson’s questionnaire for critical thinking skills. The study revealed an obvious improvement in the critical thinking skills of students. With respect to the variable of students’ grade or class, the study found no statistically significant differences in the levels of critical thinking among students.

Alhaddabi (2012), explored the availability of critical thinking skills among gifted students in secondary schools in Sana’a and Taiz, two large cities in Yemen. Using Watson’s instrument, they measured critical thinking skills among 121 students and found that the critical thinking skills of students in these two Yemeni cities did not reach the acceptable educational standards.

Nasr Allah (2015) thinking maps strategy in the development of critical thinking and the process of studying the sciences among 70 tenth grade students. The results showed statistically significant differences between the experimental and control groups. Al-Tuwaiji, (2015) investigated the achievement of 25 students in
physics and its relation to critical thinking among gifted and outstanding first-year secondary students in Aden City in Yemen. The study revealed that the achievement of gifted students exceeded 60, which is the acceptable educational standard.

In an exploratory study, Rajoub (2015) focused on the effectiveness of a training intervention program that intended to train teachers of science on active learning; this training helped eighth grade students acquire scientific concepts, develop critical thinking, and enhance their attitudes toward learning. Al-Ragoob reported statistically significant differences in the levels of critical thinking for the experimental group.

In Riyadh, Saudi Arabia, Al-Shalabi (2015) examined the effect of the Six Hats program on students’ achievement and the development of critical thinking skills of 60 eighth grade students in a science subject. The study employed a quasi-experimental research design that included two groups, namely, control and experimental. The study reported statistically significant differences in the skills of critical thinking as a whole, except for the skills of knowing the hypotheses.

Al Awamleh, Hamdi and Al-Srour (2016) investigated the effect of right intelligent system of knowledge (RISK) program in developing creative and critical thinking skills. This program was employed among a group of students in primary schools in Jordan. The sample included 53 tenth grade students. The results showed that students in the experimental group displayed statistically significant differences in the development of critical thinking skills. This finding was attributed to the intervention program. In another study, Nasr Allah (2014) studied the effect of using role play in the development of critical thinking skills by teaching science. The results of the study showed statistically significant differences between the
experimental and control group in relation to critical thinking of the experimental group.

Al-Asmari (2014) examined the levels of critical thinking skills among gifted students in secondary schools. The study also explored the differences in critical thinking skills in relation to students’ grade or class and gender. Al-Asmary used Watson’s test on a sample of 106 gifted students. The results showed that student’s abilities in using critical thinking skills did not reach the acceptable standard of 60%. The study revealed that female students showed statistically significant differences in reasoning and deduction skills. However, male students outperformed female students in the skills of interpretation and evaluation of arguments. Regarding gender, reports showed no statistically significant differences in critical thinking skills. Furthermore, no statistical significant differences were reported with respect to class.

Al-Subaie (2014) examined the level of critical thinking skills and the grade measurement among high achievers in secondary schools. Al-Qassas employed exploratory descriptive approach using Watson’s test. The study revealed that the mean of critical thinking skills was 91.55, which is 61.003. In addition, the study revealed a positive correlation between the skills of a critical thinker and learning achievement.

Harrahsha (2014) identified the influence of an intervention educational program based on the development of critical thinking skills by teaching science and motivation toward learning among students in primary schools in Jordan. The sample consisted of 62 female students. The results showed statistically significant differences in the test for critical thinking skills for the experimental group. In
another empirical study, Shana (2014) examined the effectiveness of a proposed intervention program on the development of critical thinking skills among a sample of students of psychology at the University of Batna. The study used the experimental method and showed statistically significant differences in the critical thinking scale, which reflects the effectiveness of the proposed intervention program.

Al-Haddad (2014) investigated the effect of using a proposed strategy on the development of critical thinking skills and the level of achievement of 10th grade students in the subject of general science. The researcher followed the experimental research design and found statistically significant differences between the average scores of female students in the experimental group and the average score of students in the control group. This finding was reflected in the post-test results of female students in the experimental group.

In Gaza, Hadi Al-Mutawaq (2013) focused on the influence of the use of Jigsaw strategy on the development of critical thinking skills and eighth-grade students’ attitudes toward science. Al-Mutawaq used the experimental research design, and the sample of the study included 158 students who were selected in a deliberate sampling. The sample was divided into two groups: a control group and an experimental group. The Jigsaw strategy was used in teaching the experimental group, but the traditional method of teaching was employed for students in the control group. The results showed a statistically significant difference in the selection of critical thinking in favor of the experimental group.

Agha (2013) identified the effect of the employment of the Fish Bone strategy in the development of scientific concepts and critical thinking skills in health and environmental sciences among 70 primary school students in the 10th grade. The
researcher used descriptive and experimental research designs. The study revealed statistically significant differences in favor of the experimental group. Al-Ja’aferh and Abd-Al-Kharabsheh (2007) focused on identifying the degree of gifted students’ critical thinking skills in Ubeel, Jordan. The sample included 94 students in the 11th grade. Surprisingly, the study revealed low achievement of students in critical thinking skills as a whole and for each skill. In addition to this finding, the study showed no statistically significant differences between the mean scores with respect to gender and students’ grade or class.

In Jordan, Khalaf (2007) assessed the level of critical thinking among three groups of students, namely, gifted students enrolled in special education programs, high achieving students, and ordinary students. The results showed that the level of critical thinking of the three groups was generally low and that the average performance of high achieving students was higher than the average performance of gifted students enrolled in special education programs. The study also revealed that the average performance of gifted students was higher than the average performance of ordinary students. Jarwan (2006) focused on identifying the effects of a program by solving problems on the development of critical thinking skills and creative talents in the leading centers. The results showed no statistically significant differences in favor of the experimental group).

Redwan’s (2000) study attempted to identify the effectiveness of a study program in developing critical thinking skills for a sample of 50 female and male students studying at the science branch of an elementary school in Ein Shams, Egypt. The main strategy in Radwan’s program was the analysis of reports within a competitive setting and the integration of critical thinking skills. Radwan’s program
included a chapter that presents environmental issues. Radwan’s study group took a pre- and post-assessment. The test used for the assessment was Cornell’s critical thinking test. In the analysis, Radwan found discriminating statistical evidence between the pre- and post-tests. The analysis showed that each of the critical thinking skill improved with the application of Radwan’s program. Based on the findings, Radwan recommended the reform of curriculum of the schools in all its stages to target the development of students’ critical thinking skills.

Abdul Ghani (2002) studied the effect of teaching critical thinking skills as part of the mathematics and computer curriculum on the attainment of critical thinking skills in particular and thinking abilities in general. For the assessment of the program, Abd-Algany used Torrance’s creative thinking assessment and Watson’s critical thinking assessment. The findings of the study indicated a significant statistical relationship between her program and the development of critical and creative thinking skills. Abd-Algany recommended that educational programs should provide offerings that can discriminate individual abilities; such programs should include new teaching methodologies that promote the development of students’ thinking skills.

Talib et al (2009) evaluated learning strategy and the enhancement of critical thinking on the students’ achievement in physics. Taleb used a practical approach, and his study was conducted on experimental and control groups. Taleb designed an achievement assessment and also used Watson’s critical thinking assessment. The results of Taleb’s research indicated a significant statistical difference between the experimental and control groups in the post-assessments. The result included Taleb’s
designed achievement and Watson’s assessments. Taleb recommended the necessity of assessing the critical thinking abilities of secondary school students.

Amin’s (2008) study investigated the implementation of exchanging of roles strategy in the development of critical thinking and student achievement in history subjects. In addition to Watson’s assessment, Ameen assessed students using a method she developed. The result of the study showed significant differences in the average scores of the assessments between the experimental and control groups. Differences were observed in the overall scores of Watson’s assessment and those in Watson’s activities, wherein the experimental group scored higher than the control group. Ameen concluded her research with multiple recommendations. She offers the following recommendations: (1) the importance of incorporating collaborative learning in schools, (2) training teachers on using and implementing different strategies for critical thinking in their classes, and (3) conducting further research on the thinking process in general and on critical thinking in particular.

Al-Hury (2009) conducted a study to investigate the effect of using Monrow and Aslater’s strategy and McCferland’s strategy on developing critical thinking skills in history topics. The sample of the study consisted of 209 female and males students, who were divided into experimental and control groups. The researcher used California achievement test to measure critical thinking skills. The findings of the study indicated statistical differences between the results in favor of the experimental and the control group. The experimental group was trained using Monrow and Slater’s strategy. The researchers recommended the importance of creating a suitable classroom environment that stimulates students’ critical thinking and designing programs that teach critical thinking.
Helat (2009) investigated the effect of learning historical events on the development of critical thinking of tenth grade students. The study included a sample of 165 female and male students. The researchers used Watson’s critical thinking assessment to measure the effect of their training. The results showed significant differences between the experimental and control groups in favor of the experimental group, which scored higher than the control group in the overall Watson’s assessment and in each of its five categories. The researcher recommended that further studies on thinking processes are needed, particularly in critical and creative thinking.

2.4 Problem Solving

2.4.1 Definition of Problem Solving

Problem solving is a thinking process used by individuals upon facing a problem or a challenging situation. The purpose of problem solving is to find solutions to a problem or a challenge. Facing problems and challenges is considered a frequent, dynamic event that individuals face during their development and interactions. The necessity of problem solving becomes important when the individual faces a problem that can significantly affect his or her life. Problem solving is also initiated when a previous solution to the problem fails or comes short of resolving the issue completely.

Problem solving is important on the individual and social levels. On the one hand, it can improve the ability of an individual to adapt to the changing situations and provide him or her with tools to conquer the problems or challenges. On the
other hand, it is important on the social level because it can drive the advancement and development of the society in social and technical aspects.

Problem solving skills depend on using a logical, systematic manner of thinking. The stages for resolving a problem are: (1) understanding the problem, (2) collecting pertinent information, (3) envisioning a plausible solution, (4) balancing and assessing the potential solutions, (4) executing the solutions, and (5) assessing the solution’s effectiveness in resolving the problem (Dawood & Hamdi, 2004).

A problem can be defined as “the potential to improve.” Therefore, most gifted and talented students seek problems rather than avoid them (Harris, 2011) because they have basic knowledge that can identify the deficiencies and potential areas for improvement.

Ormond (1995) viewed the problem as a situation that requires treatment or preparation to suit a certain use or application. Problem solving requires the connection between basic knowledge and the elements of the problem to establish an outcome. An outcome can range from simple to complex according to the type of the problem and its complexity.

Many people think that problem solving is equivalent to removing these problems in such a way that the problem ceases to exist. This view is not reasonable. Many problems cannot be eliminated. For example, the complete removal of dust and disease is not realistic. Problem solving signifies the processes that can help diminish or cope with the problem. Problem solving can also be viewed as the attempt to score in a situation, where achieving such goal is not possible (Harris, 2011).
Krulik and Rudnick (1980) defined problem solving as a thinking process that an individual employs based on his or her acquired previous knowledge and skills to respond to an arising, unfamiliar situation. The response aims to formulate a method that attempts to resolve the ambiguity and confusion of the problem. Lee (1999) views the problem as a new, dynamic situation that requires treatment, preparation, making a decision, or formulating a plan.

Problem solving is important because problems constantly arise; in many cases, the situation demands that the individual quickly make decisions, which can have a significant influence on an individual (Abo-Asaad, 2009).

Problem solving can be applied to the learning process of students. In such a case, problem solving skills allow the student to reform his or her role in the educational process. This scenario is attributed to the fact that problem solving can assist students to become proactive. Problem solving skills can also teach students to organize their experiences and establish improved learning. In general, problem solving greatly affects the education of the individual (Ibrahim, 2003).

Several methods are used for problem solving, which can vary significantly; these methods include trial and error, discovery, following systematic processes, data correction, and extrapolation (Jarwan, 2010).

Knowledge is versatile. Thus, teaching students different methods for problem solving is important. Problem solving is an essential skill on the academic and personal levels. This skills can increase the knowledge of the student and can lead him or her to be independent. Moreover, it can assist the individuals in making well-calculated decisions, which can manifest the control of the individual over
arising problems and challenges. Problem solving puts the student in a real-life situation that aims to balance his or her knowledge.

2.4.2 Problem Solving Stages

Problem solving consists of six stages.

2.4.2.1 First Stage: Sensing of Problem and Overall Direction

In this stage, the individual realizes the problem and seeks to resolve it in a systematic and logical pattern. In addition, the individual becomes aware of the inhibitory factors that prevent him or her from reaching a resolution or desired outcome.

2.4.2.2 Second Stage: Outlining the Problem and Data Collection

The individual states the problem using finite, simple, accurate words, which results in the creation of the general outline of the problem. Ibrahim (2003) identified three elements that can influence the outline of the problem:

1. Personal factors: unique and personal aptitudes, self-perception, emotion, and morals

2. Environmental factors: describes the effect of the environment and surroundings on the problem’s complexity and tracts. This element can include the interconnection and relation of the problem to other individuals and their influence on the problem.

3. Factors related to the problem itself: includes the nature of the problem and its volume.
Outlining the problem requires an individual to define the primary and secondary elements of the problem. In this stage, the individual should concentrate on the primary elements of the problem while excluding the elements that are not directly linked to the problem.

In outlining the problem, the individual should mainly collect data pertaining to the problem. In the initial phase, he or she should collect data by asking himself or herself the following questions: Why is this issue a problem? How does it influence me? What are the consequences of the persistence of the problem? How do I feel about the problem? What incentives do I have in changing the situation? Do I have any anxiety from the intended changes? How confident am I on my ability to execute the necessary changes?

Data collection also necessitates the individual to seek to investigate available resources that can help understand, analyze, and resolve the problem. The resources can be in the form of books and consultations with friends, teachers, or family (Dawood & Hamdy, 2004).

2.4.2.3 Third Stage: Construction of Hypotheses and Solutions

The construction of hypotheses and solutions is generally based on logical premises or evidence in the problem, which can be obvious or concealed within the problem. This stage is also linked to the personal experiences of the individual. Furthermore, it is strongly influenced by the basic knowledge of the individual, which can be retrieved and employed to assist in formulating as many plausible, potential solutions as possible (Dawood & Hamdy, 2004). The roles of the teacher in promoting this stage include the following:
1. Training students to think in all aspects and of the possible solution to the problem
2. Providing students with extra resources that can assist them in generating alternative solutions
3. Discussing the potential alternatives and reform and improving them
4. Encouraging students to generate alternatives without evaluating them

Dawood and Hamdy (2004) view the students’ role in the construction of hypotheses and solutions as a means to train the students on differentiating and appropriating different hypotheses and solutions. This role includes the following:

1. Searching for multiple, alternative solutions using available resources, such as books and experiences of others.
2. Choosing a suitable solution from the different possible solutions. The student should explain the reasoning for his or her selection of this particular solution.
3. The student should execute and evaluate the selected solution.

**2.4.2.4 Fourth Stage: Balancing Alternatives and Making Decisions**

In this stage, the individual compares the different potential alternatives of the solution and selects only one solution. The individual should be able to discuss and debate the reason for his or her selection of a particular solution. The individual should restate the solution to provide strong, accurate depiction of the solution and most importantly to formulate the solution with an embedded rubric for later evaluation.
Formulating alternative solutions may be difficult. Instead, a new, out-of-the-ordinary solution is needed. Creative thinking strategies should be engaged to achieve a new solution. One of the most applicable creative thinking strategies for the formulation of a new solution is brainstorming, which can be applied on the individual or group level.

Brainstorming enhances the thinking process and abilities and can help in solving scientific and general life problems. The main goals of brainstorming are: (a) generating creative solutions to a problem, (b) creating contradictions and challenges to opponents, and (c) identifying other problems and creating new projects. The stage of brainstorming are identification of the problem, generation of ideas, and finding a solution. According to Dawood and Hamdy (2004), brainstorming employs two basic strategies:

1. Postponing the evaluation of ideas: In this strategy, the participants are encouraged to present their ideas during the brainstorming session without any judgment or evaluation of the presented ideas. The idea is to create an atmosphere that encourages individuals’ participation and involvement without imposing any kind of prejudice. In such a setting, every participant’s idea is valued. Hence, individuals become highly engaged and responsive.

2. Increasing quantity can lead to better quality: This strategy stems from the associative school concept of “quantity leads to quality.” This rule organizes the ideas that are generated during a brainstorming session in a pyramid. Common ideas are generated in high numbers and constitute the base of the
pyramid, whereas innovative ideas are the least in number and are represented by the pyramid’s apex.

2.4.2.5 Fifth Stage: Establishing Execution Strategies

A plan for executing the selected solution is prepared in this stage. The plan should integrate all decisions and points that were agreed on. Moreover, it should include a detailed, technical description of the different tasks, assignments of the tasks, time frame for the execution of the solution, and procedures for the assessment of progress (Dawood and Hamdy, 2004).

2.4.2.6 Sixth Stage: Assessment and Reevaluation

Assessment should be conducted in every stage of problem solving. Challenges can occur in the sensing of problem, data collection, construction of the solutions, making decisions, or execution. After a challenge is identified at any stage, a problem solving strategy should be reevaluated. Assessment involves identifying concerns and finding strategies to avoid such challenges within a short time frame.

Assessment is based on the findings of experimental application or validity of the presented solution. However, result on comparable cases with similar variables can be generalized. Generalization is also possible for cases with similar relations between the variables (Ibrahim, 2003; Abo-Asad, 2003).

Guilford (1996) presented a simplified model for problem solving based on the theory of structure of intellect (SI). Guilford named his model “the structure of intellect problem solving model.” This model includes creative thinking at the stage of the generation of ideas and of finding solutions from the individual’s base of
knowledge. Guilford also considers creative thinking as the driving force for evaluation and depends on eliminating the alternatives to arrive at an original idea or a new solution (Jarwan, 2005).

2.4.3 Problem Solving Strategies

Al-Kanany (2003) compiled the following strategies:

1. Standard problem solving strategy: This strategy involves the employment of all of problem solving stages but within the standard, ordinary thinking style.

2. Creative problem solving strategy: This strategy requires a high level of sensitivity in identifying the problem and making inferences and relations in an extraordinary manner. This strategy includes the application of non-classical methods to achieve outstanding, creative results.

2.4.4 Development of Problem Solving Conduct

Al-Atoom (2004) mentioned several elements that can enable the individual to bypass the problem. These elements include the following:

1. Estimating the size of the problem: Knowing the size and components of the problem before attempting to find solutions is beneficial. Knowing the size of the problem can give insights into the breadth of the problem and its implication. The individual is efficient in identifying the needed resources and tools. This scenario prevents any element of surprise that can impede the quest for solutions. Instead, it can direct the individual to seek the right conditions and resources.
2. Outlining solutions: The establishment of more than one solution to the problem is recommended to help an individual in selecting the best-fit solution and to provide alternative solutions in case the chosen solution fails.

3. Recalling of information: An individual’s ability to recall a good amount of information from his or her knowledge base or from previous experiences can assist in assessing the problem and evaluating possibilities before any decision is made about the problem.

   Some of the supportive procedures for recalling information are the detailed documentation and the tabulating of events and experiences. These procedures enable the individual to compare the current problem and previous experiences.

4. Searching for key ideas for solutions: Finding key elements for the solution can direct the individual toward better results and can provide a road map for the construction of the solution.

   The key elements can also function as indicators for sensitive areas within the problem.

5. Training on generating multiple solutions: This element is crucial as the sole solution for a problem may fail to work. Thus, it is important to have multiple alternatives.

6. Sensible motivation and realistic outcome: The feeling of being over or under-motivated can decrease the success rate of the solution.

   The individual should maintain an appropriate objectivity and readiness to generate suitable, high-quality outcomes.
2.4.5 Previous Studies on Problem Solving

Qasim (2013) investigated the effects of a training program based on the theory of TRIZ on solving problems creatively among male and female teachers of mathematics. The results of the post-test showed statistically significant differences, which are a clear indication of the obvious effect of the training program. This program was based on the TRIZ theory on solving problems creatively by the teachers of mathematics. Buluc et al. (2010) found a specific directory for the levels of problem-solving skills, which increases when a student progresses through the years of study.

Mansour (2007) explored ways of thinking and their relationship with solving problems among a sample of sixth grade students in a primary school in Damascus. An important finding of the study shows no statistically significant correlation between some ways of thinking used by students and their performance in problem solving skills.

Selçuk et al. (2007) identified the extent of using strategies of problem solving by teachers of physics on their students. The study also examined the effect of these strategies in relation to students’ gender and grade or class. The sample included 141 students in all levels and grades. Data analysis reflected that the problem solving strategies increased with higher levels.

Qaraan, (2013) studied the effect of a behavioral counselling program on the development of problem solving skills of academic advisors in Jordan. The experimental group showed differences in problem solving skills, which could be attributed to the intervention program. Al-Nawwab (2013) identified the effect of a program intended to teach students on using thinking to solve problems and to
improve academic achievement among primary school students. The results revealed that the employed intervention program had an effective influence on solving problems.

In 1996, Ganem conducted a study entitled “Strategies for Problem Solving” involving three groups gifted and talented students, high achievers, and low achievers. The students were 10\textsuperscript{th} graders from both genders. The total number of students was 60, which was divided equally among the three groups. The study findings indicated that the problem solving strategy mostly employed by gifted and talented students were continuing activities, planning for solutions, establishing hypotheses and strategies that depend on self-activism, making decisions, and evaluating the solution. The strategy employed by high achievers consisted of identifying the problem, making relations and connections, and comparing positive and negative outcomes. Low-student achievers approached the problems negatively and they mostly applied repetitive reading. Among the three groups, the type and nature of the problem had a direct effect on the employed problem solving strategies.

Al-Adel and Abd-Alwahab’s (2002) investigated the relationship between problem solving and background knowledge of an individual within groups with varying mental abilities. The study assessed the problem-solving abilities of gifted and talented students and average students based on their background knowledge. The sample of the study consisted of 326 students from both genders (120 males and 116 females). Researchers used the High Intelligence Test and Abilities of Creative Thinking test prepared by McClelland (1973). They also used their own tests, namely, Academic Achievement, Assessment of Problem Solving, and Background Knowledge Skills. They tested the result using various statistical methods. The
results confirmed (a) the relationship between problem solving abilities and background knowledge, (b) that problem solving abilities and background knowledge are personal mental processes, (c) the advancement of gifted and talented students in problem solving, (d) the significant differences in the relations between students’ problem solving abilities and the conscious use of review and evaluation, (e) the effect of personal factors on the scores of students in all of the assessments used except for review and evaluation, (f) the effect of students’ mental abilities on the students’ scores in all the assessments, and (g) the statistically significant differences between genders in problem solving in favor of male students.

Maliha (2003) investigated the relationship between short and long-term memories and problem solving. The study sample consisted of 920 10th grade students. The researcher used three assessments:

(a) Short-term Memory Test: This test consisted of two lists. The first list contains 10 Arabic general words, whereas the second list contained 10 foreign names.

(b) Long-term Memory Test: This test involves a story about two competing soccer teams. The story includes 10 unusual Arabic names to increase the level of difficulty in remembering them.

(c) Problem Solving Ability Test: This test was prepared by the researcher and consists of eight problems with varying complexity levels from 10th grade mathematics curriculum.

The statistical analysis of the study findings revealed the following. (a) No relationship exists between the average scores of the students in short-term memory and the problem-solving abilities of students. (b) A relationship exists between long-term memory and the problem-solving abilities of students. (c) A correlation exists
between students’ scores in the Problem Solving Ability Test and the overall scores in short- and long-term memory tests.

Zins et al (1996) performed a study entitled “The Improvement of the Problem Solving Skills for the Individuals Requesting our Consultation.” The researcher conducted theoretical analysis of consultations and concluded that consultation may assist the individuals in problem solving. However, the individuals must acquire new skills that can increase the effectiveness of their problem solving process.

The researcher also concluded that direct training is of crucial importance to direct individual behavior and personal communications, all of which can increase the ability of problem solving.

Cornwell (2001) studied the effect of revealing personal psychological intelligence testing on problem solving, especially personal problems. The logistic of the study was to deliver the strong and weak abilities of an individual. The researcher then presented problems to the individual and suggested solutions and strategies for their resolution. The researcher then asked the individual about his or her opinion in the offered solution and then asked him or her to come up with other solutions.

In this way, the individual is promoted to apply his own resolution to the problem. After analyzing the findings, which included the analysis of consultees’ work and responses, the knowledge of personal strengths and weaknesses increased the awareness of the individuals and assisted them in seeking the suitable strategies for problem solving.
2.5 Critical Thinking and Problem Solving

Several studies support the fact that critical thinking is a crucial element for problem solving. Moreover, a positive correlation exists between critical thinking and the ability of the individual to perform problem solving (Farraj, 2006).

The multifaceted effect of critical thinking enables a student to: (1) understand the opposing opinions to his or her own and reevaluate his or her own virtue of thinking; (2) maximally use new methodologies, technological tools, and various methods of communication; (3) excel in his or her various study subjects; (4) practice self-learning; (5) enhances the ability of the student to inquire (Al-Halaq, 2010).

Critical thinking enables the student to examine the logistics and truth of the hypothesis and to evaluate the suitability of suggested solutions. Critical thinking is not the same as problem solving; the purpose of critical thinking is to find solution to a problem, but unlike problem solving, this approach compares opinions, ideas, and possible solutions (Abd-Alsalam, 1982).

Ennis stated two differences between critical thinking and problem solving, namely, the start and end of the processes. Critical thinking starts with a claim, an idea, or a conclusion, and ends in reaching a consensus on the value and truth of the claim, idea, or conclusion. Critical thinking asks: What is the value and truth of the thing? The problem solving process starts with the existence of a problem. The problem solving process revolves around the question: What is the solution to the problem? Problem solving ends in finding a solution that aims at solving the investigated problem.
Abu Sneineh (2002) examined the effect of using a method for solving problems on the achievement and development of the critical thinking of students at the Faculty of Educational Sciences (Alanothora). The study employed a quasi-experimental research design with experimental and control groups. The study showed relevant statistically significant differences in the achievement of students in the experimental group on the achievement test and problem solving skills.

Buluc et al. (2010) addressed critical thinking and problem solving skills among university students in training them to become elementary school teachers. The study did not found a statistically significant relationship between problem solving skills and academic level skills. However, the study found statistically significant differences between males and females in critical thinking and problem solving skills in favor of females.

In the search of Hambur et al. (2002) for critical thinking and problem solving skills, they reported that the performance of younger students was statistically significant because it was better than that of the older ones. They reported a medium statistically significant direct relationship between critical thinking and problem solving.

Ayoub (2014) investigated the relationship between critical thinking and both problem solving skill and academic achievement for students at Imam Muhammad bin Saud Islamic University. The results revealed a statistically significant but a weakly positive relationship between critical thinking and problem solving skills.

Hambur et al. (2002) evaluated the cognitive skills (critical thinking and problem solving) of graduates and found significant differences in gender; they found that male students performed better than female students in problem solving.
They also found that students’ performance has a statistically significant relation with age. Furthermore, the performance of young students is better than that of older students.

The study also reported that the type of specialization was related to students’ performance. Medical and engineering students performed better in problem solving than students in other majors. The level or grade of students had statistical significance. Students in high levels of study performed best in all areas of the test. The study also found a medium positive relationship between critical thinking and problem solving skills. Furthermore, the study showed a medium statistically significant direct relationship between each of the critical thinking skills and problem solving skills in cumulative grade point average.

Friede, et al. (2008) aimed to study the statistical relationship between critical thinking and problem-solving among a sample of 152 students. The results showed a weak statistical relationship between critical thinking and problem solving skills.

Tumkaya et al. (2009) examined the abilities of university students to perform critical thinking and problem solving skills. The sample included 353 students, who were divided into two groups: 204 social college students and 149 students from the Scientific College. A total of 50% of the sample were females. The study showed a statistically significant but weakly negative relationship between critical thinking and problem solving skills. This study found statistically significant differences between males and females in critical thinking and problem solving skills. Furthermore, it found significant differences between the type of study (scientific and social) in relation to critical thinking in favor of students in social sciences. However, the study
reported no statistically significant differences between students in the social sciences colleges and sciences colleges.

Yenic (2011) investigated the differences between critical thinking skills and problem solving skills in relation to some other variables among teachers of science who did not join in the workplace (graduates of the College of Education). The results showed no statistically significant differences between problem solving and critical thinking skills in relation to gender and level of study.

2.6 Thinking Program

Programs that focus on thinking include CORT Program, Scamper Program, TRIZ Program, Six hats Program and Al-Madinah Program. The researcher mentioned these programs.

2.6.1 SCAMPER program

SCAMPER program was developed by Bob Eberle in 1997. It includes various games that enable students to improve their creative thinking. Technology enemy, for one, uses a set of directives, the idea of stimulating questions suggest some addition to, or modify something that already exists. He also received a lot of attention as a learning tool promotes awareness, drive, fluency, flexibility and originality. Motivation comes from requests to respond to inquiries from would constitute one does not usually. The changes that the enemy stands for the following: (1) S: Alternative (for example, components, materials and people), (2) C: combining (e.g. mixing, combine with boards or other services, and integration), ( 3): Air (for example, change, job change, use part of another element), (4) M: Increase /
modification (for example, increased or reduced in size, and change shape, modify attributes), (5) P: Put to other uses (6) E: elimination (for example, and remove items, and simplify and cut to the core) functions, (7) R: Rearrange / Reverse (for example, the inside turns to the outside or upside down.

2.6.2 CORT Program

The CORT program developed by De Bono (1971). The CORT program consists of six teaching components that cover many thinking aspects. Each component includes 10 lessons, each designed to be covered in approximately 45 minutes. The program can be applied to students aged 8–22 years. Below is the description of the six components listed by Jarawan (2008).

(a) “Breadth.” This unit refers to students’ thinking and training of all aspects of a situation in any available method(s). This unit is concerned with the results of each test in comparison with the achieved objectives. In this regard, De Bono suggests that this unit should be taught at the beginning of the program, whereas the other units can be taught later.

(b) “Organization.” This unit focuses effectively on a situation and directs the students’ attention toward this situation in an organized manner.

(c) “Interaction.” This unit is concerned with the issues related to some necessary logical evidence.

(d) “Creativity.” A number of strategies are presented in this unit. Such strategies are used to create, evaluate, and review thoughts.
(e) “Feelings and Information.” This unit is concerned with the factors of excitement that influence the process of thinking.

(f) “Action.” This unit presents a general frame for obtaining problem solutions by connecting the strategies presented in previous lessons to one another or separately.

The program is applicable and independent because it can be separated from the contents of a teaching syllabus, and indeed this application is the direction of De Bono. The program provides benefits that can support the studying of teaching syllabi by testing the situations and the problems of the contents of such syllabi (De Bono, 1996).

2.6.3 AL-Madinah program

AL-Madinah program was designed by Abdeen & Zuri in 2015. The development of AL-Madinah-Program integrated the vision, objectives, scientific model, content, procedures, evaluation, and application.

The vision of AL-Madinah-Program is directed toward elevating the specific talent disciplines of talented students through the development of creative thinking abilities. The scientific model of AL-Madinah Program was based on four modern educational and talent theories: (1) successful intelligence theory; (2) concurrent theory; (3) brain-based theory; and (4) need for achievement theory. The development of AL-Madinah Program integrated three aspects: (1) the cognitive process; (2) sentimental processes; and (3) A-Madinah Program strategies. The AL-Madinah Program strategies are comprised of five strategies: (1) brain power; (2)
creative acceleration; (3) synchronization; (4) self-generating; and (5) exploitation. The AL-Madinah Program strategies are directly linked to the educational and talent theories (Abdeen & Zuri, 2015).

Each of the AL-Madinah Program strategies is the foundation for creating specialized activities that targets stimulation and development of all the categories of creative thinking abilities. The second aspect in the development of AL-Madinah Program development is the sentimental process, which concentrates on building positive internal force that is directed toward enforcing trust, ambition, and perseverance. This aspects was integrated in all the activities of the AL-Madinah Program (Alherbawi, 2016). The third aspect in the development of AL-Madinah Program is the cognitive process, which were used to support the development of creative thinking abilities (Alaswad, 2017).

2.6.4 Six Thinking Hats

This program was developed by De Bono (1997), to explain and simplify thinking and make it more efficient. By using this program, a person does one thing at a time. He moves from one thinking pattern into another. The six hats of different colors are a means that the individual uses at all times during his life. The hats emphasize that thinking is a multi-process. The six hats are as follows: (1) white hat, which represents objectivity and shows results without interest in explanations; (2) red hat, which represents emotions and keeps logic and justification away; (3) black hat, which expresses a negative evaluation; (4) yellow hat, which expresses positive
and productive thinking; (5) green hat, which signifies creative thinking; and (6) blue hat, which is the controlling hat of all hats.

The six hats are the main components of the thinking map. For example, a person wearing the sad hat, he should act sadly while he should act happily when he wears happy hat. This rule applies to the remaining hats. All hats are used in a role-play. De Bono (1997) supposed that broad thinking has a large thinking hat partitioned into six hats or six different roles of six colors. A person using these hats puts on the suitable hat to play the role. Therefore, anyone wearing a hat has a goal. Thus, each individual is considered a planner and a thinker. Accordingly, he does this for a purpose (Suror, 2003).

2.7 Theories on Critical Thinking

2.7.1 Bloom’s Taxonomy of Learning Domains

Bloom categorized human thinking abilities into six domains (Figure 2.3): a) recalling or remembering, b) understanding, c) applying, d) analyzing, e) evaluating, and f) creating. Bloom’s learning domains are arranged in ascending order of complexity, with the simplest learning domain being recalling or remembering and the most complex being the creating domain.

Each learning domain is a prerequisite for its subsequent learning domain. Thus, any successful learning should encompass all of Bloom’s domains of learning. Figure 1 illustrates the six domains of Bloom’s taxonomy and their ascending interrelationship.
Critical thinking abilities are nested within the upper three levels of Bloom’s taxonomy, namely, analyzing, evaluating, and creating. Advancing to critical thinking ability requires mastery of lower three levels of Bloom’s taxonomy, namely, recalling, understanding, and creating.

![Bloom's Category of Human Thinking Abilities](https://ar.wikipedia.org/wiki, 2014)

**2.7.2 Guilford’s Structure of Intellect Theory**

Guilford categorized mental processes into three main dimensions (Figure 2.4):

1) Operation includes five intellectual processes: a) cognition, b) memory c) divergent production, d) convergent production, and e) evaluation

2) Content dimension aims to apply the following six intellectual operations: a) visual, b) auditory, c) symbolic, d) semantic, and e) behavioral.

3) Product dimension contains the products of the application of six intellectual operations using content tools. Guilford arranged product dimension into six
levels in order of increasing complexity: a) units, b) classes, c) relations, d) systems, e) transformations, and f) implications.

![Guilford's category of mental processes](http://www.xmind.net/m/7CHc/)

According to the Guilford’s structure of intellect theory, intellectual thinking has approximately 150 components: Operations (5) x Content (6) x Products (5) = 150 (Abo Hatab, 1978).

According to Guilford, critical thinking is an evaluation process. Thus, critical thinking is an operational process that follows competency in cognition, memory, knowledge, understanding, and inference. Moreover, evaluation is subject to standardization according to specific metrics that define certain criteria (Ali, 2009).

### 2.7.3 Piaget’s Theory of Cognitive Development

Despite the fact that Piaget did not use the word “critical” in his theory of cognitive development, a clear similarity can be found between Piaget’s description of the formal operational stage and our current knowledge about critical thinking; these similarities include the ability to make generalizations, create new possibilities, and refute prejudgments (Mayer, 1993). According to Piaget, the main goal of
pedagogy is to create well-rounded individuals who are capable of creating new inventions and not only to understand and reuse old inventions made by previous generations. Piaget described the formal operational stage as the ability to weigh information and evidence and not to accept ideas without proper analysis and judgment (Elkind, 1970).

Piaget describes the adaptation of individuals as a process that includes accommodation and assimilation. He defines accommodation as the ability of an individual to integrate situations and information from the outside environment with his or her own intellectual composition. An example of this definition is the use of new, digital technologies for setting a personal calendar instead of using an agenda. Piaget defined assimilation as the ability of the individual to bring change to his or her thinking guidelines to integrate a new situation information from the surrounding environment. An example of assimilation is changing the mindsets of personal behavior to address global warming.

Another way to understand accommodation and assimilation is to consider accommodation as the personal gadget that reflects the thinking processes of the individual and assimilation as the decoding of others’ opinions. Therefore, having the ability to equally integrate the processes of accommodation and assimilation into one’s life is an indicator that the individual is most likely capable of making sound thinking and good decisions. By continuously practicing accommodations and assimilation, the ability of the individual to refrain from being bias, making approximate generalizations, or adopting false logical arguments is minimized. Piaget stressed on creating an equilibrium between assimilation and accommodation because this balance is necessary in achieving the proper interaction between the
individual and the surrounding environment. This balance leads to the ability of an individual to attain a proper intellectual balance that leads to critical thinking.

2.7.4 Richard Paul’s Theory (Paulian Critical Thinking)

In constructing Paulian critical thinking theory, Richard Paul (1993) started by determining the minimal conditions for establishing his critical thinking theory. Paul attempted to analyze the driving force and obstacles of critical thinking. He established his theory based on the following premises: a) human nature to think; b) human thinking is greatly influenced by internal and external factors, such as prejudice, illusion, ignorance, and self-deception; and c) intervention is necessary to improve the thinking process.

Paul distinguished critical thinking in the “strong sense” from that in the “weak sense.” Thinking in a strong sense means that the individual develops and practices fair-mindedness. Thus, he or she treats all thinking with high standards, including those ideas that opposes his or her thinking. A person who practices strong sense thinking constantly employs analysis and reasoning for his or her thinking and for others. Thinking in a weak sense means employing prejudice and irrational thinking process in an attempt to support one’s own position and attack or undermine the thinking of others.

Paulian theory does not recognize or manifest the difference between critical thinking and creative thinking. Paul described critical and creative thinking as qualitative. According to him, the difference between them can be manifested in the degree of their application and concentration. Therefore, Paul suggested that the
curricula, and pedagogy in general, should stress the understanding that critical thinking leads to creative thinking and vice versa.

Paul further divided the thinkers to three categories: a) critical thinkers, b) selfish thinkers, and c) non-critical thinkers. The critical thinker is described as an individual with logical reasoning, that is, a person with no prejudice and has strong thinking abilities.

A selfish thinker has weak thinking abilities. He or she is a person who concentrates on self-gain and accomplishes personal goals by using ill methods directed toward manipulating the emotions and thinking of others. A non-critical thinker is described as an individual with weak thinking abilities and is easily manipulated in terms of emotions and thinking by others (Al-Harthy, 1998).

Paul argued that critical thinking abilities progressively improves throughout the development of the individual. Critical thinking abilities first develop at ages 11–12 years old and do not cease until the age of 15 years old; a person’s abilities during this age gradually progress until age of maturity at which they become semi-stable (Al-Hamory & Al-Wahr, 1996).

2.7.5 Robert Ennis Theory

Ennis (Ennis, 1985) is a leader in the critical thinking movement. Ennis defines critical thinking as thinking focused on what to do or believe in a certain situation or event. Critical thinking is composed of two main processes. a) Critical thinking is a mental process that leads to sound, logical decisions that support or refute an idea or logic. b) Critical thinking is a strategic process facilitated by conscious, elaborative thinking to reach sound decisions and conclusions.
Ennis (1985) elaborated on the requirements for sound decisions and conclusions by categorizing the judgments into two categories: (a) the suitability of the decision(s) on established mental guidelines and knowledge and (b) the use of existing knowledge and mental guidelines in fostering and reasoning the new decision(s). This categorization is similar to the accommodation and assimilation processes described by Piaget.

Ennis (1985) described critical thinking abilities as more rigid and more comprehensive than the upper three thinking abilities in Bloom’s taxonomy, namely, analysis, evaluation, and creation. According to Ennis, notice and reason are two critical thinking abilities that should be considered in addition to the abilities described by the pedagogical Bloom’s taxonomy. The use of analysis and reasoning is strongly related to the relationship of an individual with others and its application is uniquely contingent on the situation or event. Ennis called for the application of critical thinking abilities at all stages of schooling and further argued that critical thinking abilities are more beneficial at all stages of education than the upper levels of Bloom’s taxonomy. Ennis argued that critical thinking abilities are a main requisite for the application of the scientific process because critical thinking abilities are considered an important part of scientific inquiry and processes. Thus, a critical thinker is likely to possess the ability of scientific inquiry and application because of his or her capacity to be objective and to logically and rigorously evaluate information and data according to specified standards and regulations. He can also excel in the ability to compare and find alternative solutions. Thus, he can be trusted in reaching sound and effective solutions.

According to Ennis, the critical thinking process is composed of three distinct stages (Al-Hamory and Al-wahr, 1996):
a) Basic clarification: This stage includes identifying the problem, setting the goals, and formulating adequate questions. This stage also includes the ability to generate hypotheses.

b) Data judgment: This stage includes the ability to objectively judge the reliability and suitability of the data and to differentiate between the primary and secondary or other factors that affect the situation.

c) Inference: This stage includes the ability to reach a solution and forecast possible outcomes. This stage also includes the ability to scrutinize results and evaluate evidence.

According to Ennis (1985), critical thinking abilities are directly related to cognitive and affective processes (Kennedy et al., 1991). Ennis identified 12 critical thinking abilities: 1) understanding the problem, 2) identifying ambiguity in the reasoning, 3) identifying contradiction(s), 4) recognizing the interrelationship between the problem and the result or solution, 5) identifying a focus problem or issue, 6) assessing the application of the problem or solution, 7) scrutinizing the data, 8) determining whether the solution or conclusion is adequately supported, 9) identifying the problem, 10) identifying hypotheses, 11) recognizing adequate definition(s), and 12) identifying the suitability and accuracy of the statements (Kennedy et al., 1991).

In terms of the teaching aspect of critical thinking, Ennis confirmed that acquiring skills in logical reasoning is directly related to acquiring critical thinking abilities. Ennis also supported the teaching methodologies of individualized learning, which is linked to critical thinking abilities by a clear outline. Ennis further recognized the importance of theoretical and practical approaches for enhancing
critical thinking abilities. Ennis was a supporter of publicizing critical thinking as in integrating it into all stages of education, through which the students are trained on critical thinking in school and use the skill in their daily lives outside the school (Ennis, 1985).

2.7.6 Beyer Theory

Beyer identified three aspects of critical thinking, namely, cognitive, skills, and direction. The three aspects of critical thinking interact within the individual and holistically form the critical thinking abilities. The cognitive aspect includes the prior knowledge of the individual and the ability of the individual to recognize and use the possible source(s) of related information. Relations with others also directly affect the cognitive aspect of critical thinking because it relates directly to acquired social experiences, which are directly linked to the ideology of an individual. The skills aspect of critical thinking is composed of the ability of an individual to organize, use, and evaluate his or her cognitive abilities (Kneedler, 1986). The direction aspect, such as the love to learn and the eagerness to advance, is the third aspect of critical thinking, which comes into play as a subsequent element to the cognitive and skill aspects.

Beyer considered problem solving and decision making as more comprehensive thinking processes than critical thinking. Beyer argued that problem solving and decision making are strategic thinking abilities, each of which is composed of a collection of processes that an individual uses regularly and sequentially. Critical thinking is a collection of processes that can be used individually, collectively, or in dispersive collections. Critical thinking starts by
formulating a hypothesis or an assumption that is not analogous to problem solving and decision making. Critical thinking is more complex than problem solving and decision making because it also involves scrutinizing the applied procedure, data, and results.

Beyer defined the following 10 critical thinking skills (Beyer, 1995)
- differentiation between facts that can be proven and non-facts;
- probing elements that are related to the problem and ability to filter the elements that are not linked to the problem;
- ability to evaluate the reliability of the information sources;
- identification of the accuracy of information;
- identification of amphibious information;
- inference on nested information from a given set of data;
- ability to sense prejudice or ill methods;
- ability to identify faulty logic;
- ability to identify contradictions;
- ability to evaluate the strength of evidence or claims.

2.7.7 Delphi’s Model

In 1990, a group of thinking experts met to discuss the progress of understanding critical thinking. The meeting concluded with Delphi’s Report, which reviewed up-to-date information about critical thinking and means of integrating it into curricula; Delphi’s Report lists the primary skills that comprise critical thinking (Facione, 2009).

1) Interpretation skill: This skill describes the ability to understand and express a wide range of situations, events, information, judgments, beliefs, processes, rules, and conditions. This skill contains secondary skills, such as categorizing, explain, and inferring.
2) Analysis skill: This skill pertains to the ability to formulate connections and relations between statements, questions, principles, and descriptions. Analysis skills are also composed of abilities to interpret beliefs, judgments, experiences, and justifications. They also include secondary skills, such as ability to evaluate ideas and formulate and analyze reasoning.

3) Evaluation skill: This skill is the ability to judge reliability and it depends on the situation or problem, individual’s beliefs, and personal experiences. This skill includes secondary skills, such as the abilities to weigh claims and evidence.

4) Inference Skill: This skill describes the ability to reach reasonable hypotheses or results based on the provided information, sentences, principles, evidence, judgments, beliefs, ideas, descriptions, and questions. This skill includes secondary skills, such as searching and finding alternative solutions.

5) Explanation skill: This skill describes the ability to vocalize one’s own thinking. This skills includes secondary skills, such as reporting of results, justification of procedures and results, and providing proofs.

6) Self-regulation skill: This skill defines the ability of an individual to question, scrutinize, and organize thoughts and results. This skill includes secondary skills, such as personal scrutinizing and self-correction.

2.7.8 Watson and Glaser’s Model

Watson and Glaser (1980) conceptualized critical thinking as a composite of attitudes, knowledge, and skills. According to Watson and Glaser, critical thinking is
composed of five basic steps: 1) defining the problem, 2) clarifying and outlining the problem by collecting necessary facts and information, 3) formulating possible explanations and hypotheses, 4) exploring a potential solution by selecting a hypothesis for testing, and 5) formulating a conclusion. Watson and Glaser laid the foundation for the three major pillars of critical thinking: a) ability to identify the problem, b) ability to collect and scrutinize related evidence, and c) ability to formulate and apply good skills to achieve an adequate solution. The work of Watson and Glaser was the foundation for formulating a critical thinking assessment, WGCTA test, which relates critical thinking to academic performance.

2.8 Theoretical Approaches to Problem Solving

Facing a problem imposes stress and anxiety on an individual, which in turn generates a strong drive in the individual to seek solutions to the problem. Various theoretical approaches are used in problem solving, depending on the relationship of the approach to the process of learning. Below is a summary of the theoretical approaches that attempt to understand the process of problem solving.

2.8.1 Behaviorist Approach

This approach describes the tendency of individuals to apply problem solving techniques using previous experiences from their community or surrounding environment. For example, a student raises his or her hand in response to a teacher’s question in which the student knows the answer. By contrast, the student feels anxious when the teacher asks him or her to go to the principal’s office. These behaviors are examples of mental, emotional, and physical responses to stimuli. The
response of behavior psychologists to this question is that we build on previous knowledge and observations (Sharkawy, 1998).

The behaviorist approach to problem solving is based on the premise that the individual learns problem solving by trial and error and that learning problem solving is a continuous, repetitive process. The trials and repetitions of problem solving strengthen the connections between the stimulus and the response thereby increasing the abilities and readiness of an individual on embarking on problem solving. The first trial is usually characterized as random, but the trial(s) becomes deliberate and focused as the individual experiments with the problem (Al-Zayyat, 1996).

According to the behaviorist approach, when an individual faces a problem, he or she recalls suitable methodologies from his or her past experiences. The individual attempts to connect past experiences and the current problem or attempts to find common factors and elements between the past and current experiences. When past experiences fails to solve the current problem, an individual then employ trial and error, wherein he or she attempts to find a suitable solution from behavioral configuration (Abd-Alhamid, 2012).

The behaviorist approach implies that an individual who seeks solutions to a problem faces a complex combination of stimuli and responses based on previous experiences. The strategies employed in problem solving in the behaviorist approach is composed of different aptitudes, which vary depending on strength and order of use. The behaviorist approach constructs the aptitudes in a pyramid, which reflects the arrangement of the aptitudes from the simplest to the most complex. Therefore, an individual gradually moves upward in the behaviorist amplitude pyramid by
examining the simple to complex methodologies until he or she reaches a suitable and satisfying solution (Nashwaty, 1998).

According to Brightman (1990), using past experiences as the basis for problem solving is a contradiction to the ability of an individual to reach a new, novel solution. These novel solutions do not originate from the collection of past behavioral approaches. Therefore, the behaviorist approach may not be suitable for abstract, complex problems because approaching a complex problem with new methodologies is necessary (Brightman, 1990).

2.8.2 Cognitive Approach

This approach is also referred to as connections among stimuli. The learning process is the tendency of an individual to expect consecutive events after the occurrence of a stimulus in a certain situation. For example, a driver stops at a red light not because he or she learned to stop inevitably when seeing a red light. The driver actually learned the meaning of red light, which is the possibility of getting into an accident or being stopped for running a red light by a policeman. Therefore, knowledge about the consequences of running a red light helps the driver decide how to response to the red light. We learn cognitive approach response from this knowledge (Sharkawy, 1998).

Cognitive approach defines the problem as an imbalance in the cognitive domain, which needs to be repaired by reconstructing or restructuring knowledge. A modified system is established in repairing the cognitive domain to create balance and organization. The cognitive approach encourages fruitful thinking as a means to know possible routes for problem solving. This approach is encouraged because the
problem solver needs to attain a holistic understanding of the situation or problem before he or she can dissect and scrutinize the details of the situation or problem (Jamal, 2001).

Envisioning a solution is not always a learning process wherein the learner compiles information that enables him or her to achieve a desired solution. Envisioning a solution is a gradual learning process wherein a learner comprehends the connections and relationships within a situation or problem. In this situation, the learner reorganizes information into new units to achieve a desired solution. In attempting to solve a problem, a holistic view of the problem is necessary to assess the components of the problem and their interrelationships. Refraining from dealing with the problem holistically results in the inability to understand the realistic dimension of the problem and thus the inability to achieve a reasonable solution. This scenario is similar to looking at an object from one perspective, which disables the viewer from acquiring the true configuration of the object (Abo Jado, 2000).

The four types of envisioning solutions to the problems include (Brightman, 1990):

1) Impulsive solution: In this approach, an individual eagerly attempts to embark on a solution, but the eagerness ceases thereafter. The individual then goes through a confusion state but suddenly determines a desired solution.

2) Gradual solution: Under this approach, the individual makes several unfocused, uneducated attempts to reach a solution.

3) Stable solution: In this approach, the individual attempts a solution using several steps or stages to embark on the problem. The steps or stages are characterized by being focused and structured in such a way that the
individual is fully aware of the logical sequence of the steps or stages and their interrelationships. The steps or stages lead the individual to construct several hypotheses, which he or she then narrows down throughout the progress of developing a solution.

4) Direct solution: In this approach, the solution is achieved without the development of steps or stages.

Gagne (1968), proposed eight different modes of learning: 1) learning principles, 2) learning concepts, 3) differentiation learning, 4) verbal learning, 5) learning consecutive movement, 6) learning sign or body language, 7) stimuli learning, and 8) response learning. These learning modes can be organized in a pyramid in ascending order of complexity. Motor-physical learning is nested within the first level, and learning problem solving is nested in the eight level. Thus, learning problem solving is dependent on the competency of the lower seven levels of learning and on the ability to find connections and interrelationships among the different concepts and strategies embedded in the lower levels of learning (Abd-Alhamid, 2012).

The learning model of Janeeh points to the importance of learning adequate principles and concepts and their application to problem solving. Acquiring such principles and concepts is imperative because it allows the learner to interconnect between the principles and concepts. These interconnections then allow learners to assimilate different components of their knowledge to find a solution. Therefore, problem solving is dependent not only on acquiring the principles and concepts but also on reconstructing the principles and concepts to achieve a higher level of learning. Thus, problem solving is considered as a higher level of cognitive ability
than acquiring knowledge (Odeh, 1996). Figure 2.5 illustrates Janneh’s different modes of learning.

![Diagram](image)

**Figure 2.5. Gagne’s different modes of learning**

Guilford (1986) introduced a model for problem solving based on his theory of structure of intellect for problem solving. The first stage of this model is the receipt of stimulus in the nervous system from the environment. The stimulus can be emotional, which is then filtered in a net-like tissue in the lower brain; the lower brain then acts like a gate that controls the entrance of the stimulus to the upper parts of the brain, where knowledge and understanding is located (Guilford, 1986).

The stimulus that is allowed to pass from the net-like tissue in the lower brain alerts an individual to the presence of a problem. The individual is then prompted by the nervous system to comprehend the problem. At this stage, the individual starts searching in his or her stored knowledge in the upper brain for a plausible solution. If
the individual does not find a solution, he or she reverts to outside help and search for new facts and information that could help solve the problem. While searching for new facts and information, an individual constantly scrutinizes and evaluates new information. At certain instances, an individual can reach a solution without using divergent thinking, which suggests that a person should find more than one probable solution. This method means that an individual can directly employ convergent thinking, which entails finding a unique solution as soon as he or she senses the problem. An individual can then respond to the stimulus after the acceptance of his or her memory. Figure 2.6 illustrates Guilford’s structure of intellect for problem solving.

![Diagram](image.png)

*Figure 2.6. Guilford’s structure of intellect for problem solving*
2.9 Theoretical Framework

The theoretical framework will provide the researcher an insight into some of the relevant theories to be made as points of reference in this study. This research is structured around two main pillars, namely, TRIZ theory and cognitive theory. The researcher applying 10 principles of TRIZ theory in addition to the principles of cognitive theory to design a special enrichment program, namely, MTRIZP. MTRIZP administered to talented students in Tabuk, KSA. The researcher aims to construct the program to enhance critical thinking and the problem solving abilities of talented students.

Being a study, the researcher feels the selected theories are appropriate in the designing process of the training programme which will become relevant to train talented students to see not only cognitive outcomes but also the behavioural outcomes in students' academic life in their schools.

2.9.1 TRIZ Theory

2.9.1.1 Emergence and Development of TRIZ Theory

TRIZ theory is “the creative solutions to problems” and is considered a modern theory in the Arabic region. TRIZ theory will leave a major effect in the Arabic region similar to the success of the theory in the Western countries. Many resources, including Internet websites, attest to the importance and significance of TRIZ theory (Abu Jado, 2010).
TRIZ theory was developed by the Russian scholar, Henry Altshuller, who was born in 1926. Altshuller worked as a patent officer in the Russian marine; in 1946, he started the development of TRIZ theory and published several articles and authored 14 books (Rantanen & Domb, 2008).

Altshuller noticed the myriad of creative thinking abilities in the patent submissions he screened. Altshuller and his colleagues in the patent office decided to accumulate and analyze the information in 40,000 patent submissions, which can represent a sample on creative solutions to problems. After analyzing 40,000 patent submissions, Altshuller and his colleagues concluded that the innovations depicted in the patents are a result of a systematic process and are not random or disorganized. Altshuller further concluded that many of the patent submissions followed specific creative thinking processes, which share similar stages and philosophies. Thereafter, Altshuller compiled his findings into the 40-principle TRIZ theory. TRIZ theory can be used to train individuals on creative thinking and to achieve creative solutions to many philanthropic challenges (Abu Jado, 2000).

Realizing the importance of TRIZ theory, Japan took the initiative of educating its people about this theory. Japan spent about $50,000 for the translation of TRIZ theory and conducted 2,500 TRIZ training workshops in one year (2008–2009). Similarly, the education ministry in France took on the responsibility of training 17,000 teachers as part of its national educational reform mission. TRIZ theory became well-known in more than 28 countries, and its teaching is implemented in more than 42 universities and many corporations (Abu Jado, 2000). In general, TRIZ theory leads other creative thinking theories in Western countries
(Urban, 1991); the main focus of this theory is creative thinking and innovative problem solving.

2.9.1.2 Classical TRIZ Theory

The initial TRIZ theory (1946) was composed of 35 creative thinking strategies. Between 1968 and 1971, Altshuller added five more creative thinking strategies to TRIZ theory. Thus, TRIZ theory includes a total of 40 principles. The 40 strategies were used as is without development or modification until 1985 (Terninko et al., 2001).

2.9.1.3 Modern TRIZ Theory

The update of TRIZ theory spanned five years (1985–1990) and was conclusively confined to Russia. The Russian developers of TRIZ theory aimed at implementing TRIZ theory to individual and institutions with regard to technological and non-technological aspects. The migration of the Russians out of the Soviet Union in 1990 marked the spread of TRIZ theory to the United States of America, Japan, Germany, and other countries (Rantanen & Domb, 2008).

2.9.1.4 Studies Related to TRIZ Theory

Mujahid (2015) identified the effectiveness of a proposed strategy based on TRIZ theory in the development of solving problem skills and the concept of academic self-identity in the subject of history among 25 first-grade secondary school students. The results showed statistically significant differences in favor of the experimental group. The study also revealed that the use of the proposed strategy achieved
appropriate levels of efficiency in the development of creative problem solving and the concept of academic self-identity.

Mokhtar (2015) reported the effectiveness of an intervention program. This program was based on the principals of TRIZ theory for the development of cognitive-achievement problem solving skills among first-year secondary school students in Egypt. Asheq Al-Lolo (2015) prepared a program based on TRIZ theory to examine the effect of a group of sports activities on the development of creative thinking skills. The study found significant differences in favor of the experimental group.

Sobh Al-Lolo (2015) focused on constructing a proposed program based on the principles of TRIZ theory; this study also examined the effectiveness of the program on the development of classification skills and decision-making skills among 51 ninth grade students. The researcher used the experimental research design, and the results showed statistically significant differences in favor of the experimental group. the results indicated the effectiveness of the proposed program.

Khawaldeh (2016) measured the effect of the effectiveness of a training program based on TRIZ theory on the development of administration classroom crisis by teachers of philosophy subjects in secondary schools in Cairo. The researcher prepared a training program based on TRIZ theory and constructed a research instrument to measure classroom problem management. The sample included 64 students divided into two equal groups, namely, experimental and control groups. The study showed the effectiveness of the intervention program.

Abdel-Aal (2000), identified a number of strategies in TRIZ theory that are applied in teaching geography to develop the geographical concepts and critical
thinking skills of first-year secondary school students. This program was applied on a sample of 64 male and female students who were divided into experimental and control groups. Critical thinking and achievement tests were employed. The results indicate statistically significant differences in favor of the experimental group.

Saeed (2011) examined the effectiveness of a training program that was based on TRIZ strategies on the dimensions of thinking and academic achievement in the subject of psychology among secondary school students. The results showed statistically significant differences for the experimental group, which could be attributed to the employment of the principles of TRIZ theory. Abdul Rahman (2014) determined the influence of the effectiveness of using TRIZ theory in the development of creative thinking and academic achievement in the skills in the subject of mathematical finance. The results showed the effectiveness of the training program.

Abdullah Mahdi (2014) reported the effectiveness of a training model on the development of creative problem solving skills of students in secondary schools. Gad Jad al-Haq (2014) used 16 principles of TRIZ theory to construct a program and examine its effectiveness. The effectiveness of the program was shown in the development of problem solving skills.

Jad Al-Mawla (2013) examined TRIZ theory in the innovative solutions of problems and its application on students in special education. The study indicated the possibility of using TRIZ principles for different age groups of students with special needs.

Al-Abd Al-Karim (2013), investigated the effect of a training program based on TRIZ theory in the development of parallel thinking among a sample of trainees
with government jobs. The results showed statistically significant differences in the experimental group because of the application of TRIZ principles.

Nour Hassan (2013) determined the effect of using TRIZ theory to develop the taste-rhetorical skills of members of a mental group in second-grade secondary school taught; the skills were taught using TRIZ theory strategies. Sabri and Al-Hazmi (2013) wanted to determine the effectiveness of some principles of TRIZ theory on the development of innovative thinking skills of talented primary school students in Medina, Saudi Arabia. The study showed the effectiveness of these strategies.

Lathin (2013) focused on the development of sports communication skills and creative mathematical solution to the problems in the light of TRIZ theory for creative learning. The results showed the effectiveness of the program in improving communication skills and provide creative solutions to the problems. Raeed (2013) reported the efficiency of an intervention program based on TRIZ theory to develop the creative problem solving skills of 10th grade primary school students.

Al-Khayat (2012) identified the effect of a training program based on TRIZ theory on the development of thinking skills of students of Al-Balqa University in Jordan. The study reached a conclusion that shows the positive effect of this theory. Turky (2011) used a similar theory and examined the effect of TRIZ theory on teaching, the ability to solve problems, and the achievement of first grade secondary students. Turky reported the effectiveness of teaching based on this theory.

Suleiman (2011) focused on the effectiveness of TRIZ theory in the development of scientific thinking and academic achievement in science subject
among fourth grade students. The study reported results that reflected the effectiveness of the program.

Sheikh and Al-Qadhi (2010) identified the effect of a training program based on TRIZ strategies on the development of innovative thinking in Al-Jawf, Saudi Arabia. The study found that the training program contributed to the development of innovative thinking skills among students. In another study, Khamis (2010) identified the effectiveness of the proposed program in developing the achievement of first grade secondary students. Khamis reported the effectiveness of the proposed program.

Louri (2009) studied the effectiveness of the program in developing the skills of students in solving educational and life problems. The results showed a shift in students’ capabilities in almost all their problems, which indicates the success of the TRIZ program. Al-Refaai (2006) explored the effects the program in developing the innovative thinking of talented students in Asir, Saudi Arabia. The results reflected the effectiveness of the principles of TRIZ theory.

2.9.1.5 Application of TRIZ Theory to MTRIZP

This study uses the following 10 principles from TRIZ theory: (1) segmentation, (2) extraction, (3) merging, (4) inversion, (5) self-service, (6) changing color, (7) nesting, (8) universality, (9) blessing in disguise, and (10) copying. The selected principles are suitable for application in the design of MTRIZP enrichment program, which includes activities that focus on the delivery and application of each selected TRIZ principle. MTRIZP is designed to employ TRIZ systematic method. This method uses the identification of contradiction or problem and alternative solution,
application of a solution, and reevaluation of that solution. By gaining competency in the selected TRIZ principles, MTRIZP is expected to excel in the innovation of the students and expanding their knowledge to enable them to find solutions to challenging real-life situations. MTRIZP can provide basic tools that can be used to expand the critical thinking and problem solving abilities of talented students and unleash their innovativeness.

Table 2.1: The selected principles in MTRIZ

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<td>(4) inversion</td>
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<tr>
<td>(5) self-service</td>
<td>(10) copying</td>
</tr>
</tbody>
</table>

2.9.2 Cognitive Theory

Cognitive theory was developed by Jean Piaget in 1936. Piaget was interested in understanding the reason children gave wrong answers to IQ questions that required logical thinking. Piaget wanted to understand not only how well children could count, spell, or solve problems in the IQ test, but also how fundamental concepts, such as the idea of a number, time quantity, justice, affect learning. Piaget’s work led to the systematic study of cognitive development and to the development of tests that could expose cognitive development. According to Piaget, the thinking ability of
children is not an underdeveloped thinking compared with the thinking of adults. The processes of children’s thinking differ from that of adults.

Piaget’s work showed that children are born with the basic framework of thinking abilities, which then evolves in response to many environmental stimuli to enable learning and build knowledge. Cognitive theory is unique given that it addresses the development of thinking in children and not learning as a whole. Moreover, cognitive theory is specifically concerned with children. Cognitive theory categorizes the development of children to stages instead of gradually increasing the amount or complexity of knowledge, including concepts, ideas, behaviors, and others. The three basic components of cognitive theory are (1) schemas, (2) assimilation and accommodation, and (3) stage of development (Piaget, 1936).

Schemas are the set of mental representations that an individual uses to understand and respond to situations. Schemas are stored mental patterns and recognitions retrieved as situations arise and as needed. Wadsworth (2004) compared schemas with index cards that are sorted and filed in the brain. Certain situations call for specific, appropriate cards, which are then retrieved and applied. Therefore, schemas are the building blocks that trigger and formulate behavior and responses. When a child has appropriate schemas to respond to an arising stimulus, the mental state of the child is described as being in a state of cognitive or mental equilibrium (Piaget, 1952).

Exposure to a situation or a stimulus will initiate the retrieval of schemas. However, the schemas may not fit the arising situation. Thus, the individual must modify existing schemas to assimilate new information. This situation is called adaptation. In many instances, the schemas fail to act properly. Thus, they need to be
modified to function properly. This situation is called accommodation. The emergence of new situations and the drive to assimilate and accommodate is led by the desire to reach equilibrium given that individuals do not like to be frustrated or feel out of control. Assimilation and accommodation are on-going processes that modify schemas and expand the knowledge and adjustment of an individual. Assimilation and accommodation principles do not imply a gradual increase in the knowledge, but rather the expansion of knowledge through leaps (Piaget, 1952; Wadsworth, 2004).

The third component of cognitive theory is stages of development. According to Piaget (1936), all children go through universal, specific, sequential developmental stages. These stages are related to the age to the child, but the competencies in the stages is influenced by individual variations. Therefore, children progress from one developmental stage to the proceeding stage at different rates. All children go through the same stages but later stages of development may not be achieved by some children (Piaget, 1952). The stages of development are as follows:

1. Sensorimotor (0–2 years)
2. Preoperational (2–7 years)
3. Concrete operational (7–11 years)
4. Formal operational (11 + years).

Cognitive theory was not intended for educational applications, but its systematic approach on how and when children learn facilitated its influence on the educational system. Cognitive theory is based on biological maturation and the evolution of readiness notion. Such a notion suggests that children should be allowed to acquire a competency level in the development stage before moving on to the next.
2.9.2.1 Application of Cognitive Theory to MTRIZP

The mental developmental capacity of talented students exceeds that of average students. MTRIZP aims to apply the essence of cognitive theory to facilitate units or leaps of development. This approach enables MTRIZP to promote the development of talented students thereby enabling them to perform complex tasks by immersing them in challenging situations. Such situations can provide the necessary leaps in the development of talented students. The talented students who comprises the sample group in this study are at an age when they can apply logical thinking in a less egocentric manner and employ critical thinking and problem solving when faced with diverse and challenging situations. MTRIZP aims to advance the formal operational stage of talented students by allowing to them to think in an abstract manner and combine and classify items in a sophisticated way using their high-order reasoning. By advancing the operational stage of talented students, MTRIZP enables students to think creatively and use abstract reasoning. The collaborative, competitive nature of MTRIZP allows talented students to further expand their cognition development as a result of their direct exposure and interactions with other talented students.
2.10 Conclusion

This chapter reviews literature related to the purpose of the study, which includes definitions of talented students, critical thinking, and problem solving. This chapter also presents a review of some studies related to the scope of this study.

Figure 2.7: Theoretical framework of current study.
CHAPTER 3

DEVELOPMENT OF THE PROGRAM'S MODULE (MTRIZP)

3.1 Introduction

This chapter discusses the use of TRIZ theory and its adaptation to MTRIZP. This chapter discusses the motives for designing the MTRIZP, as well as the principles, tools, goals, target groups, activities, and expected outcomes of MTRIZP.

3.2 Definition of TRIZ

The aim of TRIZ theory since its development has always been to provide individuals with systematic strategies that can promote creative thinking (Tannant, 2003). Saveansky describes TRIZ theory as a systematic, scientific approach aimed at finding innovative solutions to problems (Saveansky, 2000). TRIZ theory is composed of three main parts:

a) Logical analysis of the system, its components, and its challenges. Logical analysis can help clarify the origin of the problem and remove the ambiguities surrounding it.

b) Employment of appropriate scientific principles and inclusion of examples that illustrate the methodologies for each step of a scientific principle. This scientific approach is widely known for its effectiveness in problem solving.

c) Use of suitable tools to bypass psychological inhibitions that can limit the pursuit of effective problem solving.
3.2.1 Basic Assumptions of TRIZ Theory

3.2.1.1 Contradictions

Contradictions represent an important principle in TRIZ theory. Contradiction occurs when one finds a positive solution to a problem in the system, or in one component of the system, but such solution creates a negative impact on the system as a whole or on one of its components (Hallburton & Roze 2004). Thus, an attempt to solve a problem creates another problem, in which case an innovative solution is required to enhance the system without adversely affecting it or its parts (Urban, 1991). Contradictions are expected to occur in any system, and they indicate the lack of compatibility between a problem and its solution. This incompatibility should be identified and resolved, or its negative effect(s) on the system should be minimized.

3.2.1.2 Final, Ideal Solution

Final, ideal solution theory is based on the vision that the system is aimed at operating efficiently such that all its components are working at their best performance levels without negative effects on the system. A vision of the final desired state of the system is crucial before attempting the use of TRIZ theory. Such a vision can facilitate and clarify the process of finding creative solutions to problems (Kowalick, 1997).

3.2.1.3 Resources

Resources represent another important aspect of TRIZ theory. Several resources can be used, such as institutions or corporations, but such resources are not well utilized
or are not well known to their anticipated users. Publicizing available resources can help resolve contradictions (Kowalick, 1997).

3.2.2 TRIZ Principles

TRIZ (Gadd, 2011) consists of 40 inventive principles, which are reflected in the contradiction matrix and extraction principles. Technical and physical contradictions can be solved by implementing the 40 principles. The set of 40 principles is a major tool for problem solving in TRIZ and its usage is relatively easy and effective (Gadd, 2011).
<table>
<thead>
<tr>
<th></th>
<th>Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Segmentation</td>
</tr>
<tr>
<td>2.</td>
<td>Extraction</td>
</tr>
<tr>
<td>3.</td>
<td>Local quality</td>
</tr>
<tr>
<td>4.</td>
<td>Asymmetry</td>
</tr>
<tr>
<td>5.</td>
<td>Merging</td>
</tr>
<tr>
<td>6.</td>
<td>Universality</td>
</tr>
<tr>
<td>7.</td>
<td>Nesting</td>
</tr>
<tr>
<td>8.</td>
<td>Weight</td>
</tr>
<tr>
<td>9.</td>
<td>Prior Counteraction</td>
</tr>
<tr>
<td>10.</td>
<td>Prior action</td>
</tr>
<tr>
<td>11.</td>
<td>Cushion in advance</td>
</tr>
<tr>
<td>12.</td>
<td>Equipotentiality</td>
</tr>
<tr>
<td>13.</td>
<td>The other way Round</td>
</tr>
<tr>
<td>14.</td>
<td>Curvature increase</td>
</tr>
<tr>
<td>15.</td>
<td>Dynamics</td>
</tr>
<tr>
<td>16.</td>
<td>Partial or excessive actions</td>
</tr>
<tr>
<td>17.</td>
<td>Another dimension</td>
</tr>
<tr>
<td>18.</td>
<td>Mechanical Compensation</td>
</tr>
<tr>
<td>19.</td>
<td>Periodic action</td>
</tr>
<tr>
<td>20.</td>
<td>Continuity of useful action</td>
</tr>
<tr>
<td>21.</td>
<td>Rushing Through</td>
</tr>
<tr>
<td>22.</td>
<td>Blessing in Disguise</td>
</tr>
<tr>
<td>23.</td>
<td>Feedback</td>
</tr>
<tr>
<td>24.</td>
<td>Intermediary</td>
</tr>
<tr>
<td>25.</td>
<td>Self-service</td>
</tr>
<tr>
<td>26.</td>
<td>Copying</td>
</tr>
<tr>
<td>27.</td>
<td>Cheap disposables</td>
</tr>
<tr>
<td>28.</td>
<td>Replace mechanical system</td>
</tr>
<tr>
<td>29.</td>
<td>Pneumatics and hydraulics</td>
</tr>
<tr>
<td>30.</td>
<td>Flexible Membranes</td>
</tr>
<tr>
<td>31.</td>
<td>Porous materials</td>
</tr>
<tr>
<td>32.</td>
<td>Color changes</td>
</tr>
<tr>
<td>33.</td>
<td>Homogeneity</td>
</tr>
<tr>
<td>34.</td>
<td>Discarding and Recovering</td>
</tr>
<tr>
<td>35.</td>
<td>Phase transitions</td>
</tr>
<tr>
<td>36.</td>
<td>Thermal Expansion</td>
</tr>
<tr>
<td>37.</td>
<td>Oxidation</td>
</tr>
<tr>
<td>38.</td>
<td>Accelerated Oxidation</td>
</tr>
<tr>
<td>39.</td>
<td>Inert atmosphere mechanical system</td>
</tr>
<tr>
<td>40.</td>
<td>Composite Materials</td>
</tr>
</tbody>
</table>
TRIZ theory comprises the 40 principles compiled by Altshuller from the analysis and inferences of patents. Altshuller (2002) believed that TRIZ theory features special characteristics, which include the following:

a) Engineering foundations that focus on the development of techniques of the systems
b) Creative methods for solving technical, administrative, and pedagogical problems
c) Ability to solve contradictions for technological and non-technological problems.

This study used ten principles following the Explain of this Principles:

1. Segmentation Principle: This principle refers to the possibility of solving problems by splitting the system into several parts, each of which is independent from the others. If the system is already divided, splitting it further can increase the likelihood of solving the problem.

2. Extraction Principle: This principle refers to the possibility of solving problems by selecting components that work well, keeping them functional, and identifying the harmful components or parts or those that do not work well for separation and disposal.

3. Merging Principle: This principle indicates the spatial and temporal links between systems that result in similar or contiguous operations. This principle also refers to
the collection of things or similar or identical components that perform functions and balanced operations so that they are close or contiguous in terms of time and place.

4. Nesting Principle: This strategy usually includes measures that are contrary to those used in solving problems. If things are fixed, we make them move, and if they are moving, we fix them.

5. Inversion Principle: This principle enables the system to serve itself by performing supportive functions, namely, maintenance, difference treatment, and use of wasted resources.

6. Blessing in Disguise Principle: This principle points to changing the color of a thing or its external environment.

7. Changing Color and Transparency Principle: This principle refers to the process of containing something in something else, which in turn can be contained in another and so on. This principle also refers to passing a certain something in the cavity of something else.

8. Universality Principle: This principle refers to facilitating the capability of the system to handle several functions or tasks or making every part of the system able to carry out the largest number of job performance, hence the minimal need for other platforms.

9. Copying Principle: This principle refers to the use of items or harmful effects on the environment to obtain positive effects.

10. Self-service Principle: This principle refers to the possibility of solving problems using a simple copy instead of using complicated things and replacing a thing with its copy.
3.2.3 Principle of TRIZ Theory in Solving Problems

Initially, a problem in the system should be considered within specific constraints (specific situation). The specific constrains of the problem are removed to generalize the problem. Once the problem is generalized, the strategies of TRIZ theory can be screened to identify the most suitable principle for the problem, which is then used to solve the problem. Finally, the generalized solution of the problem is extrapolated to the original specific problem (Al-Amer, 2009).

3.2.4 Previous Studies in TRIZ Theory

In 2003, Abo Jado conducted a study that aimed to investigate the effect of a training program on 10th graders. Abo Jado’s program was based on the 15 strategies of TRIZ theory; he implemented the program on 100 male and female 10th grade. Abo Jado formed study and control groups according to the gender of participants. The result of Abo Jado’s study showed that the students who received the training program excelled.

In 2004, Marsh et al. investigated the possibility of applying TRIZ theory in teaching. The results showed that all of the 40 strategies of TRIZ theory were effective in resolving educational problems for teachers and students in elementary to post-secondary levels.

Al-Faqeeh (2004) reported to the Center for Talent Care in Jeddah findings in a study that investigated TRIZ theory and its importance and effect as an enrichment program for gifted and talented students. Al-Faqeeh’s Program was based on 15 creative strategies of TRIZ theory, which were applied twice a week. Al-Faqeeh also
noted the possibility of integrating TRIZ theory in the curriculum, specifically in the disciplines of mathematics and science.

Al-Amer (2008) conducted a study that aimed to develop a training program based on the 16 strategies of TRIZ theory. Al-Amer investigated the effectiveness of the program in enhancing creative thinking, including fluency, flexibility, and originality, in solving mathematical problems. Al-Amer’s study sample comprised 60 high-achieving female students in the ninth grade in Ha’el, KSA. The study consisted of a study group and a control group. The result of Al-Amer’s program showed that the students who received the training program performed better than those who did not.

In a study to investigate the effectiveness of a program that was based on TRIZ theory, Bin Khamees (2010) aimed to enhance creative thinking and achievement in the subject of biology for 10th grade female students in Jeddah, KSA. The study and control groups comprised 30 and 25 students, respectively. The results of the study indicated the effectiveness of the program in enhancing creative thinking and achievement.

3.3 Motives for Program Design

1. The relative modernity of TRIZ theory as it became known in the last few years in the United States, Europe, and other countries of the world.
2. The small number of studies conducted on TRIZ theory despite its importance and its application in many disciplines, including the field of education.
3. The importance of creating systematic procedures, which are based on specialized theory, for teaching critical thinking and problem solving.
4. The low level of students’ critical thinking and problem-solving skills within the different stages of schooling, as well as the necessity of developing such skills.

5. TRIZ theory was originally applied to technical and design disciplines, but the limited application of TRIZ theory to education is promising, which prompted the researcher to use TRIZ theory to gain further insights into its effectiveness in teaching.

The program has been modified for the following reasons:

1. To be proportionate for the talented students.
2. To make it easier for students by using the principle of only 10
   Rather than the principle of 40.
3. To expand each principle in terms of examples, exercises
   and applications.
4. To choose the principles that improve critical thinking and
   problem solving which is the objective of the study.
5. To select the suitable activities for the current era.

3.4 Program Design

The program follows the following pillars:

1. The basics of TRIZ theory, as well as the basic structure of the first training program founded on TRIZ theory in the Arabic world, which was developed by Abu-Jado.
2. Accurate, detailed, and sequential steps in the administration of the program to assist students in comprehending the principles and methods of application of TRIZ theory in solving problems.
3. Fulfilling the goals of the training program require versatility in the use of strategies and methodologies during training.

4. The trainer is the center player in the educational training. Thus, the role of the trainer should be emphasized in all aspects, including logistics and program implementation.

5. The precise outline of the roles of the trainer and trainees in the program during all the implementation stages of the program.

The design of the MTRIZP Program was rooted in dynamic elements that can be easily applied. The design of MTRIZP is an attempt to create a suitable program that enables talented students to easily acquire knowledge and build a solid foundation. The core of the MTRIZP Program is to advance the critical thinking and problem-solving skills of students. Thus, the MTRIZP Program encourages talented students to ask questions and engage in the process of developing novel solutions to current and emerging problems. The MTRIZP Program was designed to fit the environment and issues faced by talented Arabic students.

The design of the MTRIZP Program concentrated on 10 elements. The inclusion of these 10 elements considered the figure 3.1) the suitability to the time frame of MTRIZP administration such that talented students can have adequate training to become competent in all 10 elements; 2) the holistic excitement and pleasure derived from the content and delivery of the program, which are crucial aspects to increase the enthusiasm of talented students toward acquiring competencies in critical thinking and problem solving.
MTRIZP was chosen as the basis for this study because of the following characteristics:

1) MTRIZP consists of multiple methods for solving technical problems in such a way that the technical application is dependent on the cognitive framework.

2) MTRIZP was designed to bypass and/or overthrow psychological learning barriers.

3) MTRIZP utilizes methodologies that are used to address advanced problems, which require resourceful, creative applications.

4) MTRIZP is efficient in analyzing expected outcomes and in selecting suitable means/processes to achieve desired outcomes. MTRIZP is effective in screening available resources and in choosing the appropriate resources and/or their adaptation to process requirements.
Table 3.2: Comparison between TRIZ and MTRIZ

<table>
<thead>
<tr>
<th></th>
<th>TRIZ</th>
<th>MTRIZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contains 40 principles</td>
<td>Contains 10 principles</td>
<td></td>
</tr>
<tr>
<td>Many of the principles are presented by one session</td>
<td>Each principle is presented in two sessions</td>
<td></td>
</tr>
<tr>
<td>The principle is briefly explained</td>
<td>Expands on the training principle in a comprehensive manner</td>
<td></td>
</tr>
<tr>
<td>Work individually or collectively</td>
<td>Work cooperatively</td>
<td></td>
</tr>
<tr>
<td>Improve multiple skills</td>
<td>improve critical thinking skills and problem solving</td>
<td></td>
</tr>
</tbody>
</table>

3.5 Development of MTRIZP

The development of a training program involves creating a package of materials about a specific subject or activities from which people can be trained and learn new knowledge. The training program in the current study includes activities that are expected to enhance the critical thinking and problem-solving skills of talented students and thereby enable them to use their learned skills to solve daily life problems. The activities in this training program were developed on the basis of TRIZ, particularly from the aspects of age and the individual and cultural backgrounds of talented students. Acquiring thinking skills is a significant contributor to students’ well-being (Fisher, 2005; Qatami, 2005) that enables them to develop their thinking abilities and become independent learners. Additionally, an enjoyable and non-threatening environment is required for the program to be successful.
In the conceptual framework in Chapter 1, the following 10 principles were chosen:

1) Segmentation
2) Extraction
3) Merging
4) Inversion
5) Self-service
6) Changing color
7) Nesting
8) Universality
9) Blessing in disguise
10) Copying

MTRIZPP is developed with graded activities to help talented students enhance their critical thinking and problem-solving skills. The following aspects are modifications and adaptations made to the original program: goals, lessons, learning outcomes, objectives, and activity procedures.

3.6 Modifications MTRIZ Program

MTRIZP should be modified to facilitate its suitability and effectiveness in teaching talented students. Al-Khatib (2001) recommended modifications or adaptations to the general curriculum if it were to be used to teach talented students. The researcher referred to education literature to support the modifications and adaptations made to the teaching methods of the TRIZ Program. Special education literature on adaptations and modifications for talented students was also reviewed (Al-Khatib,
Adaptations and modifications of the MTRIZP were conducted in the present study. The element of modified were conducted that the original version of MTRIZP focuses on explaining principles, whereas the modified version includes three exercises and other extra activities. Appropriate pictures were included in each exercise and example. Pictures sustain the attention of students, boost their comprehension through visual perception, and enhance the number of senses used in learning. Some phrases were adapted to the Arab environment, including the chronological age of the students who participated in the study. The number of periods assigned for each exercise was increased to 20 periods instead of 10 periods. This fragmentation increases understanding and facilitates a quick analysis of skills. This increase was implemented in several lessons. Thus, the total number of periods became 32 periods, including the periods of revision and evaluation. The formulation of some exercises was modified. Simple language in short and clear phrases was used.

New arrangements for exercises were provided with the following sequence:

a) Homework was developed to increase the impact of learning and to benefit dissemination. Students are asked to solve additional training exercises at home, which would be later presented to the teacher for evaluation.

b) Definitions clarify the basic meaning of the training and the meanings of basic words. This item is not originally included in the TRIZ.
c) Trainings include those that require students to solve problems as a group or individually. These trainings are not included in the original program.

d) An example of a solution includes examples of each lesson with picture and video displays. The previous version of the TRIZ Program used written solutions for training without pictures and videos.
<table>
<thead>
<tr>
<th>No</th>
<th>Modifications (Elements and procedure)</th>
<th>Original Version (TRIZ)</th>
<th>Modified Version (MTRIZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Original trainings</td>
<td>The original program does not include extra assignments.</td>
<td>The modified program includes extra assignments.</td>
</tr>
<tr>
<td>2</td>
<td>Appropriate pictures and videos were inserted for each training and example.</td>
<td>No pictures or videos are included in the original version.</td>
<td>This new modification is not in the original version.</td>
</tr>
<tr>
<td>3</td>
<td>The number of periods assigned for each lesson was increased. Thus, the number of periods in the MTRIZPP is 20 instead of 10 in the original program.</td>
<td>The period assigned for each lesson is about 20 min within one week.</td>
<td>The period assigned for each lesson was increased to about 90 min within one week.</td>
</tr>
<tr>
<td>4</td>
<td>Tasks and activities</td>
<td>The original program does not include major activities or exercises.</td>
<td>The modified program includes major activities and exercises.</td>
</tr>
<tr>
<td>5</td>
<td>Some phrases were adapted to the Arab environment, including the chronological age of the students participating in the study.</td>
<td>For example, inclusion</td>
<td>Containment</td>
</tr>
<tr>
<td>6</td>
<td>New arrangements for trainings were provided.</td>
<td>Original version</td>
<td>Modified version</td>
</tr>
<tr>
<td></td>
<td>Training-solving</td>
<td>The training-solving in the original version is done individually.</td>
<td>The training-solving in the modified version is done as a group and individually</td>
</tr>
<tr>
<td></td>
<td>Number of principles</td>
<td>The number of principles in the original program is 40.</td>
<td>The number of principles in the modified version of the MTRIZPP is 10.</td>
</tr>
<tr>
<td></td>
<td>Homework</td>
<td>Homework is not included in the original version.</td>
<td>Homework was developed to increase the impact of learning and to benefit dissemination. This new modification is not in the original version.</td>
</tr>
<tr>
<td></td>
<td>Definition</td>
<td>This item does not exist in the original program.</td>
<td>Definitions clarify the basic meaning of the training and the meaning of basic words.</td>
</tr>
<tr>
<td></td>
<td>Example of solution with illustrative picture</td>
<td>This item does not exist in the original version.</td>
<td>An illustrative picture was added to the example of a solution.</td>
</tr>
</tbody>
</table>
3.7 Expected Program Outcomes

After the implementation of the program in the KSA, the trainees (students) exposed to the activities and training of the program should be able to achieve the following training and pedagogical goals:

1. Increase the awareness of students with regard to the most important problems faced by societies and develop their abilities to solve such problems using specific strategies.

2. Provide systematic and organized opportunities for students to gain exposure to other people’s experiences and thereby acquire the abilities to accept and comprehend the views of others.

3. Equip students with the necessary skills for problem solving. Trainees employ TRIZ theory and evaluate their solutions.

4. Enable students to form a vision regarding the ideal approach to solving personal and social problems.

5. Provide trainees with critical thinking and problem-solving skills for their subjective utilization in different life situations.

6. Enhance the collaborative skills of trainees and develop their abilities to employ metrics for assessing proposed suggestions.

3.8 Innovative Principles of the Training Program

The program in this study uses the principles of TRIZ theory as the core of its training modules. These principles are aimed at enhancing the critical thinking and problem-solving skills of students. The current training program only uses 10 TRIZ principles instead of the 40 TRIZ principles for the following reasons:
a) Employing all of 40 TRIZ principles in one study and by one author is difficult. Moreover, using all the TRIZ principles requires long training sessions and extensive financial support.

b) Some of the unused TRIZ principles are not fit for the sample of this study because such principles target technical, technological, and non-pedagogical applications.

c) The selected TRIZ principles are closely linked to pedagogy.

d) The selected TRIZ principles were chosen after consultation with experts in the field.

3.9 Execution of the Program

The program is collectively administered to the experimental group in the frequency of one 45-min session per day per week. The training for each of the selected TRIZ theory principle spans two days. The following is an outline of the sessions:

1. Introduction of the principle of TRIZ theory, which is the focus of the activity for each session. In introducing the TRIZ principle, care is taken to simplify TRIZ principle. A myriad of scientific, practical examples are provided by the trainer. The trainees are then asked to provide other examples of the TRIZ strategy.

2. The problems faced by the students or the society in which they live in are introduced. The problems are analyzed from different aspects. Here, the trainees are introduced to the meaning of a problem, its causes, and its positive and negative implications.
3. The trainees are trained in finding ideal, final solutions to the problems discussed during the sessions.

4. The principle of TRIZ theory, as emphasized during the sessions, is used to find solutions to the problems discussed during the training sessions.

5. The trainees evaluate the solutions after presenting the derived solutions.

6. A problem is assigned to the trainees for resolution using the principle of TRIZ theory discussed in the training session.

7. Educational methodologies are used in the training program. Such methodologies include collaborative learning, discussion, dialogue, brainstorming, research, and homework.

3.10 Principles Used in the Program

The strategies, as defined by Altshuller, (2002).are as follows:

3.10.1 Segmentation Principle

This principle refers to the possibility of solving problems by splitting the system into several parts, each of which is independent from the others. If the system is already divided, splitting it further can increase the likelihood of solving the problem.

The recommendations for the segmentation principle are as follows:

a) Divide the main system/problem into several parts to ease extractions and combinations.

b) Divide the main system into several parts to enable the removal and retrieval of some parts as needed.
c) Divide each part of the system into sub-parts, e.g., liquid; gas; solid → powder → particles.

d) Increase the degree of segmentation of the system.

### 3.10.2 Extraction Principle

This principle refers to the possibility of solving problems by selecting components that work well, keeping them functional, and identifying the harmful components or parts or those that do not work well for separation and disposal.

The recommendations for the extraction principle are as follows:

a) Identify and maintain the parts of the system that work well, and identify and eliminate the parts that are not working properly.

b) A part of the system that prohibits the completion of the desired outcome should be isolated and eliminated.

c) Identify the most important part of the system and develop a new system that includes only this particular part.

### 3.10.3 Merging Principle

This principle indicates the spatial and temporal links between systems that result in similar or contiguous operations. This principle also refers to the collection of things or similar or identical components that perform functions and balanced operations so that they are close or contiguous in terms of time and place.

The recommendations for the merging principle are as follows:

a) Combine the analogous parts spatially.
b) Combine the analogous parts temporally.

c) Combine the implementation of connected parts simultaneously.

3.10.4 Nesting Principle

This strategy usually includes measures that are contrary to those used in solving problems. If things are fixed, we make them move, and if they are moving, we fix them.

The recommendations for the nesting principle are as follows:

a) Include one part within another or put one part in the interior of another.
b) Insert one part into another part of the system.
c) Increase the number of overlapped parts in the system.
d) Show the activities of the operation when needed and do not show the activities when not needed.

3.10.5 Inversion Principle

This principle enables the system to serve itself by performing supportive functions, namely, maintenance, difference treatment, and use of wasted resources.

The recommendations of the inversion principle are as follows:

a) Invert the stable and dynamic parts of the system.
b) Replace parts of the system with other parts that possess opposite characteristics, e.g., white with black and full with empty.
c) Invert a part of the system from top to bottom.
d) Invert the desired outcome of the system.
3.10.6 Blessing in Disguise Principle

This principle points to changing the color of a thing or its external environment.

The recommendations for the blessing in disguise principle are as follows:

a) Employ the parts of the system that respond negatively to achieve positive outcomes.

b) Maximize the negative effect in such a way that makes unable to portray the negative effect on the system or its surrounding.

c) Eliminate a negative part by merging it with another part that cancels the negative effect.

3.10.7 Changing Color and Transparency Principle

This principle refers to the process of containing something in something else, which in turn can be contained in another and so on. This principle also refers to passing a certain something in the cavity of something else.

The recommendations of the changing color and transparency principle are as follows:

a) Change the color of the outcome or the color of its surrounding.

b) Change the transparency of the system or the transparency of its surroundings.

c) Use glowing colors.
3.10.8 Universality Principle

This principle refers to facilitating the capability of the system to handle several functions or tasks or making every part of the system able to carry out the largest number of job performance, hence the minimal need for other platforms.

The recommendation for the universality principle is as follows:

Enable each part of the system to perform more than its own task. Thus, only a few systems are required.

3.10.9 Copying Principle

This principle refers to the use of items or harmful effects on the environment to obtain positive effects.

The recommendations for the copying principle are as follows:

a) Use a simple, economical copy of the system instead of the original complicated, expensive system.

b) Use a photo to replace the system, with which it can be magnified or shrunk according to arising needs.

3.10.10 Self-service Principle

This principle refers to the possibility of solving problems using a simple copy instead of using complicated things and replacing a thing with its copy.

The recommendations for the self-service principle are as follows:

a) Enable the system to serve itself by doing additional support tasks.
b) Enable the system to serve itself through adaptation and self-correction.

c) Employ available and consumed resources within the system to achieve the desired self-service.

3.11 Teaching Materials

The training program was based on user’s indication that they were extracted from theories in literature.
<table>
<thead>
<tr>
<th>No.</th>
<th>Principle</th>
<th>Activity 1</th>
<th>Activity 2</th>
<th>Activity 3</th>
<th>Skills</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Segmentation</td>
<td>Problem solving</td>
<td>Problem solving</td>
<td>Critical thinking</td>
<td>Problem identification</td>
<td>Assumptions</td>
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<td>Nesting</td>
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<td>Problem solving</td>
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<td>Problem identification</td>
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<tr>
<td>3</td>
<td>Blessing in Disguise</td>
<td>Problem solving</td>
<td>Critical thinking</td>
<td>Interpretations</td>
<td>Problem identification</td>
<td>Making decisions</td>
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<tr>
<td>4</td>
<td>Color Changes</td>
<td>Critical thinking</td>
<td>Critical thinking</td>
<td>Interpretations</td>
<td>Problem solving</td>
<td>Discussions</td>
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<td>Discussions</td>
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<td>Activity 3</td>
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<td>Outlining of problem</td>
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<tr>
<td>5</td>
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<td>Critical thinking</td>
<td>Critical thinking</td>
<td>Interpretations</td>
<td>Critical thinking</td>
<td>Discussions</td>
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<td>Discussions</td>
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<td>Activity 3</td>
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<td></td>
<td>Outlining of problem</td>
</tr>
<tr>
<td>6</td>
<td>Self-service</td>
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<td>Critical thinking</td>
<td>Discussions</td>
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<td>Construction of alternatives</td>
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<td>7</td>
<td>Extraction</td>
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<td>Deduction</td>
<td>Problem solving</td>
<td>Construction of alternatives</td>
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<tr>
<td>8</td>
<td>Inversion</td>
<td>Problem solving</td>
<td>Critical thinking</td>
<td>Deduction</td>
<td>Critical thinking</td>
<td>Construction of alternatives</td>
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<td>9</td>
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<td>Critical thinking</td>
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<td>Making decisions</td>
<td>Critical thinking</td>
<td>Deduction</td>
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<td>Problem solving</td>
<td>Making decisions</td>
<td>Problem solving</td>
<td>Assessment</td>
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</table>
3.12 Reliability of MTRIZP

The researcher prepared the training program as follows. The arbitration of doctoral and master’s campaigns was conducted in special education, talent and guidance and science education, and child psychology in universities, the Ministry of Education, and talent centers; this approach was adopted to judge the appropriateness of the program and the clarity of language, as well as to gather recommendations on how to achieve the objectives of the activities. The arbitrators were also asked to provide recommendations, to express their views, and to modify the MTRIZP in the way they see fit. The researcher adopted the recommendations that the arbitrators agreed upon (70%). The adopted recommendations included change, addition, or deletion of some paragraphs, activities, or meetings. MTRIZP was amended as advised by the arbitrators.

3.13 Conclusion

This chapter discusses the process development of the MTRIZP Program in relation to the scope of the purpose of the study, including the goals, pillars, characteristics, sentimental processes, cognition processes, content, and application.
CHAPTER 4

METHODOLOGY

4.1 Introduction

This research examines the effectiveness of using the MTRIZP to enhance the critical thinking and problem-solving skills of gifted and talented students in Saudi Arabia. As mentioned in Chapter 1, this research aims to answer the following questions:

1. Do the critical thinking and problem-solving skills of the participants in the experimental and control groups significantly differ in the pre-test?
2. Does the application of the MTRIZP exert any significant effects on the critical thinking and problem-solving skills of gifted and talented students?
3. Is the critical thinking of gifted and talented students affected by age, birth order, class, father’s education, and mother’s education after applying MTRIZP?
4. Are the problem-solving skills of gifted and talented students affected by age, birth order, class, father’s education, and mother’s education after applying the MTRIZP?
5. What are the views of the respondents regarding the MTRIZP?

This chapter is aimed at describing, clarifying, and rationalizing the research design that was tailored to answer the research questions. Population, sample, and sampling procedures are discussed, along with the description of the data collection instruments. The pilot study, data collection procedures, and analysis method are explained.
4.2 Research Design

Social science research is classified into two major paradigms, namely, quantitative and qualitative research methods. In general, research that relies primarily on the collection of quantitative data and qualitative data is referred to as “quantitative research” and “qualitative research,” respectively. The quantitative approach deals with the identified problem by testing a theory, measuring with numbers, and analyzing using statistical techniques (Creswell, 2005). By contrast, qualitative research, according to Wiersma (2005), is rooted in descriptive analysis and is essentially an inductive process, that is, reasoning from a specific situation to a general conclusion. Moreover, Libarkin and Kurdziel (2002) considered such type of research as an unconstrained approach to studying phenomena. However, most theorists agree that one approach is not inherently better than others and that a mixed method that combines two approaches is the best, with the two approaches capitalizing on the strengths and compensating for the weaknesses of each other (Creswell, 2003).

Mixed-method studies involves at least one quantitative method and one qualitative method; neither of these methods is inherently linked to any particular inquiry paradigm (Gay, Mills, & Airasian, 2009; Green, Caracelli, & Graham, 1989; Tashakkori & Teddlie, 1998). In other words, mixed-method studies include research that combines qualitative and quantitative approaches into the research methodology of a single study or multiphase study. According to Creswell (2003), a mixed-method approach should be employed when both quantitative and qualitative data are acquired and that a combination of both types of data is better than using either types in terms of clarifying the research problem.
In the light of the previously mentioned information, this current study employs a mixed-method approach. The use of a mixed method is a necessary step for developing new, comprehensive, and explanatory models of assessment and data interpretation. In the context of this study, quantitative data are collected from an experiment, whereas qualitative data are acquired from semi-structured interviews.

Researchers should select and innovate within six designs for mixed-method research; all variants of mixed-method designs might be sub-summed within these six types (Creswell, 2003; Gay, Mills, & Airasian, 2009).

a) QUAN-QUAL Model or Sequential Explanatory Design (Collection and analysis of quantitative data, followed by the collection and analysis of qualitative data as a supplement. Priority is given to quantitative data. Qualitative data are only used to support the findings.)

b) QUAL-QUAN Model or Sequential Exploratory Design (Collection and analysis of qualitative data, followed by the collection and analysis of quantitative data. Priority is given to qualitative data. Quantitative data are only used to support the findings.)

c) Sequential Transformative Design (Both methods may be used first. Priority may be given to any of them.)

d) Concurrent Triangulation Design (Two methods are used separately to confirm, cross-validate, or corroborate the findings. Priority is equal.)

e) Concurrent Nested Design (This method is similar to concurrent triangulation design, but it gives less priority, wherein one method is embedded or nested within a predetermined method.)
f) Concurrent Transformative Design (Researchers use a specific theoretical perspective on the basis of ideologies, conceptual framework, and research questions.)

Some of the hypotheses mentioned in the early parts of the paper are tested using quantitative methods. Subsequently, qualitative data are collected. The qualitative findings should provide support to the understanding of the quantitative findings of this research. Thus, the current study embraces the concurrent triangulation design proposed by Creswell (2003) using the data collected from the experiment and interviews to answer different research questions; these questions complement one another with regard to achieving the overarching research objective.

Research questions 1 to 4 are answered by collecting data from the experiment. Research question number 5 is answered with the data obtained from the interview. In other words, questions 1 to 4 are quantitative, whereas question 5 is qualitative in nature.

This study depends on quasi-experimental method. The current study is also to experimentally develop the level of critical thinking and problem solving of talented students at the Tabok city in Saudi Arabia. This type of development includes an experimental (treatment) group and a control group, which have been pre-tested and post-tested. The experimental sample is randomly selected from the whole population.

Talented students were selected from among all talented students in the Tabok talented center in the 7th–9th grades. The samples were divided into two groups: control and experimental. The two groups are pre-tested before the implementation of the experiment. A post-test is conducted after completing the
implementation of the measurement tools (i.e., the currently used normal program for the control group and the MTRIZ Program for the experimental group) to evaluate the critical thinking problem solving of the talented student. The post-tests are then compared to determine the effectiveness of the treatment. The study is conducted by using the Watson test and Hupner test as the pre- and post-tests.

The data are collected by using both qualitative (interview protocol) and quantitative (experimental) data collection methods. Qualitative data were collected, and the qualitative findings of this research provided supports to have deeper understanding of the quantitative findings of this research.

4.3 Population of the Study

The population of this study comprises gifted and talented students from Tabuk Gifted and Talented Student Center located in the city of Tabuk, Saudi Arabia. These students were in seventh, eighth, and ninth grades at the time of the study. Based on data obtained from the Ministry of Education, this study involves the participation of 216 gifted and talented male students around the age of 13 years.

Tabuk Gifted and Talented Student Center is an exclusive center for gifted and talented students, who are tested by the Ministry of Education prior to their enrolment to the Center. The Center in Tabuk was selected because it is located in one of the main cities in Saudi Arabia and it is easily accessible to the researcher. The participating students in seventh, eighth, and ninth grades were chosen because of their age, which meets the requirements of this research.
4.4 Samples and Sampling Procedure

Out of the 216 students, 80 were randomly selected from the name list obtained from the Center’s administration. The sample is divided into control and experimental groups. The control and experimental groups include 40 students each. Four teachers from the Center are selected according to their experience with the groups. Two of the teachers are trained to apply the MTRIZP to the experimental groups, and the other two teachers are trained to apply the regular program to the control group. Table 4.1 illustrates the sampling process.

Table 4.1
Distribution of study participants from the Tabuk Talent Center

<table>
<thead>
<tr>
<th>Gender</th>
<th>Group</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Experimental</td>
</tr>
<tr>
<td>Male</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>216</td>
</tr>
</tbody>
</table>

4.5 Variables

The independent variable used in this study is the application of the MTRIZP, whereas the dependent variables are as follows:

a) Levels of critical thinking skills reflected in five dimensions as measured by Watson scale (1964)

b) Levels of problem-solving skills reflected in five dimensions as measured by Heppner and Petersen scale (1982).

Qualitative data are obtained from the control and experimental groups to measure the two dependent variables.
4.6 Assessment

This study uses two different assessments, namely, Watson’s Critical Thinking Assessment and Hamdi’s Problem Solving Assessment.

4.6.1 Watson’s Critical Thinking Assessment

Watson’s Critical Thinking test was developed by Watson in 1925. This test was later amended by Glaser and then finalized in 1964. Watson’s test was utilized in the western region of KSA after its adaptation to the KSA environment by Abdul Salam and Sulaiman in 1982 (Abdul-Salam & Sulaiman, 1982).

Watson’s Critical Thinking test aims to measure five subcategories of critical thinking: (1) assumptions, (2) interpretation, (3) discussion assessment, (4) deduction, and (5) inference.

The scoring of Watson’s Critical Thinking test is based on the metrics of the test. Correct answers receive one point, whereas wrong answers receive zero. The same scoring is applied to all questions of the test. The level on the scale varies between 0 to 15 Grade, The overall grade ranges from 0 to 75 Grade.

4.6.1 (a) Validity of Watson’s Critical Thinking Assessment

The internal consistency coefficient was measured by implementing it on a pilot sample of 30 participants, which was computed using Pearson's formula. The correlation coefficient of each item was calculated using SPSS, which was statistically significant at levels 0.01 and 0.05.
Thus, the test is highly consistent and valid as a tool for the study. The internal consistency coefficient of the critical thinking test was identified by calculating the Pearson's correlation coefficient for the five dimensions and the entire the test. Table 4.2 shows the results of Pearson's correlation.

**Table 4.2**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Assumption</th>
<th>Interpretation</th>
<th>Discussion assessment</th>
<th>Deduction</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation</td>
<td>0.82</td>
<td>0.84</td>
<td>0.81</td>
<td>0.87</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Table 4.2 shows that the values of the correlation coefficients of the critical thinking test dimensions ranged from 0.81 to 0.95 These values were statistically significant at 0.01 and 0.05 levels, which imply consistency between the test dimensions. The values of the correlation coefficients between each dimension within the entire test ranged from 0.76 to 0.94. These values are statistically significant at 0.01 and 0.05 level, which indicates high internal consistency and validity.

### 4.6.1 (b) Reliability of the Critical Thinking Scale

The data collected using the test from the pilot sample of 30 participants was also used to calculate the reliability of the test using the Cronbach's alpha method. Table 4.3 presents the results for each dimension in the test.

**Table 4.3**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Assumption</th>
<th>Interpretation</th>
<th>Discussion assessment</th>
<th>Deduction</th>
<th>Inference</th>
<th>Overall Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach's Alpha</td>
<td>0.83</td>
<td>0.74</td>
<td>0.73</td>
<td>0.75</td>
<td>0.72</td>
<td>0.91</td>
</tr>
</tbody>
</table>
The Cronbach's alpha values in Table 4.3 indicate a high level of reliability. The Cronbach's alpha of the test was 0.91, which indicates that the test is appropriate for the present study.

4.6.2 Happnar’s Problem Solving Assessment

In this study, problem-solving skills were measured by utilizing Happnar’s Problem Solving Assessment (Happnar, 1978). Happnar’s Problem Solving Assessment was adapted for the Arabic environment by Hamdi (1998). Happnar’s Assessment is divided into five sub-categories, namely, (1) problem identification, (2) outlining the problem, (3) construction of alternatives, (4) making decisions, and (5) assessment. The test comprises 40 statements, and each subcategory consists of eight statements. Hamdi (1998) consulted a panel of experts regarding the modified Happnar’s test. The panel consisted of 18 doctorate- and master-level education experts, who examined each item of the test for suitability. The judging of items was considered according to its intended purpose in the test. The items that were retained in the test consisted of those items that were approved by 90% of the judging panel.

4.6.2 (a) Grading Method for Problem Solving Assessment

(1) The Problem Solving Assessment test comprises 40 statements. The test is preferably administered to children ages 10 years and up.

(2) The details for the test grading are listed in Table 4.4.
Table 4.4
Grading rubric for the Problem Solving Assessment

<table>
<thead>
<tr>
<th>Item</th>
<th>Test category</th>
<th>Measured by responses to statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General attitude</td>
<td>1; 6; 11; 16; 21; 26; 31; 36.</td>
</tr>
<tr>
<td>2</td>
<td>Identification of the problem</td>
<td>2; 7; 12; 17; 22; 27; 32; 37.</td>
</tr>
<tr>
<td>3</td>
<td>Generating alternatives</td>
<td>3; 8; 13; 18; 23; 28; 33; 38</td>
</tr>
<tr>
<td>4</td>
<td>Making a decision</td>
<td>4; 9; 14; 19; 24; 29; 34; 39</td>
</tr>
<tr>
<td>5</td>
<td>Assessment</td>
<td>5; 10; 15; 20; 25; 30; 35; 40</td>
</tr>
</tbody>
</table>

(3) Test grades can range from 40 to 160 points.

(4) Each test category can range from 8 to 32 points.

(5) The results of the test can be explained as follows:

(a) 40–80 points indicate lack of problem solving skills

(b) 80+ points indicate proficiency in problem solving

4.6.2 (b) Validity of the Problem-solving Scale

The content of this scale was validated by a panel of experts from universities in Jordan and Saudi Arabia, as well as from the Ministry of Education, to judge the suitability of each paragraph of the test, its content and relevance, clarity of language, and the extent of its representation of the dimensions of the scale that was developed to measure it. For the purposes of this study, validation was performed to retain the paragraphs deemed suitable by the arbitrators (80%).
4.6.2 (c) Reliability of the Problem-solving Scale

The reliability of the internal consistency coefficients for problem solving was determined using Cronbach’s alpha. The dimensions were rescaled after four weeks following the initial application. For the purposes of this study, the researcher applied this measure on a sample comprising 40 gifted students from Tabuk Center to determine the validity and reliability of the scale factor. Table 4.5 shows the stability of such dimensions for consistency and repetition.

Table 4.5
Reliability coefficients (Cronbach’s alpha) for the dimensions of the problem-solving measure in this study

<table>
<thead>
<tr>
<th>Stability of reliability coefficient</th>
<th>Stability of the internal consistency coefficient (Cronbach’s alpha)</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.78</td>
<td>0.74</td>
<td>General attitude</td>
</tr>
<tr>
<td>0.80</td>
<td>0.83</td>
<td>Identification of the problem</td>
</tr>
<tr>
<td>0.74</td>
<td>0.77</td>
<td>Generating alternatives</td>
</tr>
<tr>
<td>0.75</td>
<td>0.72</td>
<td>Making decisions</td>
</tr>
<tr>
<td>0.77</td>
<td>0.80</td>
<td>Assessment</td>
</tr>
</tbody>
</table>

Table 4.5 shows that the scale as a whole is consistent as shown in the coefficient of 0.93. The table also indicates that the measure of the dimensions is stable, with the internal consistency ranging from 0.72 to 0.83. The overall stability of the scale reaches 0.81, and those of the dimensions range from 0.74 to 0.80. All reliability coefficients indicate good reliability.
4.7 Interview

This work used a semi-structured interview methodology to allow new ideas to emerge from the interviewees. Class interviews were administered to the experimental group administered with MTRIZP. The main goal of the interview was to diagnose the attitudes of the talented students toward the learning that occurred during the administration of the MTRIZP. The interview questions were adapted from Watson and Happnar and were translated to Arabic by an Arabic language expert. The interviews were conducted in Arabic language. After the completion of the interviews, the interview data were translated to English and then validated by educational psychology experts. Two cycles of qualitative coding were initiated. The first cycle of coding was aimed at emphasizing the “real voice” of the participants, whereas the second cycle of coding was aimed at developing a sense of conceptual, thematic, and theoretical organization from the codes in the first cycle. In vivo coding was employed in the first cycle, whereas thematic analysis was performed in the second cycle.

4.7.1 Validity of Interview

The interview questions were examined by three educational psychologists and three teachers to ensure the suitability of the content and to guarantee that the questions could fully serve the goal of the interviews. After the review of the questions, the feedback of the reviewers was used to make necessary adjustments to the questions. The final version of the interview questions consisted of those that target critical thinking and problem-solving abilities. Three English language
professors validated the translated version of the questions adapted from Watson and Happnar, as well as the translation of the interview data.

4.7.2 Reliability of Interview

All interviews administered to the experimental group were evaluated using an inter-rater. A teacher was trained to conduct the interviews and record the responses objectively. The teacher was diligently trained to ensure that the students fully understood the questions and that the responses of the students were aligned with the target concepts sought through the interview questions. The trained teacher recorded and compiled the results of the interviews in the data recording worksheet. The trained teacher then discussed the data with the researcher. The teacher and researcher examined the students’ responses and determined the attitudes of the students toward the MTRIZP.

4.8 Pilot Study

The goals of the pilot study were to examine the difficulty of the tests and to assess the suitable period for completing the test. During the pilot study phase, the researcher aimed to obtain insights that would benefit the actual study and assess the reliability of the design and conduct of the study.

The pilot study involved talented students from Tabuk City. The criteria for selecting the participants in the pilot study were exactly the same as those used for the main study. The pilot study sample consisted of 40 male students. The subjects were divided into two groups, namely, an experimental group, which was administered with the MTRIZP, and a control group, which were administered with the usual
talent program offered by the Ministry of Education. The pilot study was conducted by the same two teachers who conducted the main study.

4.8.1 Sample of the Pilot Study

The pilot study involved a group of talented students from Tabuk City. The participants shared similar characteristics with the students from the main study in the academic year of 2014/2015. The study sample comprised 40 males. The reliability of the instruments was established during this phase. The subjects were divided into experimental and control group. The researcher performed the pilot study with the help of the same two teachers who conducted the main study.

The pilot study was conducted to test the difficulty of the items and the amount of time needed by the subjects to complete the tests. The pilot study was designed to help the researcher gain knowledge in coding the observed items. The results of the pilot study were expected to provide the researcher with ideas for possible questions that could be raised in the actual study.

4.8.2 Procedure for Identifying Talented Students in Saudi Arabia

In Saudi Arabia, students are accepted into talented programs according to the following criteria:

1) Academic achievement: The overall grade average of the student in previous academic years should be greater than or equal to 90%.

2) Renzolli’s behavioral guidelines.
3) High achievement in the Mental and Creative Abilities Tests. The student is identified as talented if he or she scores at least 120 points in the Mental Ability Test or 130 points or higher in the Kessler Test.

4) Application of Torrance Creative Thinking Test (Al-Nafea et al., 2000).

4.8.3 Data Collection in the Pilot Study

The pre-tests were administered two days before the administration of the MTRIZP Program for the experimental group and the Ministry of Education talent program for the control group. The post-tests were conducted four weeks after the completion of the two programs. Data were collected within five weeks spanning the following phases.

4.8.3 (a) Phase One: Pre-Test

Phase one was administered two days before the instructional programs. This phase involved the use of the Watson and Happnar Tests, which measure critical thinking and problem-solving abilities, respectively. In this phase, the students were allowed to ask questions to understand the testing procedure, and the instructor was allowed to clarify unclear/vague test questions.

4.8.3 (b) Phase two: Administering the Talent Programs

The experimental group received four weeks of MTRIZP instructions, whereas the control group received the usual instructions for the talent program offered by the Ministry of Education.
4.8.3 (c) Phase Three: Post-Tests

Both the experimental and control groups completed the Watson and Happnar Tests four weeks after the conclusion of the instructional programs.

4.9 Research Procedure

The study procedure included the following:

1) Permission to start the study with the talented students of Tabuk Center in Tabuk City was obtained from the Ministry of Education in KSA.

2) The sample was selected from the population. The participants were assigned to the four teaching programs following the steps discussed earlier.

3) Training on the implementation of the MTRIZP was provided to the teachers in the experimental group in coordination with the administrators of Tabuk City.

4) Instructions in using the interview questions were provided to the teachers in the experimental group.

5) The study instruments (Watson and Happnar Tests) were implemented to group the participating students according to their learning abilities before the actual teaching of MTRIZP.

6) Watson and Happnar Tests were administered as a pre-test to the study sample in preparation for the actual practical implementation of MTRIZP.

7) Watson and Happnar Tests were re-administered as a post-test to the study sample following the completion of the MTRIZP in the experimental group.
8) The SPSS program was used to conduct statistical analyses and summarize the findings. Interpretation, discussion, and comparison of the results with those from other studies were also conducted. Recommendations were then put forward.

4.10 Main Study

The data of the main study were collected from Tabuk City, KSA, in October, November, and December 2015. The process of administering the instruments in the pilot study was employed in the main study.

4.10.1 Data Collection Procedures in the Main Study

The research instruments were collected in Tabuk City, KSA, in October, November, and December 2015. The instruments were collected in four phases in the span of 10 weeks.

4.10.1 (a) Phase One

The administration of the measurement instruments was conducted in one day. The pre-test included the implementation of the instrument (Watson and Happnar Tests) to measure the critical thinking and problem-solving skills of participants. Their scores before and after the application of the programs were also compared in the pre-test. Watson and Happnar Tests were administered to the two groups on the first day.
4.10.1 (b) Phase Two

The experimental group received the training for 10 weeks, whereas the control groups did not receive training after the pre-tests. The experimental group was taught under the MTRIZP, whereas the control group was taught under the currently used program. Interviews were conducted by the teacher and the researcher. The implementation of the MTRIZP was also recorded.

4.10.1 (c) Phase Three

The same instruments (Watson and Happnar Tests) were distributed as post-tests after the implementation of the MTRIZP to measure the performance of the participants after the training. The tests were administered for 45 mins in one day.

4.10.1 (d) Phase Four: Experimental Group Interview

The experimental group was interviewed after completion of the post-test. Each student was interviewed individually by a trained teacher. The interview results were compiled by the trained teacher, who then discussed the data with the researcher. The goal of the interviews was to measure the effect of the MTRIZP implementation on the attitudes and performance of the participants.

4.11 Data Analyses

Data were analyzed to fulfill the objectives and hypotheses of the study. Statistical software SPSS version 20 was employed to analyze the quantitative data. Several
statistical analysis methods were utilized. These methods are explained in the following subsections, along with a discussion of the qualitative data analyses.

4.11.1 Quantitative Data Analyses

Based on the research questions, different statistical analyses methods were applied in the statistical software to analyze the quantitative data. Table 4.6 summarizes the statistical tests used to obtained the results.

<table>
<thead>
<tr>
<th>Table 4.6</th>
<th>Quantitative data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Statistical Analysis</td>
</tr>
<tr>
<td>To examine the existence of any significant difference in the critical thinking and problem-solving skills of the participants in the experimental and control groups during the pre-test.</td>
<td>Independent t-test</td>
</tr>
<tr>
<td>To examine the existence of any significant effect of the application of the MTRIZP on the critical thinking and problem-solving skills of the participants.</td>
<td>Independent t-test</td>
</tr>
<tr>
<td>To examine the existence of any effect of age, birth order, class, father’s education, and mother’s education on the critical thinking skills of the participants after applying the MTRIZP.</td>
<td>ANOVA and Kruskal Wallis Test</td>
</tr>
<tr>
<td>To examine the existence of any effect of age, birth order, class, father’s education, and mother’s education on the problem-solving skills of the participants after applying the MTRIZP.</td>
<td>ANOVA and Kruskal Wallis Test</td>
</tr>
</tbody>
</table>

The following discussion highlights the appropriate types of statistical tests that should be used for the purpose of data analysis, as shown in Tables 4.7, 4.8, and 4.9.
Table 4.7
Appropriate statistical tests for the overall scores of the critical thinking and problem-solving skills of the participants

<table>
<thead>
<tr>
<th>Test</th>
<th>Experimental</th>
<th>Control</th>
<th>Statistical tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall score of critical thinking</td>
<td>Post Normal</td>
<td>Normal</td>
<td><strong>Parametric</strong></td>
</tr>
<tr>
<td></td>
<td>Pre Normal</td>
<td>Normal</td>
<td><strong>Parametric</strong></td>
</tr>
<tr>
<td><strong>Statistical tests</strong></td>
<td><strong>Parametric</strong></td>
<td><strong>Parametric</strong></td>
<td></td>
</tr>
<tr>
<td>Overall score of problem-solving skills</td>
<td>Post Normal</td>
<td>Normal</td>
<td><strong>Parametric</strong></td>
</tr>
<tr>
<td></td>
<td>Pre Normal</td>
<td>Non-normal</td>
<td><strong>Non-parametric</strong></td>
</tr>
<tr>
<td><strong>Statistical tests</strong></td>
<td><strong>Parametric</strong></td>
<td><strong>Non-parametric</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.8 shows the appropriate statistical tests for the critical thinking domains.

Table 4.8
Appropriate statistical tests for critical thinking domains

<table>
<thead>
<tr>
<th>Test</th>
<th>Experimental</th>
<th>Control</th>
<th>Statistical tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumption</td>
<td>Post Non-normal</td>
<td>Normal</td>
<td><strong>Non-parametric</strong></td>
</tr>
<tr>
<td></td>
<td>Pre Non-normal</td>
<td>Normal</td>
<td><strong>Non-parametric</strong></td>
</tr>
<tr>
<td><strong>Statistical tests</strong></td>
<td><strong>Non-parametric</strong></td>
<td><strong>Parametric</strong></td>
<td></td>
</tr>
<tr>
<td>Interpretation</td>
<td>Post Non-normal</td>
<td>Normal</td>
<td><strong>Non-parametric</strong></td>
</tr>
<tr>
<td></td>
<td>Pre Non-normal</td>
<td>Non-normal</td>
<td><strong>Non-parametric</strong></td>
</tr>
<tr>
<td><strong>Statistical tests</strong></td>
<td><strong>Non-parametric</strong></td>
<td>Non-parametric</td>
<td></td>
</tr>
<tr>
<td>Discussion</td>
<td>Post Non-normal</td>
<td>Normal</td>
<td><strong>Non-parametric</strong></td>
</tr>
<tr>
<td></td>
<td>Pre Normal</td>
<td>Normal</td>
<td><strong>Parametric</strong></td>
</tr>
<tr>
<td><strong>Statistical tests</strong></td>
<td><strong>Non-parametric</strong></td>
<td><strong>Parametric</strong></td>
<td></td>
</tr>
<tr>
<td>Deduction</td>
<td>Post Normal</td>
<td>Normal</td>
<td><strong>Parametric</strong></td>
</tr>
<tr>
<td></td>
<td>Pre Non-normal</td>
<td>Normal</td>
<td><strong>Non-parametric</strong></td>
</tr>
</tbody>
</table>
Table 4.9 shows the appropriate statistical tests for the problem-solving domains.

**Table 4.9**
**Appropriate statistical tests for problem-solving domains**

<table>
<thead>
<tr>
<th>Test</th>
<th>Experimental</th>
<th>Control</th>
<th>Statistical tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical tests</td>
<td>Non-parametric</td>
<td>Parametric</td>
<td></td>
</tr>
<tr>
<td>Inference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post</td>
<td>Non-normal</td>
<td>Normal</td>
<td>Non-parametric</td>
</tr>
<tr>
<td>Pre</td>
<td>Non-normal</td>
<td>Normal</td>
<td>Non-parametric</td>
</tr>
<tr>
<td>Statistical tests</td>
<td>Non-parametric</td>
<td>Parametric</td>
<td></td>
</tr>
</tbody>
</table>

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4.11.2 Qualitative data analyses

The data were obtained via interviews. Two cycles of qualitative coding were initiated. The first cycle of coding was aimed at emphasizing the “real voice” of the participants, whereas the second cycle of coding was aimed at developing a sense of conceptual, thematic, and theoretical organization from the codes in the first cycle (Cooper, 2009; Saldaña, 2015).

In vivo coding was employed in the first cycle, whereas thematic analysis was performed in the second cycle.

4.11.2 (a) In vivo Coding

In vivo coding was performed to analyze the qualitative data collected. In vivo coding is appropriate for almost all qualitative studies, particularly those that prioritize the voice of participants. In vivo codes refer to words or short phrases expressed by the participants themselves (Strauss, 1987). Stringer (1999) maintains that in vivo coding is particularly useful in educational research wherein the voice of adolescents is often marginalized. Through in vivo coding, the actual words of adolescents enhance and deepen the understanding of researchers.

In vivo coding requires thorough readings of every sentence. Phrases or words within responses should also be distinguished to “crystallize and condense meanings.” Therefore, codes must appear next to every line of data. However, in vivo codes can be applied with low frequency, e.g., one word or phrase for every three to five sentences, depending on the research objective. In vivo codes could be used as the sole coding method for small-scale studies (Charmaz, 2006; Saldaña, 2015).
In the context of the present study, in vivo coding was employed in the first cycle of coding to obtain the actual voice of the teachers and students involved in the application of MTRIZP. Their actual voice represented their experience in the experiment process and could thus carry some themes that were not included in the conceptual framework of this study. The coding of the actual voice of the participants was followed by the second cycle of coding that involved thematic analyses.

4.11.2 (b) Thematic Analyses

Thematic analyses, or the search for themes in data, were conducted after the in vivo coding in the first cycle. A theme might be identified at the manifest level (observable in the response) or at the latent level (underlying the phenomenon). At the manifest level, a theme serves as a common denominator to the group and organizes a set of data. At the latent level, themes are interpretive and insightful discoveries of the nature or meaning of our daily lives. In summary, themes capture the phenomenon being investigated and help researchers deepen their understanding.

Similar to coding, thematic analysis method is a strategic choice in the research design, which includes primary questions, goals, conceptual framework, and literature review. Ryan and Bernard (2003) suggest that themes can be found in data by looking for qualities, such as metaphors, expressions, linguistic connectors, shifts in topics, theoretical issues suggested by responses, and those that have never been discussed previously (emerging theme). Kvale (1995) and Rubin and Rubin (1995) maintain that interviewers do not uncover some preexisting meanings but instead support interviewees in developing their meanings throughout the course of their
interviews. These themes should be stated as simple as possible and then woven together to explain why something happened or what something means. The percentages of selected data for assessing phenomena can be calculated, but this approach is not necessary in research that involves quantitative methods.

Thematic analyses in the present study comprised the second cycle of coding. The goal of the thematic analyses was to categorize the “actual voice” collected from the previous cycle. Owing to the different ways in which the participants expressed their actual voices, thematic coding was employed to organize the data into categories that would be analyzed to support the quantitative findings and to answer the qualitative research question of the study.

Qualitative data are collected from interviews before they are excerpted, coded, and themed. Further analyses are performed based on codes and themes. Apart from answering research questions 5 and 6, the qualitative findings can also be utilized to explain or support the quantitative findings related to research questions 1 to 4.

4.12 Ethical Issues

Researchers working on any study should consider ethical issues or dilemmas. Careful focus should be set on the subjects of inquiries, research procedures, and human rights of participants (Schurink, 2009). In the present study, several issues were considered to avoid any unethical complexities. For example, the identities and responses of the participants were coded for anonymity and preserve confidentiality. They were advised that the collected information would be treated as confidential.
and used only for academic research and that their basic human rights would not be violated.

4.13 Conclusion

This chapter discussed the methodology adopted in the study. The instruments and summary of the pilot study data analyses were also presented. The large sample size in the actual study was expected to produce identical findings despite the likely emergence of different amplitudes of connections among variables.
CHAPTER 5

RESULTS

5.1 Introduction
The results of data analysis are presented in this chapter, p values used as 0.05. Data were collected and processed in light of the research questions and hypotheses posed in Chapter 1 of this study.

5.2 Characteristics of Participants and Groups
The characteristics of the participants and groups in the current study are as follows.

5.2.1 Demographic Characteristics of Participants
The current study involved two groups, namely, experimental and control groups, each of which involved 50 students. Students aged 13 years mainly comprised the sample (40%), followed by those aged 14 years (36.3%) and 12 years (23.8%). In terms of the order of birth, the participants were mostly firstborns (47.5%), followed by middle children (30%) and youngest (22.5%). In terms of class, seventh class students received the highest incidence with 38.8%, followed by those in the eighth (35%) and ninth (26.3%) classes. In terms of the education of the students’ fathers, a majority of the fathers held university bachelor’s degrees (37.5%), followed by those who finished secondary school or lower (36.25%) and those at the postgraduate level (26.25%). In terms of the education of the students’ mothers, half of the mothers finished secondary school and lower (50%), followed by university bachelors (30%) and postgraduates (15%). These data are shown in Table 5.1.
Table 5.1
Demographic characteristics of participants

<table>
<thead>
<tr>
<th>Demographic data</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>40</td>
<td>50.0</td>
</tr>
<tr>
<td>Control</td>
<td>40</td>
<td>50.0</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>19</td>
<td>23.75</td>
</tr>
<tr>
<td>13 years</td>
<td>32</td>
<td>40.0</td>
</tr>
<tr>
<td>14 years</td>
<td>29</td>
<td>36.25</td>
</tr>
<tr>
<td>Birth Order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eldest</td>
<td>38</td>
<td>47.5</td>
</tr>
<tr>
<td>Middle child</td>
<td>24</td>
<td>30.0</td>
</tr>
<tr>
<td>Youngest</td>
<td>18</td>
<td>22.5</td>
</tr>
<tr>
<td>Class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seven</td>
<td>31</td>
<td>38.75</td>
</tr>
<tr>
<td>Eight</td>
<td>28</td>
<td>35.0</td>
</tr>
<tr>
<td>Nine</td>
<td>21</td>
<td>26.25</td>
</tr>
<tr>
<td>Father’s education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
<td>29</td>
<td>36.25</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>30</td>
<td>37.5</td>
</tr>
<tr>
<td>Postgraduate</td>
<td>21</td>
<td>26.25</td>
</tr>
<tr>
<td>Mother’s education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
<td>44</td>
<td>55.0</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>24</td>
<td>30.0</td>
</tr>
<tr>
<td>Postgraduate</td>
<td>12</td>
<td>15.0</td>
</tr>
</tbody>
</table>

5.3 Difference in Participants’ Characteristics Between Groups

The differences in the characteristics of the participants in the control and experimental groups are described in the following subsections.

5.3.1 Difference in Demographic Characteristics Between Groups

Chi-square is the appropriate statistical test for determining any differences in the demographic characteristics of participants in the control and experimental groups. Comparison was performed to determine whether any changes in the demographic characteristics of the participants affected the outcomes of this study after applying the intervention program.
The results shown in Table 5.2 indicate no difference in the demographic characteristics of participants.

**Table 5.2**

Differences in demographic characteristics between groups

<table>
<thead>
<tr>
<th>Demographic characteristics</th>
<th>Experimental No. (%)</th>
<th>Control No. (%)</th>
<th>Pearson Chi-Square</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 12 years</td>
<td>12 (30%)</td>
<td>7 (17.5%)</td>
<td>3.130</td>
<td>0.209</td>
</tr>
<tr>
<td>13 years</td>
<td>17 (42.5%)</td>
<td>15 (37.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 years</td>
<td>11 (27.5%)</td>
<td>18 (45%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth order</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eldest</td>
<td>21 (52.5%)</td>
<td>17 (42.5%)</td>
<td>0.810</td>
<td>0.667</td>
</tr>
<tr>
<td>Middle child</td>
<td>11 (27.5%)</td>
<td>13 (32.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youngest</td>
<td>8 (20%)</td>
<td>10 (25%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seven</td>
<td>16 (40%)</td>
<td>15 (37.5%)</td>
<td>0.080</td>
<td>0.961</td>
</tr>
<tr>
<td>Eight</td>
<td>14 (35%)</td>
<td>14 (35%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nine</td>
<td>10 (25%)</td>
<td>11 (27.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fathers’ education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
<td>17 (42.5%)</td>
<td>12 (30%)</td>
<td>1.443</td>
<td>0.486</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>13 (32.5%)</td>
<td>17 (42.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
<td>10 (25%)</td>
<td>11 (27.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mothers’ education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
<td>21 (52.5%)</td>
<td>23 (57.5%)</td>
<td>1.591</td>
<td>0.451</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>11 (27.5%)</td>
<td>13 (32.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
<td>8 (20%)</td>
<td>4 (10%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.4 Descriptive Outcomes of the Problem-solving and Critical Thinking Skills of Participants

Table 5.3 illustrates the mean (±SD) and median of the participants’ problem-solving and critical thinking skills obtained in the pre-and post-tests. Similarities were observed in the participants’ problems-solving and critical thinking skills and in their
overall scores in the pre-tests. Higher means and medians were observed in the results of the experimental group than in those of the control group.

Table 5.3  
Descriptive results of participants’ problem-solving and critical thinking skills in the pre- and post-tests.

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-tests</th>
<th>Post-tests</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental</td>
<td>Control</td>
<td>Experimental</td>
<td>Control</td>
<td>Experimental</td>
<td>Control</td>
</tr>
<tr>
<td></td>
<td>Mean (±SD)</td>
<td>Median</td>
<td>Mean (±SD)</td>
<td>Median</td>
<td>Mean (±SD)</td>
<td>Median</td>
</tr>
<tr>
<td>Problem-solving skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General attitude</td>
<td>2.65 (0.41)</td>
<td>2.63</td>
<td>2.81 (0.43)</td>
<td>2.75</td>
<td>3.07 (0.44)</td>
<td>3.06</td>
</tr>
<tr>
<td>Identification of problem</td>
<td>2.94 (0.36)</td>
<td>3.00</td>
<td>3.02 (0.47)</td>
<td>3.06</td>
<td>3.18 (0.34)</td>
<td>3.19</td>
</tr>
<tr>
<td>Generating alternatives</td>
<td>3.05 (0.37)</td>
<td>3.00</td>
<td>3.00 (0.44)</td>
<td>3.00</td>
<td>3.22 (0.32)</td>
<td>3.25</td>
</tr>
<tr>
<td>Making decisions</td>
<td>2.96 (0.31)</td>
<td>3.00</td>
<td>3.04 (0.45)</td>
<td>3.13</td>
<td>3.23 (0.33)</td>
<td>3.19</td>
</tr>
<tr>
<td>Assessment</td>
<td>2.88 (0.37)</td>
<td>2.88</td>
<td>3.00 (0.37)</td>
<td>2.88</td>
<td>3.17 (0.41)</td>
<td>3.19</td>
</tr>
<tr>
<td>Total</td>
<td>2.90 (0.23)</td>
<td>2.88</td>
<td>2.98 (0.35)</td>
<td>2.89</td>
<td>3.14 (0.22)</td>
<td>3.15</td>
</tr>
<tr>
<td>Critical thinking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assumption</td>
<td>17.98 (2.92)</td>
<td>18.00</td>
<td>17.85 (2.90)</td>
<td>17.00</td>
<td>21.25 (3.69)</td>
<td>20.50</td>
</tr>
<tr>
<td>Interpretation</td>
<td>18.10 (2.78)</td>
<td>19.00</td>
<td>18.35 (3.18)</td>
<td>19.00</td>
<td>22.13 (2.35)</td>
<td>22.00</td>
</tr>
<tr>
<td>Discussion</td>
<td>17.28 (3.10)</td>
<td>17.50</td>
<td>17.53 (3.11)</td>
<td>17.00</td>
<td>22.95 (2.63)</td>
<td>22.00</td>
</tr>
<tr>
<td>Deduction</td>
<td>17.53 (3.19)</td>
<td>18.00</td>
<td>18.48 (3.78)</td>
<td>18.00</td>
<td>19.68 (2.40)</td>
<td>20.00</td>
</tr>
<tr>
<td>Inference</td>
<td>6.63 (2.55)</td>
<td>7.00</td>
<td>7.38 (2.51)</td>
<td>7.00</td>
<td>10.30 (3.35)</td>
<td>10.00</td>
</tr>
<tr>
<td>Total</td>
<td>15.50 (1.56)</td>
<td>15.80</td>
<td>15.92 (1.40)</td>
<td>16.20</td>
<td>19.26 (1.19)</td>
<td>19.10</td>
</tr>
</tbody>
</table>

5.5 Results

The results of the research questions are described as follows.

5.5.1 Results of the First Question

The first research question is “Do the critical thinking and problem-solving skills of the participants in the experimental and control groups significantly differ in the pre-test?” An independent t-test was used to identify differences in the overall scores of
the critical thinking skills of the participants in the experimental and control groups. The result showed no significant difference between the two groups as shown in Table 5.4.

**Table 5.4**
**Differences in critical thinking skills between groups in the pre-tests**

<table>
<thead>
<tr>
<th>Overall score of critical thinking</th>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental</td>
<td>15.50</td>
<td>1.56</td>
<td>−0.415</td>
<td>−1.07</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>15.92</td>
<td>1.40</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Independent t-test

The Mann–Whitney statistical test was used to determine any differences in the problem-solving skills of the participants in the experimental and control groups during the pre-tests. No significant difference was found, as shown in Table 5.5.

**Table 5.5**
**Differences in problem-solving skills between groups in the pre-tests.**

<table>
<thead>
<tr>
<th>Overall score of problem-solving skills</th>
<th>Group</th>
<th>Mean Rank</th>
<th>Mann–Whitney U</th>
<th>Z value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental</td>
<td>39.23</td>
<td>749.00</td>
<td>−0.491</td>
<td>0.623</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>41.78</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mann–Whitney

An independent t-test was used to identify any differences in the discussions between the experimental and control groups in the pre-tests. The Mann–Whitney test was used to determine any differences in the assumption, interpretation, deduction, and inference between the experimental and control groups in the pre-tests. No significant difference was observed in the critical thinking domains of the participants in the experimental and control groups in the pre-tests, as shown in Table 5.6.
Table 5.6
Differences in critical thinking domains between groups in the pre-tests

<table>
<thead>
<tr>
<th>Critical thinking</th>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Discussion</td>
<td>Experimental</td>
<td>17.28</td>
<td>3.10</td>
<td>−0.25</td>
<td>−1.63</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>17.53</td>
<td>3.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assumption</td>
<td>Experimental</td>
<td>42.23</td>
<td>731.00</td>
<td>−0.67</td>
<td>0.502**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>38.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interpretation</td>
<td>Experimental</td>
<td>38.40</td>
<td>716.00</td>
<td>−0.81</td>
<td>0.416**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>42.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deduction</td>
<td>Experimental</td>
<td>37.48</td>
<td>679.00</td>
<td>−1.17</td>
<td>0.241**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>43.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inference</td>
<td>Experimental</td>
<td>37.81</td>
<td>692.50</td>
<td>−1.04</td>
<td>0.297**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>43.19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Independent t-test ** Mann–Whitney

An independent t-test was used to determine any differences in the general attitude and identification of problem between the experimental and control groups. The Mann–Whitney test is the appropriate statistical test for identifying differences in generating alternatives, making decisions, and assessment between the experimental and control groups in the pre-tests. No significant difference was found in the problem-solving skills between the experimental and control groups in the pre-tests, as shown in Table 5.7.
Table 5.7
Differences in problem-solving domains between groups in the pre-tests

<table>
<thead>
<tr>
<th>Problem-solving skills</th>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>General attitude</td>
<td>Experimental</td>
<td>2.65</td>
<td>0.41</td>
<td>−0.16</td>
<td>−0.35</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>2.81</td>
<td>0.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification of</td>
<td>Experimental</td>
<td>2.94</td>
<td>0.36</td>
<td>−0.08</td>
<td>0.09</td>
<td>−0.26</td>
</tr>
<tr>
<td>problem</td>
<td>Control</td>
<td>3.02</td>
<td>0.47</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generating alternatives</td>
<td>Experimental</td>
<td>42.01</td>
<td>739.50</td>
<td>−0.586</td>
<td>−0.586</td>
<td>0.558**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>38.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making decisions</td>
<td>Experimental</td>
<td>37.28</td>
<td>671.00</td>
<td>−1.251</td>
<td>−1.251</td>
<td>0.211**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>43.73</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td>Experimental</td>
<td>38.03</td>
<td>701.00</td>
<td>−0.961</td>
<td>−0.961</td>
<td>0.337**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>42.98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Independent t-test  ** Mann–Whitney

5.5.2 Results of the Second Question

The second research question is “Does the application of the MTRIZP exert any significant effects on the critical thinking and problem-solving skills of gifted and talented students?” An independent t-test was used to determine any differences in the overall scores of the problem-solving skills and critical thinking of the participants in the experimental and control groups in the post-tests. The result showed a significant difference between the two groups. The mean (±SD) of the
scores of problem-solving skills and critical thinking of the students in the experimental group was higher than that in the control group, as shown in Table 5.8.

Table 5.8
Differences in problem-solving skills and critical thinking skills between groups in the post-tests

<table>
<thead>
<tr>
<th>Overall score</th>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem-solving skills</td>
<td>Experimental</td>
<td>3.17</td>
<td>0.22</td>
<td>0.39</td>
<td>0.28 - 0.49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>2.79</td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical thinking</td>
<td>Experimental</td>
<td>19.26</td>
<td>1.19</td>
<td>4.70</td>
<td>3.93 - 5.46</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>14.59</td>
<td>2.11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Independent t-test

A paired t-test was also used to determine any differences in the overall scores of the problem-solving skills and critical thinking skills of students in the experimental group in the pre- and post-tests. The means of the scores of the problem-solving skills and critical thinking of the students were higher in the post-tests than in the pre-tests. This outcome indicated an improvement in the problem-solving skills and critical thinking of the experimental group, as shown in Table 5.9.

Table 5.9
Differences in problem-solving skills and critical thinking of the experimental group in the pre- and post-tests

<table>
<thead>
<tr>
<th>Overall score</th>
<th>Sessions</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem-solving skills</td>
<td>Pre-test</td>
<td>2.90</td>
<td>0.23</td>
<td>−0.28</td>
<td>−0.38 - −0.17</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>3.17</td>
<td>0.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical thinking</td>
<td>Pre-test</td>
<td>15.50</td>
<td>1.56</td>
<td>−3.76</td>
<td>−4.39 - −3.13</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>19.20</td>
<td>1.19</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Paired t-test
The Wilcoxon Signed Rank test was used to determine any differences in the overall scores of the problem-solving skills of the control group in the pre- and post-tests. The negative mean rank for the difference between the pre-test and post-test was significantly higher than the positive mean rank. This finding indicates low problem-solving skills in the post-test (Table 5.10).

### Table 5.10
Differences in problem-solving skills of the control group in the pre- and post-tests

<table>
<thead>
<tr>
<th>Session</th>
<th>Rank</th>
<th>N</th>
<th>Mean rank</th>
<th>Z value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post – Pre</td>
<td>Negative Ranks</td>
<td>26</td>
<td>22.52</td>
<td>-2.36</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>Positive Ranks</td>
<td>14</td>
<td>16.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ties</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wilcoxon Signed Rank test

A paired t-test was used to determine any differences in the overall critical thinking scores of the control group in the pre- and post-tests. The mean of the students’ critical thinking scores was higher in the pre-test than in the post-test. This finding indicates low critical thinking in the post-test (Table 5.11).

### Table 5.11
Difference in students’ critical thinking between the pre-test and post-test of control group

<table>
<thead>
<tr>
<th>Critical thinking</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>95% CI</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>15.92</td>
<td>1.40</td>
<td>1.35</td>
<td>0.71</td>
<td>1.99</td>
</tr>
<tr>
<td>Post</td>
<td>14.57</td>
<td>2.11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Paired t test
An independent t-test was used to determine any differences in the assessment of the experimental and control groups in the post-tests. The Mann–Whitney test was used to determine any differences in the general attitude, identification of problem, generation of alternatives, and decision making of the experimental and control groups in the post-tests. A significant difference was found in the domains of problem solving in the experimental and control groups. The means and mean ranks were higher in the experimental group than in the control group. The findings are shown in Table 5.12.

<table>
<thead>
<tr>
<th>Problem-solving skills</th>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Assessment</td>
<td>Experimental</td>
<td>3.17</td>
<td>0.41</td>
<td>0.36</td>
<td>0.20</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>2.81</td>
<td>0.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General attitude</td>
<td>Experimental</td>
<td>50.19</td>
<td>412.50</td>
<td>−3.75</td>
<td>&lt;0.001**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>30.81</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification of problem</td>
<td>Experimental</td>
<td>50.60</td>
<td>396.00</td>
<td>−3.91</td>
<td>&lt;0.001**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>30.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation of alternatives</td>
<td>Experimental</td>
<td>52.95</td>
<td>302.00</td>
<td>−4.82</td>
<td>&lt;0.001**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>28.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision making</td>
<td>Experimental</td>
<td>45.76</td>
<td>589.50</td>
<td>−2.05</td>
<td>0.041**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>35.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Independent t-test ** Mann–Whitney

As independent t-test is the appropriate statistical test to determine any differences in the deduction between the experimental and control groups in the post-tests. The Mann–Whitney test is the appropriate statistical test to determine any differences in
assumption, interpretation, discussion, and inference between the experimental and control groups in the post-session. A significant difference was found in the critical thinking domains of the students in the experimental and control groups. Specifically, the means and mean ranks were higher in the experimental group than in the control group, as shown in Table 5.13.

The level of confidence (p value) set for the data analysis at 0.05, but some results (table 5.8 till table 5.13) after conducting the statistical tests showed very high significance therefore their p values appeared as 0.000. in this case we have to write as <0.001

### Table 5.13
Differences in critical thinking domains between groups in the post-tests

<table>
<thead>
<tr>
<th>Critical thinking</th>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Deduction</td>
<td>Experimental</td>
<td>19.68</td>
<td>2.40</td>
<td>2.68</td>
<td>1.36</td>
<td>3.99</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>17.00</td>
<td>3.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean rank</td>
<td>Mann–Whitney U</td>
<td>Z value</td>
</tr>
<tr>
<td>Assumption</td>
<td>Experimental</td>
<td>53.04</td>
<td></td>
<td>298.50</td>
<td>−4.846</td>
<td>&lt;0.001**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>27.96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interpretation</td>
<td>Experimental</td>
<td>55.38</td>
<td></td>
<td>205.00</td>
<td>−5.749</td>
<td>&lt;0.001**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>25.63</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussion</td>
<td>Experimental</td>
<td>59.31</td>
<td></td>
<td>47.50</td>
<td>−7.273</td>
<td>&lt;0.001**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>21.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inference</td>
<td>Experimental</td>
<td>49.44</td>
<td></td>
<td>442.50</td>
<td>−3.459</td>
<td>0.001**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>31.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Independent t-test  ** Mann–Whitney
A paired t-test was used to determine any differences in the problem-solving skills of the experimental group in the pre- and post-tests. The test focused on general attitude, identification of problem, and assessment. The Wilcoxon Signed Rank test was used to identify any differences in the generation of alternatives and decision making in the pre- and post-tests. The problem-solving skills of students showed higher means and mean ranks (higher positive ranks) in the post-test than in the pre-test. Results are shown in Table 5.14.

<table>
<thead>
<tr>
<th>Problem solving skills</th>
<th>Session</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General attitude</td>
<td>Pre</td>
<td>2.65</td>
<td>0.41</td>
<td>-0.42</td>
<td>-0.58</td>
<td>-0.26</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>3.07</td>
<td>0.44</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification of problem</td>
<td>Pre</td>
<td>2.94</td>
<td>0.36</td>
<td>-0.24</td>
<td>-0.40</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>3.18</td>
<td>0.34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td>Pre</td>
<td>2.88</td>
<td>0.37</td>
<td>-0.28</td>
<td>-0.47</td>
<td>-0.10</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>3.17</td>
<td>0.41</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rank</td>
<td>N</td>
<td>Mean rank</td>
<td>Z value</td>
<td>p value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation of alternatives</td>
<td>Post - Pre</td>
<td>Negative Ranks</td>
<td>13</td>
<td>13.62</td>
<td>-2.267</td>
<td>0.023**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Positive Ranks</td>
<td>22</td>
<td>20.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ties</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision making</td>
<td>Post - Pre</td>
<td>Negative Ranks</td>
<td>7</td>
<td>10.00</td>
<td>-3.040</td>
<td>0.002**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Positive Ranks</td>
<td>21</td>
<td>16.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ties</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Paired t-test ** Wilcoxon Signed Ranks Test
The Wilcoxon Signed Ranks test was used to determine any differences in the problem-solving skills of the control group in the pre- and post-tests. A significant difference was observed in the general attitude, generation of alternatives, and assessment. A higher mean rank was found in the pre-tests (negative mean ranks) than in the post-tests. Results are shown in Table 5.15.

<table>
<thead>
<tr>
<th>Problem-solving skills</th>
<th>Rank</th>
<th>N</th>
<th>Mean rank</th>
<th>Z value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General attitude</td>
<td>Post - Pre</td>
<td>Negative Ranks</td>
<td>27</td>
<td>21.43</td>
<td>−2.265</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Positive Ranks</td>
<td>13</td>
<td>18.58</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ties</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification of problem</td>
<td>Post - Pre</td>
<td>Negative Ranks</td>
<td>24</td>
<td>19.33</td>
<td>−1.702</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Positive Ranks</td>
<td>13</td>
<td>18.38</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ties</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation of alternatives</td>
<td>Post - Pre</td>
<td>Negative Ranks</td>
<td>23</td>
<td>18.61</td>
<td>−2.240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Positive Ranks</td>
<td>11</td>
<td>15.18</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ties</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision making</td>
<td>Post - Pre</td>
<td>Negative Ranks</td>
<td>17</td>
<td>18.97</td>
<td>−0.428</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Positive Ranks</td>
<td>17</td>
<td>16.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ties</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td>Post - Pre</td>
<td>Negative Ranks</td>
<td>24</td>
<td>22.92</td>
<td>−2.246</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Positive Ranks</td>
<td>15</td>
<td>15.33</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ties</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wilcoxon Signed Ranks test
The Wilcoxon Signed Rank test was used to determine any differences in the critical thinking domains of the experimental group in the pre- and post-tests. The critical thinking domains showed higher mean ranks (positive ranks) in the post-tests than in the pre-tests. Results are shown in Table 5.16.

<table>
<thead>
<tr>
<th>Critical thinking</th>
<th>Rank</th>
<th>N</th>
<th>Mean rank</th>
<th>Z value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General attitude</td>
<td>Post - Pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negative Ranks</td>
<td>9</td>
<td>14.72</td>
<td>−3.744</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Positive Ranks</td>
<td>31</td>
<td>22.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ties</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification of problem</td>
<td>Post - Pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negative Ranks</td>
<td>4</td>
<td>10.13</td>
<td>−4.703</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Positive Ranks</td>
<td>33</td>
<td>20.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ties</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation of alternatives</td>
<td>Post - Pre</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Negative Ranks</td>
<td>2</td>
<td>2.00</td>
<td>−5.326</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Positive Ranks</td>
<td>36</td>
<td>20.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ties</td>
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<tr>
<td>Decision making</td>
<td>Post - Pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negative Ranks</td>
<td>12</td>
<td>14.08</td>
<td>−2.937</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>Positive Ranks</td>
<td>26</td>
<td>22.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ties</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td>Post - Pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negative Ranks</td>
<td>8</td>
<td>10.00</td>
<td>−4.102</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Positive Ranks</td>
<td>29</td>
<td>21.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ties</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wilcoxon Signed Ranks Test

Paired t-test was used to determine any differences in the critical thinking domains of the control group (assumption, discussion, deduction, and inference) in the pre- and post-tests. The Wilcoxon Signed Rank test was used to identify any differences in
interpretation of the control group in the pre- and post-tests. A significant difference was found in discussion, deduction, and interpretation, with the means and mean ranks (negative ranks) being higher in the pre-tests in the post-tests (Table 5.17).

<table>
<thead>
<tr>
<th>Critical thinking</th>
<th>Session</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Assumption</td>
<td>Pre</td>
<td>17.85</td>
<td>2.90</td>
<td>0.93</td>
<td>-0.29</td>
<td>2.14</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>16.93</td>
<td>2.86</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussion</td>
<td>Pre</td>
<td>17.53</td>
<td>3.11</td>
<td>2.98</td>
<td>1.69</td>
<td>4.26</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>14.55</td>
<td>3.16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deduction</td>
<td>Pre</td>
<td>18.48</td>
<td>3.78</td>
<td>1.48</td>
<td>0.11</td>
<td>2.84</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>17.00</td>
<td>3.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inference</td>
<td>Pre</td>
<td>7.38</td>
<td>2.51</td>
<td>-0.30</td>
<td>-1.48</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>7.68</td>
<td>2.76</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rank</th>
<th>N</th>
<th>Mean rank</th>
<th>Z value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpretation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post - Pre</td>
<td>-2.438</td>
<td>0.015**</td>
<td></td>
</tr>
<tr>
<td>Rank</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Ranks</td>
<td>23</td>
<td>18.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive Ranks</td>
<td>10</td>
<td>14.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ties</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Paired t-test ** Wilcoxon Signed Ranks Test
5.5.3 Results of the Third Question

The third research question is “Is the critical thinking of gifted and talented students affected according to age, birth order, class, father’s education, and mother’s education after applying the MTRIZP?” The results are explained below.

5.5.3 (a) Age

ANOVA statistical test was used to determine any differences in the students’ critical thinking in terms of age. In terms of age, a significant difference was observed in the students’ critical thinking in the pre-tests. No significant difference was observed in the post-tests. This result indicates improvement in the critical thinking of the students of certain ages (Table 5.18).

Table 5.18
Differences in overall scores of participants’ critical thinking based on their age in the pre- and post-tests

<table>
<thead>
<tr>
<th>Sessions</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>Df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>12</td>
<td>15.97</td>
<td>1.78</td>
<td>2</td>
<td>3.371</td>
<td>0.045</td>
</tr>
<tr>
<td>13 years</td>
<td>17</td>
<td>15.80</td>
<td>0.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 years</td>
<td>11</td>
<td>14.53</td>
<td>1.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>12</td>
<td>19.53</td>
<td>1.32</td>
<td>2</td>
<td>1.158</td>
<td>0.325</td>
</tr>
<tr>
<td>13 years</td>
<td>17</td>
<td>18.93</td>
<td>1.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 years</td>
<td>11</td>
<td>19.47</td>
<td>1.02</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA

5.5.3 (b) Birth Order

ANOVA statistical test was used to determine any differences in the participants’ critical thinking based on birth order. No significant difference was found in the
students’ critical thinking based on their birth order in the pre- and post-tests (Table 5.19).

<table>
<thead>
<tr>
<th>Sessions</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eldest</td>
<td>21</td>
<td>15.89</td>
<td>1.41</td>
<td>2</td>
<td>2.472</td>
<td>0.098</td>
</tr>
<tr>
<td>Middle</td>
<td>11</td>
<td>15.49</td>
<td>1.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>child</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youngest</td>
<td>8</td>
<td>14.50</td>
<td>2.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eldest</td>
<td>21</td>
<td>19.47</td>
<td>1.16</td>
<td>2</td>
<td>0.758</td>
<td>0.476</td>
</tr>
<tr>
<td>Middle</td>
<td>11</td>
<td>18.93</td>
<td>1.32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>child</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youngest</td>
<td>8</td>
<td>19.18</td>
<td>1.12</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANCOVA

5.5.3 (c) Class

ANOVA is the appropriate statistical test for determining any differences in the participants’ critical thinking based on their class. In terms of class, no significant difference was observed in the students’ critical thinking in the pre-tests. In the post-tests, a significant difference was observed in the participants’ critical thinking, wherein class eight students received the highest overall scores of critical thinking, followed by class nine and seven students (Table 5.20).
Table 5.20
Differences in overall scores of participants’ critical thinking based on class in the pre- and post-tests

<table>
<thead>
<tr>
<th>Sessions</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seven</td>
<td>16</td>
<td>15.56</td>
<td>1.96</td>
<td>2</td>
<td>0.026</td>
<td>0.974</td>
</tr>
<tr>
<td>Eight</td>
<td>14</td>
<td>15.43</td>
<td>1.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nine</td>
<td>10</td>
<td>15.50</td>
<td>1.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seven</td>
<td>16</td>
<td>18.71</td>
<td>0.87</td>
<td>2</td>
<td>4.807</td>
<td>0.014</td>
</tr>
<tr>
<td>Eight</td>
<td>14</td>
<td>19.94</td>
<td>1.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nine</td>
<td>10</td>
<td>19.18</td>
<td>1.19</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA

5.5.3 (d) Father’s Education

ANOVA statistical test was used to determine any differences in the participants’ critical thinking based on their fathers’ education. No significant difference was observed in the participants’ critical thinking based on their fathers’ education in the pre- and post-tests (Table 5.21).

Table 5.21
Differences in overall scores of participants’ critical thinking based on their fathers’ education in the pre- and post-tests

<table>
<thead>
<tr>
<th>Sessions</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
<td>17</td>
<td>15.68</td>
<td>1.39</td>
<td>2</td>
<td>0.957</td>
<td>0.393</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>13</td>
<td>15.02</td>
<td>1.98</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Postgraduate</td>
<td>10</td>
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<td>1.13</td>
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<td></td>
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</tr>
<tr>
<td>Post</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Secondary and lower</td>
<td>17</td>
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<td>0.96</td>
<td>2</td>
<td>0.221</td>
<td>0.803</td>
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</table>
### 5.5.3 (e) Mother’s Education

ANOVA statistical test was used to determine any differences in the participants’ critical thinking based on their mothers’ education. A significant difference was observed in the participants’ critical thinking based on their mothers’ education in the pre-tests. The highest mean was found in mothers’ education at the postgraduate level. No significant difference was found in the participants’ critical thinking based on their mothers’ education in the post-tests. This result indicates improvement in the participants’ critical thinking after applying the intervention program (Table 5.22).

#### Table 5.22
Differences in overall scores of participants’ critical thinking based on their mothers’ education in the pre- and post-tests

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<tr>
<th>Sessions</th>
<th>No.</th>
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<th>p value</th>
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<tbody>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
<td>21</td>
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<td>1.52</td>
<td>2</td>
<td>3.707</td>
<td>0.034</td>
</tr>
<tr>
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<td>14.98</td>
<td>1.52</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Postgraduate</td>
<td>8</td>
<td>16.73</td>
<td>1.14</td>
<td></td>
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<tr>
<td>Post</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Secondary and lower</td>
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<td>Postgraduate</td>
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<td>19.23</td>
<td>1.52</td>
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</tbody>
</table>

ANOVA

### 5.5.3 (f) Critical Thinking Domains Based on Age

ANOVA statistical test was used to determine any differences in the discussion based on age in the pre-tests. The Kruskal Wallis test was used to identify differences
in assumption, interpretation, deduction, and inference based on age. Significant differences were found in interpretation and inference, as shown in Table 5.23.

Table 5.23
Differences in participants’ critical thinking domains based on age in the pre-tests

<table>
<thead>
<tr>
<th>Domain</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussion</td>
<td>12 years</td>
<td>12</td>
<td>18.58</td>
<td>3.29</td>
<td>2</td>
<td>1.575</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>17</td>
<td>16.71</td>
<td>3.22</td>
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<tr>
<td></td>
<td>14 years</td>
<td>11</td>
<td>16.73</td>
<td>2.45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Mean Rank</th>
<th>Chi-square</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 years</td>
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<td>0.542</td>
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<td>13 years</td>
<td>17</td>
<td>22.06</td>
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<tr>
<td>14 years</td>
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<td>19.41</td>
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<table>
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<tr>
<th>Domain</th>
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<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumption</td>
<td>12 years</td>
<td>12</td>
<td>22.96</td>
<td>7.403</td>
<td>0.025**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>17</td>
<td>23.97</td>
<td>7</td>
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<tr>
<td></td>
<td>14 years</td>
<td>11</td>
<td>12.45</td>
<td>12.6</td>
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</table>

<table>
<thead>
<tr>
<th>Deduction</th>
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<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 years</td>
<td>12</td>
<td>20.63</td>
<td>0.543</td>
<td>0.762**</td>
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<tr>
<td>13 years</td>
<td>17</td>
<td>21.74</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>14 years</td>
<td>11</td>
<td>18.45</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inference</th>
<th>No.</th>
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<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 years</td>
<td>12</td>
<td>24.08</td>
<td>7.614</td>
<td>0.022**</td>
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<td></td>
</tr>
<tr>
<td>13 years</td>
<td>17</td>
<td>23.24</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>14 years</td>
<td>11</td>
<td>12.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*ANOVA  ** Kruskal Wallis Test

ANOVA was used in the post-tests to determine any differences in deduction based on age. The Kruskal Wallis test was used to identify differences in assumption, interpretation, discussion, and inference based on age. A significant difference was found in assumption, wherein participants aged 12 years showed the highest means for assumption. Significant improvements in interpretation and inference were found as a result of the non-significant values in the post-tests in comparison with those in the pre-tests (Table 5.24).
Table 5.24
Differences in participants’ critical thinking domains based on age in the post-tests

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deduction</td>
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<td>19.67</td>
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<td>2</td>
<td>0.149</td>
</tr>
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<td></td>
<td>13 years</td>
<td>17</td>
<td>19.88</td>
<td>2.29</td>
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</tr>
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<td></td>
<td>14 years</td>
<td>11</td>
<td>19.36</td>
<td>3.01</td>
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<table>
<thead>
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<th>Chi-square</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumption</td>
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<td>12</td>
<td>26.38</td>
<td>6.700</td>
</tr>
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<td></td>
<td>13 years</td>
<td>17</td>
<td>15.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>11</td>
<td>22.09</td>
<td></td>
</tr>
<tr>
<td>Interpretation</td>
<td>12 years</td>
<td>12</td>
<td>21.42</td>
<td>2.998</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>17</td>
<td>23.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>11</td>
<td>15.50</td>
<td></td>
</tr>
<tr>
<td>Discussion</td>
<td>12 years</td>
<td>12</td>
<td>19.33</td>
<td>3.509</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>17</td>
<td>17.82</td>
<td></td>
</tr>
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<td></td>
<td>14 years</td>
<td>11</td>
<td>25.91</td>
<td></td>
</tr>
<tr>
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<td>19.75</td>
<td>0.099</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>14 years</td>
<td>11</td>
<td>21.27</td>
<td></td>
</tr>
</tbody>
</table>

*ANOVA  ** Kruskal Wallis Test

5.5.3 (g) Critical Thinking Domains Based on Birth Order

ANOVA was used in the pre-tests to determine any differences in discussion based on birth order. The Kruskal Wallis test was used to identify differences in assumption, interpretation, deduction, and inference. The only significant result was found in interpretation, with the highest mean ranks observed for the eldest, followed by middle children and the youngest (Table 5.25).
### Table 5.25
Differences in participants’ critical thinking domains based on birth order in the pre-tests

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Discussion</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eldest</td>
<td>21</td>
<td>18.10</td>
<td>3.36</td>
<td>2</td>
<td>2.226</td>
<td>0.122*</td>
</tr>
<tr>
<td>Middle child</td>
<td>11</td>
<td>17.00</td>
<td>2.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youngest</td>
<td>8</td>
<td>15.50</td>
<td>2.93</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
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<th>Chi-square</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assumption</strong></td>
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<td></td>
</tr>
<tr>
<td>Eldest</td>
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<td>17.79</td>
<td>5.751</td>
<td>0.056**</td>
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<td>Middle child</td>
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<td>19.41</td>
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<td></td>
</tr>
<tr>
<td>Youngest</td>
<td>8</td>
<td>29.13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Interpretation** |     |           |            |         |
| Eldest      | 21  | 23.69     | 6.608      | 0.037** |
| Middle child| 11  | 21.05     |            |         |
| Youngest    | 8   | 11.38     |            |         |

| **Deduction** |     |           |            |         |
| Eldest      | 21  | 22.29     | 3.621      | 0.164** |
| Middle child| 11  | 22.14     |            |         |
| Youngest    | 8   | 13.56     |            |         |

| **Inference** |     |           |            |         |
| Eldest      | 21  | 21.45     | 0.307      | 0.858** |
| Middle child| 11  | 19.59     |            |         |
| Youngest    | 8   | 19.25     |            |         |

*ANOVA  **Kruskal Wallis Test

ANOVA was used in the post-tests to determine any differences in deduction based on birth order. The Kruskal Wallis test was used to identify differences in assumption, interpretation, discussion, and inference. No significant difference was found in the students’ critical thinking in all domains in the post-tests (Table 5.26).
Table 5.26
Differences in participants’ critical thinking domains based on birth order in the post-tests

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>2.68</td>
<td>2</td>
<td>1.504</td>
<td>0.236*</td>
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<td>20.00</td>
<td>2.49</td>
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<td>0.52</td>
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<td></td>
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<td>1.921</td>
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<td>23.50</td>
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<tr>
<td>Youngest</td>
<td>8</td>
<td>14.13</td>
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</tr>
</tbody>
</table>

*ANOVA ** Kruskal Wallis test

5.5.3 (h) Critical Thinking Domains Based on Class

ANOVA was used to determine any differences in discussion based on class in the pre-tests. The Kruskal Wallis test was used to identify differences in assumption, interpretation, deduction, and inference based on class. No significant difference was found in all domains of critical thinking based on class in the pre-tests. Results are shown in Table 5.27.
Table 5.27
Differences in participants' critical thinking domains based on class in the pre-tests

<table>
<thead>
<tr>
<th>Domain</th>
<th>Class</th>
<th>No.</th>
<th>Mean</th>
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<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussion</td>
<td>Seven</td>
<td>16</td>
<td>17.44</td>
<td>3.10</td>
<td>2</td>
<td>0.222</td>
<td>0.802*</td>
</tr>
<tr>
<td></td>
<td>Eight</td>
<td>14</td>
<td>17.50</td>
<td>3.41</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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</table>

<table>
<thead>
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<th>No.</th>
<th>Mean Rank</th>
<th>Chi-square</th>
<th>p value</th>
</tr>
</thead>
<tbody>
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<td>22.38</td>
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<td>0.650**</td>
</tr>
<tr>
<td>Eight</td>
<td>14</td>
<td>18.46</td>
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<td></td>
</tr>
<tr>
<td>Nine</td>
<td>10</td>
<td>20.35</td>
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<td></td>
</tr>
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</table>

<table>
<thead>
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<th>No.</th>
<th>Mean Rank</th>
<th>Chi-square</th>
<th>p value</th>
</tr>
</thead>
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<td>10</td>
<td>22.10</td>
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<th>Mean Rank</th>
<th>Chi-square</th>
<th>p value</th>
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</thead>
<tbody>
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<td>20.13</td>
<td>0.040</td>
<td>0.980**</td>
</tr>
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<td>Eight</td>
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<td>20.54</td>
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<td>21.05</td>
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<th>p value</th>
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<tr>
<td>Inference</td>
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<td>16</td>
<td>20.03</td>
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<td>0.963**</td>
</tr>
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<td></td>
<td>Nine</td>
<td>10</td>
<td>21.30</td>
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<td></td>
</tr>
</tbody>
</table>

*ANOVA  ** Kruskal Wallis test

ANOVA was used in the post-test to determine any differences in deduction based on class. The Kruskal Wallis test was used to identify differences in assumption, interpretation, discussion, and inference. A significant difference was found in deduction, wherein class nine participants obtained the highest scores, followed by those in class eight and seven. A significant difference was also found in assumption, with the class eight participants having the highest mean ranks. Results are shown in Table 5.28.
Table 5.28
Differences in participants’ critical thinking domains based on class in the post-tests

<table>
<thead>
<tr>
<th>No.</th>
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<th>p value</th>
</tr>
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<tbody>
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<td>16</td>
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<td>1.93</td>
<td>2</td>
<td>9.230</td>
<td>0.001*</td>
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<td></td>
</tr>
<tr>
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<tbody>
<tr>
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<td>23.28</td>
<td>9.317</td>
<td>0.009**</td>
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<tr>
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</tr>
<tr>
<td>Nine</td>
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</tbody>
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<table>
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<th>Mean Rank</th>
<th>Chi-square</th>
<th>p value</th>
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<tbody>
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<td>0.481</td>
<td>0.786**</td>
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<tr>
<td>Eight</td>
<td>14</td>
<td>19.36</td>
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<tr>
<td>Nine</td>
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<table>
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<th>Mean Rank</th>
<th>Chi-square</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seven</td>
<td>16</td>
<td>18.56</td>
<td>1.336</td>
<td>0.513**</td>
</tr>
<tr>
<td>Eight</td>
<td>14</td>
<td>23.29</td>
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</tr>
<tr>
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<td>15.84</td>
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<td>Eight</td>
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</tr>
</tbody>
</table>

*ANOVA  **Kruskal Wallis test

5.5.3 (i) Critical Thinking Domains Based on Father’s Education

ANOVA was used to determine any differences in discussion based on fathers’ education. The Kruskal Wallis test was used to identify differences in assumption, interpretation, deduction, and inference based on fathers’ education. No significant difference was found in all domains of critical thinking based on fathers’ education in the pre-tests (Table 5.29).
Table 5.29
Differences in participants’ critical thinking domains based on fathers’ education in the pre-tests

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
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<th>F value</th>
<th>p value</th>
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</thead>
<tbody>
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<td>Discussion</td>
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<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Secondary and lower</td>
<td>17</td>
<td>17.82</td>
<td>3.63</td>
<td>2</td>
<td>1.702</td>
<td>0.196*</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>13</td>
<td>16.00</td>
<td>2.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
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<td>18.00</td>
<td>2.71</td>
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<thead>
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<th>p value</th>
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<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
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<td>17.62</td>
<td>1.862</td>
<td>0.394**</td>
</tr>
<tr>
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<td>13</td>
<td>22.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
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<td>22.35</td>
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<table>
<thead>
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<th>Chi-square</th>
<th>p value</th>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
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<td>1.302</td>
<td>0.522**</td>
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<tr>
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<td>19.95</td>
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<table>
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<th>p value</th>
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<tbody>
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<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
<td>17</td>
<td>21.65</td>
<td>0.302</td>
<td>0.860**</td>
</tr>
<tr>
<td>Bachelor’s</td>
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<td>19.46</td>
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<td></td>
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<tr>
<td>Postgraduate</td>
<td>10</td>
<td>19.90</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*ANOVA  ** Kruskal Wallis test

ANOVA was used in the post-tests to determine any differences in deduction based on fathers’ education. The Kruskal Wallis test was used to identify differences in assumption, interpretation, discussion, and inference based on fathers’ education. No significant difference was observed for all domains of critical thinking based on fathers’ education in the post-tests (Table 5.30).
### Table 5.30
Differences in participants’ critical thinking domains based on fathers’ education in the post-tests

<table>
<thead>
<tr>
<th>Domain</th>
<th>Group</th>
<th>No.</th>
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<tr>
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<td>0.266**</td>
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<td>19.90</td>
<td>1.60</td>
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<tr>
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</tr>
<tr>
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</tr>
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<td>20.30</td>
<td>1.50</td>
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<td></td>
</tr>
</tbody>
</table>

*ANOVA  ** Kruskal Wallis test

#### 5.5.3 (j) Critical Thinking Domains Based on Mother’s Education

ANOVA was used to determine any differences in discussion based on mothers’ education in the pre-tests. The Kruskal Wallis test was used to identify differences in assumption, interpretation, deduction, and inference based on mothers’ education. A significant difference was found in deduction based on mothers’ education, wherein
the highest mean rank was observed in students whose mothers who received postgraduate education (Table 5.31).

Table 5.31
Differences in participants’ critical thinking domains based on mothers’ education in the pre-tests

<table>
<thead>
<tr>
<th>Discussion</th>
<th>No.</th>
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<th>p value</th>
</tr>
</thead>
<tbody>
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<td>21</td>
<td>17.67</td>
<td>3.06</td>
<td>2</td>
<td>1.130</td>
<td>0.334*</td>
</tr>
<tr>
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<td>11</td>
<td>16.09</td>
<td>1.87</td>
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</tr>
<tr>
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<td>17.88</td>
<td>4.32</td>
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</table>

<table>
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<th>Chi-square</th>
<th>p value</th>
</tr>
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</tr>
<tr>
<td>Postgraduate</td>
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<td>23.81</td>
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<th>Chi-square</th>
<th>p value</th>
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<td>0.873**</td>
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<td>19.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
<td>8</td>
<td>21.88</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Mean Rank</th>
<th>Chi-square</th>
<th>p value</th>
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<td>17.18</td>
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<tr>
<td>Postgraduate</td>
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<table>
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<th>p value</th>
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<td>Postgraduate</td>
<td>8</td>
<td>25.19</td>
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<td></td>
</tr>
</tbody>
</table>

*ANOVA  ** Kruskal Wallis test

ANOVA was used in the post-tests to determine any differences in deduction based on mothers’ education. The Kruskal Wallis test was used to identify differences in assumption, interpretation, discussion, and inference based on mothers’ education. No significant difference was observed for all domains of critical thinking based on mothers’ education in the post-tests (Table 5.32).
Table 5.32  
Differences in participants’ critical thinking domains based on mothers’ education in the post-tests

<table>
<thead>
<tr>
<th>Deduction</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
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<td>21</td>
<td>19.76</td>
<td>2.05</td>
<td>2</td>
<td>0.152</td>
<td>0.860*</td>
</tr>
<tr>
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<td>11</td>
<td>19.82</td>
<td>2.86</td>
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<tr>
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<td>8</td>
<td>19.25</td>
<td>2.87</td>
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<table>
<thead>
<tr>
<th>No.</th>
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<th>Chi-square</th>
<th>p value</th>
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<tbody>
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<tr>
<td>11</td>
<td>18.23</td>
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<td>25.88</td>
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</table>

<table>
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<th>Chi-square</th>
<th>p value</th>
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<td>3.130</td>
<td>0.209**</td>
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<td>15.50</td>
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<td></td>
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<tr>
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<th>Chi-square</th>
<th>p value</th>
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<td>2.818</td>
<td>0.244**</td>
</tr>
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<td>Postgraduate</td>
<td>8</td>
<td>22.88</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Inference</th>
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<th>Mean Rank</th>
<th>Chi-square</th>
<th>p value</th>
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</thead>
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<tr>
<td>Secondary and lower</td>
<td>21</td>
<td>24.10</td>
<td>5.464</td>
<td>0.065**</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>11</td>
<td>19.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
<td>8</td>
<td>13.06</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*ANOVA ** Kruskal Wallis test

5.5.4 Results of the Fourth Question

The fourth research question is “Are the problem-solving skills of gifted and talented students affected after applying the MTRIZP?” according to age, birth order, class, father’s education, and mother’s education The results are explained below.
5.5.4 (a) Age

ANOVA statistical test was used to determine any differences in the students’ problem-solving skills based on age. A significant difference was found in the overall scores of the problem-solving skills of students based on age in the pre-tests.

For the post-tests, no significant difference was observed in the overall scores of problem-solving skills. This result indicates improvement in the students’ problem-solving skills as a result of the application of the intervention program (Table 5.33).

Table 5.33
Differences in overall scores of participants’ problem-solving skills based on age in the pre- and post-tests

<table>
<thead>
<tr>
<th>Sessions</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>12</td>
<td>2.96</td>
<td>0.15</td>
<td>2</td>
<td>6.479</td>
<td>0.004</td>
</tr>
<tr>
<td>13 years</td>
<td>17</td>
<td>2.77</td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 years</td>
<td>11</td>
<td>3.03</td>
<td>0.28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>12</td>
<td>3.13</td>
<td>0.28</td>
<td>2</td>
<td>0.667</td>
<td>0.519</td>
</tr>
<tr>
<td>13 years</td>
<td>17</td>
<td>3.22</td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 years</td>
<td>11</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA

5.5.4 (b) Birth Order

ANOVA statistical test was used to determine any differences in the participants’ problem-solving skills based on their birth order. No significant difference was found in the participants’ problem-solving skills in the pre- and post-tests. Results are shown in Table 5.34.
Table 5.34
Differences in overall scores of participants’ problem-solving skills based on birth order in the pre- and post-tests

<table>
<thead>
<tr>
<th>Sessions</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eldest</td>
<td>21</td>
<td>2.88</td>
<td>0.20</td>
<td>2</td>
<td>0.283</td>
<td>0.755</td>
</tr>
<tr>
<td>Middle child</td>
<td>11</td>
<td>2.89</td>
<td>0.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youngest</td>
<td>8</td>
<td>2.95</td>
<td>0.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Post</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eldest</td>
<td>21</td>
<td>3.21</td>
<td>0.25</td>
<td>2</td>
<td>1.198</td>
<td>0.313</td>
</tr>
<tr>
<td>Middle child</td>
<td>11</td>
<td>3.09</td>
<td>0.16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youngest</td>
<td>8</td>
<td>3.19</td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA

5.5.4 (c) Class

ANOVA statistical test was used to determine any differences in the participants’ problem-solving skills based on class. No significant difference was found in the participants’ problem-solving skills based on class in the pre- and post-tests, as shown in Table 5.35.

Table 5.35
Differences in overall scores of participants’ problem-solving skills based on class in the pre- and post-tests

<table>
<thead>
<tr>
<th>Sessions</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>Df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seven</td>
<td>16</td>
<td>2.91</td>
<td>0.18</td>
<td>2</td>
<td>0.522</td>
<td>0.597</td>
</tr>
<tr>
<td>Eight</td>
<td>14</td>
<td>2.93</td>
<td>0.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nine</td>
<td>10</td>
<td>2.84</td>
<td>0.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Post</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seven</td>
<td>16</td>
<td>3.20</td>
<td>0.25</td>
<td>2</td>
<td>0.305</td>
<td>0.739</td>
</tr>
<tr>
<td>Eight</td>
<td>14</td>
<td>3.14</td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nine</td>
<td>10</td>
<td>3.18</td>
<td>0.22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.5.4 (d) Father’s Education

ANOVA statistical test was used to determine any differences in the participants’ problem-solving skills based on their fathers’ education. No significant difference was found in the participants’ problem-solving skills based on their fathers’ education in the pre- and post-tests. Results are shown in Table 5.36.

<table>
<thead>
<tr>
<th>Sessions</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
<td>17</td>
<td>2.84</td>
<td>0.17</td>
<td>2</td>
<td>1.792</td>
<td>0.181</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>13</td>
<td>2.99</td>
<td>0.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
<td>10</td>
<td>2.88</td>
<td>0.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
<td>17</td>
<td>3.15</td>
<td>0.21</td>
<td>2</td>
<td>0.495</td>
<td>0.614</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>13</td>
<td>3.16</td>
<td>0.17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
<td>10</td>
<td>3.23</td>
<td>0.28</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA

5.5.4 (e) Mother’s Education

ANOVA was used to determine any differences in the problem-solving skills of participants based on their mothers’ education. No significant difference was found in the participants’ problem-solving skills based on their mothers’ education in the pre- and post-tests. Results are shown in Table 5.37.
Table 5.37
Differences in overall scores of participants’ problem-solving skills based on their mothers’ education in the pre- and post-tests

<table>
<thead>
<tr>
<th>Sessions</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
<td>21</td>
<td>2.84</td>
<td>0.29</td>
<td>2</td>
<td>1.408</td>
<td>0.258</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>11</td>
<td>2.98</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
<td>8</td>
<td>2.93</td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary and lower</td>
<td>21</td>
<td>3.18</td>
<td>0.19</td>
<td>2</td>
<td>2.628</td>
<td>0.086</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>11</td>
<td>3.07</td>
<td>0.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
<td>8</td>
<td>3.29</td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA

5.5.4(f) Domains of Problem-solving Skills Based on Age

ANOVA statistical test was used in the pre-tests to determine any differences in the participants’ domains of problem-solving skills (general attitude, identification of problem, and assessment) based on age. The Kruskal Wallis test was used to identify differences in the generation of alternatives and decision making based on age. A significant difference was found in the identification of problem, generation of alternatives, and decision making. Results are shown in Table 5.38.
Table 5.38
Differences in participants’ domains of problem-solving skills based on age in the pre-tests

<table>
<thead>
<tr>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>Df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General attitude</td>
<td>12 years</td>
<td>12</td>
<td>2.52</td>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>17</td>
<td>2.68</td>
<td>0.46</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>11</td>
<td>2.73</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>Identification of problem</td>
<td>12 years</td>
<td>12</td>
<td>3.05</td>
<td>0.28</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>17</td>
<td>2.74</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>11</td>
<td>3.15</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td>12 years</td>
<td>12</td>
<td>2.97</td>
<td>0.51</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>17</td>
<td>2.79</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>11</td>
<td>2.93</td>
<td>0.37</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th>Mean Rank</th>
<th>Chi-square</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generation of alternatives</td>
<td>12 years</td>
<td>12</td>
<td>23.25</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>17</td>
<td>13.12</td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>11</td>
<td>28.91</td>
</tr>
<tr>
<td>Decision making</td>
<td>12 years</td>
<td>12</td>
<td>27.75</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>17</td>
<td>14.09</td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>11</td>
<td>22.50</td>
</tr>
</tbody>
</table>

*ANOVA ** Kruskal Wallis test

ANOVA was used in the post-tests to determine any differences in the participants’ domains of problem-solving skills (general attitude, identification of problem, generation of alternatives, and assessment) based on age. The Kruskal Wallis test was used to identify differences in decision making based on age. The only significant result was observed in the domain of decision making. The outcome in this domain was different from that in the pre-tests, wherein students aged 13 years received higher mean ranks in the post-tests than in the pre-tests. This result indicated an improvement in the participants’ decision making. No differences were observed in the domains of problem identification generation of alternatives. This
result indicates that the students benefitted from the intervention program (Table 5.39).

<table>
<thead>
<tr>
<th>Table 5.39</th>
<th>Differences in participants’ domains of problem-solving skills based on age in the post-tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
</tr>
<tr>
<td>General attitude</td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>12</td>
</tr>
<tr>
<td>13 years</td>
<td>17</td>
</tr>
<tr>
<td>14 years</td>
<td>11</td>
</tr>
<tr>
<td>Identification of problem</td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>12</td>
</tr>
<tr>
<td>13 years</td>
<td>17</td>
</tr>
<tr>
<td>14 years</td>
<td>11</td>
</tr>
<tr>
<td>Generation of alternatives</td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>12</td>
</tr>
<tr>
<td>13 years</td>
<td>17</td>
</tr>
<tr>
<td>14 years</td>
<td>11</td>
</tr>
<tr>
<td>Assessment</td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>12</td>
</tr>
<tr>
<td>13 years</td>
<td>17</td>
</tr>
<tr>
<td>14 years</td>
<td>11</td>
</tr>
</tbody>
</table>

*ANOVA  ** Kruskal Wallis test

5.5.4 (g) Problem-solving Skills Domains Based on Birth Order

For the pre-tests, ANOVA was used to determine any differences in the participants’ domains of problem-solving skills (general attitude, identification of problem, and assessment) based on birth order. The Kruskal Wallis test was used to identify differences in the generation of alternatives and decision making based on birth order. No significant difference was found in all domains of problem-solving skills in the pre-tests. Results are shown in Table 5.40.
Table 5.40  
Differences in participants’ domains of problem-solving skills based on birth order in the pre-tests

<table>
<thead>
<tr>
<th>Domain</th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General attitude</td>
<td>12 years</td>
<td>21</td>
<td>2.67</td>
<td>0.50</td>
<td>2</td>
<td>0.139</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>11</td>
<td>2.59</td>
<td>0.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>8</td>
<td>2.66</td>
<td>0.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification of problem</td>
<td>12 years</td>
<td>21</td>
<td>2.93</td>
<td>0.29</td>
<td>2</td>
<td>0.580</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>11</td>
<td>2.89</td>
<td>0.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>8</td>
<td>3.06</td>
<td>0.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td>12 years</td>
<td>21</td>
<td>2.83</td>
<td>0.24</td>
<td>2</td>
<td>1.022</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>11</td>
<td>2.88</td>
<td>0.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>8</td>
<td>3.05</td>
<td>0.31</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th>Mean Rank</th>
<th>Chi-square</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generation of alternatives</td>
<td>12 years</td>
<td>21</td>
<td>21.26</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>11</td>
<td>17.05</td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>8</td>
<td>23.25</td>
</tr>
<tr>
<td>Decision making</td>
<td>12 years</td>
<td>21</td>
<td>20.50</td>
</tr>
<tr>
<td></td>
<td>13 years</td>
<td>11</td>
<td>25.77</td>
</tr>
<tr>
<td></td>
<td>14 years</td>
<td>8</td>
<td>13.25</td>
</tr>
</tbody>
</table>

*ANOVA  ** Kruskal Wallis test

ANOVA was used in the post-tests to determine any differences in the participants’ domains of problem-solving skills (general attitude, identification of problem, generation of alternatives, and assessment) based on birth order. The Kruskal Wallis test was used to identify differences in the participants’ decision making based on birth order. No significant difference was found in all domains of problem-solving skills in the post-tests. Results are shown in Table 5.41.
Table 5.41
Differences in participants’ domains of problem-solving skills based on birth order in the post-tests

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>Mean</th>
<th>SD</th>
<th>df</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General attitude</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>21</td>
<td>3.09</td>
<td>0.51</td>
<td>2</td>
<td>0.302</td>
<td>0.741*</td>
</tr>
<tr>
<td>13 years</td>
<td>11</td>
<td>2.98</td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 years</td>
<td>8</td>
<td>3.13</td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification of problem</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>21</td>
<td>3.18</td>
<td>0.37</td>
<td>2</td>
<td>0.007</td>
<td>0.993*</td>
</tr>
<tr>
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*N Mean Rank Chi-square p value

ANOVA ** Kruskal Wallis test

5.5.4 (h) Domains of Problem-solving Skills Based on Class

ANOVA was used in the pre-tests to determine any differences in the participants’ domains of problem-solving skills (general attitude, identification of problem, and assessment) based on class. The Kruskal Wallis test was used to identify differences in the participants’ domains of generation of alternatives and decision making based on class. No significant difference was found in all domains of problem-solving skills in the pre-tests. Results are shown in Table 5.42.
Table 5.42
Differences in participants’ domains of problem-solving skills based on class in the pre-tests

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*ANOVA  ** Kruskal Wallis test

ANOVA was used in the post-tests to determine any differences in the participants’ domains of problem-solving skills (general attitude, identification of problem, generation of alternatives, and assessment) based on class. The Kruskal Wallis test was used to identify differences in the participants’ domain of decision making based on class. No significant difference was found in all domains of problem-solving skills in the pre-tests. Results are shown in Table 5.43.
Table 5.43
Differences in participants’ domains of problem-solving skills based on class in the post-tests

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*ANOVA  ** Kruskal Wallis test

5.5.4 (i) Domains of Problem-solving Skills Based on Father’s Education

ANOVA was used in the pre-tests to determine any differences in the domains of problem-solving skills (general attitude, identification of problem, and assessment) of the participants based on their fathers’ education. The Kruskal Wallis test was used to identify differences in the domains of generation of alternatives and decision making based on fathers’ education. No significant difference was found in all domains of problem-solving skills in the pre-tests. Results are shown in Table 5.44.
ANOVA was used in the post-tests to determine any differences in the domains of problem-solving skills (general attitude, identification of problem, generation of alternatives, and assessment) of the participants based on their fathers’ education. The Kruskal Wallis test was used to identify differences in the domain of decision making based on fathers’ education. No significant difference was found in all domains of problem-solving skills in the post-tests. Results are shown in Table 5.45.
Table 5.45
Differences in participants’ domains of problem-solving skills based on fathers’ education in the post-tests

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*ANOVA  ** Kruskal Wallis test

5.5.4 (j) Domains of Problem-solving Skills Based on Mother’s Education

ANOVA was used in the pre-tests to determine any differences in the domains of problem-solving skills (general attitude, identification of problem, and assessment) of the participants based on their mothers’ education. The Kruskal Wallis Test was used to identify differences in the domains of generation of alternatives and decision making based on mothers’ education. A significant difference was found in the domain of decision making based on mothers’ education, with the participants whose
mothers held university degrees receiving the highest mean ranks. Results are shown in Table 5.46.

Table 5.46
Differences in participants’ domains of problem-solving skills based on their mothers’ education in the pre-tests

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*ANOVA  ** Kruskal Wallis test

ANOVA was used in the post-tests to determine any differences in the domains of problem-solving skills (general attitude, identification of problem, generation of alternatives, and assessment) of the participants based on their mothers’ education. The Kruskal Wallis test was used to identify differences in the domain of decision making based on mothers’ education. A significant difference was found in the domain of general attitude, wherein class nine students obtained the highest means. No significant difference was found in the domain of decision making in terms of mothers’ education. This result indicated improvements in the decision making of the
participants, especially for those whose mothers held secondary school degrees and lower (Table 5.47).

<p>| Table 5.47 | Differences in participants’ domains of problem-solving skills based on mothers’ education in the post-tests |</p>
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<td>Postgraduate</td>
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*ANOVA  ** Kruskal Wallis test

5.6 Results of the Fifth Question

The fifth research question is “What are the views of the respondents regarding the MTRIZP?” Ten participants were invited to be interviewed. The following excerpts represent the interviewees’ responses.

(1) The first question: What is your opinion about the impact of the MTRIZP?
An analysis of qualitative data revealed the first theme, which was “support of gifted students.” An in-depth analysis led to the emergence of two codes: “helps them to learn new ways of thinking” and “useful.” As examples of the first code, the responses of two of the participants are given below.

“This program has helped me to find ways to deal with life differently.”

(p6)(Appebdex :D,Pg 359,Line 11, Paragraph 1)

“The program helped me to solve problems every day.” (p3)

(Appedex :D,Pg 359,Line 12, Paragraph 1)

“Useful” was the second code to be identified under the first theme. Two representative responses of two participants are as follows:

“The program is useful for the gifted students.” (p2)

(Appedex :D,Pg 359,Line 13, Paragraph 2)

“Therefore, it can be beneficial to sort out every day problems through some of its applications.” (p4) (Appedex :D,Pg 359,Line 14, Paragraph 2)

The analysis of data also revealed a second theme, namely, “excellent.” The response grouped under this theme were further categorized under two codes: “beneficial” and “strong program.” Below are two representative responses for the first code:

“An excellent program.” (p1) (Appedex:D,Pg 360,Line 1, Paragraph 3)

“Figured out the excellency of this program to support talented students.” (p9) (Appedex :D,Pg 360,Line 2, Paragraph 3)
The examples of the responses that were grouped under “strong program” are as follows.

The second code was “strong program.” One participant offered the following responses:

“It is a strong program.” (p7) (Appebdex :D,Pg 360,Line 4, Paragraph 4)

“It was very important.” (p10) (Appebdex :D,Pg 359,Line 18, Paragraph 4)

(2) The second question was Do you think that the activities of the MTRIZP Program are suitable for gifted students?

Figure 5.8 shows that two themes were identified to answer the second research question. These two themes were appropriate and exciting activities. Two codes emerged under the first theme, namely, “motivation” and “aspiration.” An example of the responses for “motivation” is

“Activities gave me motivation to study.” (p7) (Appebdex :D,Pg 360,Line 6, Paragraph 1)

“Aspiration” was identified as the second code under the first theme. Examples of the responses for “aspiration” are:

“Activities gave me aspiration.” (p6) (Appebdex :D,Pg 360,Line 7, Paragraph 1)

“I like the program to have more of these activities.” (p1) (Appebdex :D,Pg 360,Line 8, Paragraph 2)
The second theme that was used to answer the second research question was “exciting activities.” Two codes were identified, namely, “fun activities” and “amusing,” based on the responses under this theme. One participant stated, “Activities were fun” (p3) (Appebdex :D,Pg 360,Line 8, Paragraph 1), whereas another participant mentioned, “Activities were exciting” (p4) (Appebdex :D,Pg 360,Line 9, Paragraph 2).

The second code was “amusing.” Examples of the responses for this code are

“They were presented in funny and humorous ways.” (p5) (Appebdex :D,Pg 360,Line 10, Paragraph 3)

“They were not of formal manner.” (p8) (Appebdex :D,Pg 360,Line 11, Paragraph 3)

(3) The third sub-question: Do you think that the activities of the MTRIZP develop critical thinking skills? Why?

Two themes were identified in answering this sub-question. These themes are “develop critical thinking” and “know the phrase ‘critical thinking’.” The analysis of the responses supporting the first theme led to the emergence of two codes, namely, “strategies used in this program” and “training to use skills.” An example of the first code is:

“The activities were suitable for the outstanding students, and they help to raise their critical thinking.” (p4) (Appebdex :D,Pg 359,Line 11, Paragraph 1)

The second code was “training to use skills.” One participant mentioned that,
“Future training on this topic can develop the way of thinking of those students.” (p1) (Appendix: D, Pg 360, Line 13, Paragraph 1)

The second theme was “know the phrase ‘critical thinking’.” Two codes emerged from the responses grouped under this theme. The first code was “the activities elevated their critical thinking.” A good representative example of the responses for this code is:

“I felt that the activities elevated my critical thinking and made me know exactly what critical thinking means.” (p7) (Appendix: D, Pg 360, Line 15, Paragraph 2)

The second code was “know now the importance of the role of critical thinking role.” An example of this code is:

“I feel that I now know how important the role of critical thinking is in this life.” (p10) (Appendix: D, Pg 360, Line 16, Paragraph 2)

(4) The fourth sub-question was: Do you think that the activities of the MTRIZP developed your problem-solving skills?

Data analysis revealed two themes after answering this sub-question. These themes are: “help solving problems” and “more capable of dealing with expected problems.” The analysis of the responses under the first theme yielded two codes: “improve their brainstorming” and “learn skills.” An example of responses under the first code is:

“The activities have contributed to improve their brainstorming skill in an innovative way.” (p6) (Appendix: D, Pg 361, Line 2, Paragraph 1)
An example of the responses categorized under the second code, which is “learn skills,” is:

“This program should be implemented to improve problem-solving skills.” (p10)
(Appebdex :D,Pg 361,Line 4, Paragraph 1)

Two codes emerged from the responses in the second theme. These codes were “more capable of dealing with expected problems,”. The first code was “problem solved with those around them.” For example, one participant declared that:

“This program gave me the ability to solve old problems with my brothers and friends.” (p9) (Appebdex :D,Pg 361,Line 5, Paragraph 2)

The second code was “to deal with new problems.” The following extracted response is one of the responses that were grouped under this code:

“It helps me to deal with new problems, and even I was able to solve problems of other students, and in general I became more self-confident.” (p2)
(Appebdex :D,Pg 361,Line 8, Paragraph 2)

(5) The fifth sub-question: What do you suggest to improve the MTRIZ Program?

Two codes emerged after analyzing the responses that supported this theme. The first code was “should be used by all students.” For example, one participant stated that:

“They thought that students should participate in the design, and it should be used by all students, not only the talented ones.” (p1) (Appebdex :D,Pg 361,Line 10, Paragraph 1)
The second code was “continue using such program.” An example of the response for the code is:

“I lack such programs.” (p8) (Appebdex :D,Pg 361,Line 12, Paragraph 2)

The second theme was “increase the principles.” Two codes emerged after analyzing the participants’ responses in support of this theme: “need to continue such programs” and “increase their number and preferably partially divide it.” An example of the response for the first code is:

“I need more training on such program.” (p7) (Appebdex :D,Pg 361,Line 14, Paragraph 3)

An example of the response for the second code, “increase their number and preferably partially divide it,” is given below.

“You should increase the number of participants and preferably partially divide it to fix it in our minds.” (p9) (Appebdex :D,Pg 361,Line 16, Paragraph 4)

5.7 Conclusion

This chapter reports the results of the statistical analysis related to the data collected from the Watson test, Happner's test, and interviews. The significance of the findings and the effect size are also explained and illustrated in the tables and figures.
CHAPTER 6
DISCUSSION, IMPLICATION, AND RECOMMENDATIONS

6.1 Introduction

Five objectives were achieved in the current study. The first objective is to examine the existence of any significant difference in the critical thinking and problem-solving skills of participants in the experimental and control groups in the pre-tests. The second objective is to examine any significant effect of the application of the MTRIZP Program on the critical thinking and problem-solving skills of gifted and talented students. The third objective is to examine the existence of any effect of age, birth order, class, father’s education, and mother’s education on the critical thinking of gifted and talented students after applying MTRIZP. The fourth objective is to examine the existence of any effect of age, birth order, class, father’s education, and mother’s education on the problem-solving skills of gifted and talented students after applying MTRIZP. The fifth objective is to examine the respondents’ perspective of students and teachers in the MTRIZP Program. Age, birth order, and parents’ level of education were considered as secondary independent variables.

A pre-test and post-test control group design was used in this study to verify whether the MTRIZ Program could enhance critical thinking and problem-solving skills. The sample comprised 80 talented male students from the seventh, eighth, and ninth grades.

These students studied in the Tabuk Talented and Gifted Student Center for a certain period of time. The MTRIZ Program was specifically developed for the study. The independent variable used in this study was the MTRIZ Program. The
factors used as secondary independent variables were parents’ level of education, class, age, and birth order. The dependent variable was the post-test scores of the students in the critical thinking test and problem solving test.

Data were collected during the second semester of the school year 2015–2016. Participating students were asked to answer the critical thinking test and problem solving test as a pre-test two weeks before the training program. The students were randomly assigned to either the experimental group or the control group. The students were promptly asked to answer the critical thinking test and problem solving test as post-test. This chapter discusses the interpretations of the findings.

This study attempted to answer the following questions:

1. Do the critical thinking and problem-solving skills of the participants in the experimental and control groups significantly differ in the pre-test?
2. Does the application of the MTRIZP exert any significant effects on the critical thinking and problem-solving skills of gifted and talented students?
3. Is the critical thinking of gifted and talented students affected by age, birth order, class, father’s education, and mother’s education after applying MTRIZP?
4. Are the problem-solving skills of gifted and talented students affected by age, birth order, class, father’s education, and mother’s education after applying MTRIZP?
5. What are the views of the respondents regarding MTRIZP?
6.2 Major Findings of the Study

Data analysis showed a statistically significant difference between the scores of the experimental group (subjected to the MTRIZ Program) and the scores of the control group (subjected to the Ministry-recommended program) in the post-tests. The effect of the pre-test results of the students’ critical thinking and problem-solving skills were controlled. In brief, the students’ scores in the experimental group increased in the post-tests as a result of the implementation of the MTRIZ Program. The overall outcomes of this study indicate that the Program provides talented students with training in critical thinking and problem solving.

MTRIZP was administered to the experimental group. By contrast, the control group received the training program of the Tabuk Talented and Gifted Student Center. The main findings of the application of the MTRIZ Program can be summarized as follows.

6.2.1 The MTRIZ Program Positively Affected the Overall Critical Thinking Test and Problem-solving Test

1. Results at a p value of 0.001 indicated statistically significant differences between the average performances of the control and experimental groups in the critical thinking and problem-solving tests (Table 5.10). The result favors the experimental group.

2. Results at a p value of 0.001 indicated statistically significant differences between the average performances of the experimental group in pre-and post-tests (Table 5.11). The result favors the post-test. The findings are attributed to several factors, especially the characteristics of the MTRIZ Program.
The success of the MTRIZ Program can be attributed to various factors. The participants in this study were seventh to ninth grade students who were in their teenage years. Teenagers are known to experience rapid changes in their emotional and psychological development because of varied reasons. First, they constantly search for and organize facts. Second, they tend to assess issues using their sense of logic and primitive knowledge. Third, they pursue alternatives and new approaches because of changes in their emotional and mental developments. Fourth, these students engage in abstract thinking and are highly imaginative. Fifth, teenage students are attracted to debates and discussions on facts. This finding concurs with the report of (Zoghul & Hindawi, 2013).

The students in this study are not only teenagers but also gifted individuals who possess important traits, such as a noticeably great interest in learning about the world around them, the capability to identify challenges and confront them successfully, impressive problem-solving abilities, and a great degree of courage.

During the training program in which the MTRIZP was implemented, various activities were used, with each session comprising three activities. As shown in the results of question two of the interviews, both students and teachers were satisfied with the activities. Explanations about the activities were sufficient and encouraging. The training activities assisted the students in acquiring knowledge on how to employ the strategies that helped them improve their creative skills. The other aspects that were enhanced by the activities of the program were their sentimental processes, communication, self-confidence, and collaboration. The students were also encouraged to be proactive and motivated. Such aspects showed marked improvement, as observed in the interviews carried out with the students.
Furthermore, MTRIZP was designed and constructed to meet the needs of gifted students.

The qualitative results of this study supported the quantitative results, which indicated that MTRIZP exerted a positive effect on the growth of the gifted students’ thinking and problem-solving skills. This improvement contributed to their abilities to think and find solutions. Furthermore, this positive change provided an opportunity for them to reach advanced levels in critical thinking and problem solving.

**6.2.3 The Effect of MTRIZP on Critical Thinking Skills**

This study targeted all aspects of critical thinking skills: (1) deduction, (2) assumption, (3) interpretation, (4) discussion and inference.

Significant statistical differences at a p value of < 0.01 were observed in the enhancement of critical thinking skills of the control and experimental groups, with the results favoring the experimental group (Table 5.13).

The interviews with the students (Q1, Q3) confirmed the positive effect of the MTRIZP on the critical thinking skills of the talented students.

The researcher believes that each category of critical thinking skill can be nurtured and developed independently.

The following sections summarize and explain the results.
6.2.3 (a) Deduction

Significant statistical differences at a p value of < 0.01 were observed in the enhancement of deduction of the control and experimental groups. The result favors the experimental group (Table 5.13).

The activities of the MTRIZP helped the students reach conclusions that went beyond the limits of available evidence. These activities stimulated students to reach generalizations that could go beyond the information provided by preconceived points of view.

6.2.3 (b) Assumption

Significant statistical differences at a p value of < 0.01 were observed in the enhancement of assumption of the control and experimental groups. The results favor the experimental group (Table 5.13).

The activities of MTRIZP encouraged the students to make judgment about the value of ideas or the value of things. These activities also stimulated the students to consider both the reliability of ideas and their types.

3.2.3 (c) Interpretation

Significant statistical differences at a p value of < 0.01 were observed in the enhancement of interpretation of the control and experimental groups. The result favors the experimental group (Table 5.13).
The activities of MTRIZP encouraged student involvement in cognitive activities. These activities taught learners to be more concerned about the whole rather than its parts.

The activities also helped students shift their focus from examples to rules. In addition, the students were able to move from basic knowledge/ideas to collective ideas.

6.2.3 (d) Discussion

Significant statistical differences at a p value of < 0.01 were observed in the enhancement of the discussion of the control and experimental groups. The result favors the experimental group (Table 5.13).

The activities of MTRIZP focused on providing the students with the ability to analyze the elements of a situation. MTRIZP activities encouraged the students to detect existing relations between the parts of a situation and establish new relationships between those parts.

6.2.3 (e) Inference

Significant statistical differences at a p value of < 0.01 were observed in the enhancement of inference of the control and experimental groups. The results favor the experimental group (Table 5.13).

The activities of MTRIZP enabled the students to add new knowledge by relying on either hypotheses/assumptions or preliminary knowledge and information.
that were available to the students. Thus, this skill helped the students in their reasoning.

6.3 Effect of MTRIZP on Problem-solving Skills

This study targeted all aspects of Problem-solving skills, namely, (1) general attitude, (2) identification of problem, (3) assessment, (4) generation of alternatives, and decision making.

Significant statistical differences were observed at a p value of < 0.01 in the enhancement of problem-solving skills of the control and experimental groups. The result favors the experimental group (Table 5.12).

The interviews with the students (Q1, Q4) confirmed the positive effect of the MTRIZP on the Problem-solving skills of the talented students.

The researcher believes that each category of problem-solving skill can be nurtured and developed independently.

The following sections summarize and explain the results.

6.3.1 (a) General Attitude

Significant statistical differences were observed at a p value of < 0.01 in the enhancement of general attitude of the control and experimental groups. The result favors the experimental group (Table 5.14).

The activities of MTRIZP helped the students think and deal with unfamiliar concepts. The activities prompted the students to formulate and develop new
approaches. Notably, MTRIZP activities were effective in improving the problem-solving skills of the students, along with their confidence in their abilities.

6.3.1 (b) Identification of the Problem

Significant statistical differences were observed at a p value of < 0.01 in the enhancement of the problem identification of the control and experimental groups. The result favors the experimental group (Table 5.14).

The activities of MTRIZP encouraged the students to define the problem and come up with multiple solutions.

In addition, MTRIZP activities required students to describe in detail the problem and the solutions. The enhancement of their skill in problem identification added to the development of their creative thinking skills.

6.3.1 (c) Assessment

Significant statistical differences were observed at a p value of < 0.01 in the enhancement of assessment of the control and experimental groups. The result favors the experimental group (Table 5.14).

The activities of MTRIZP stimulated the interaction of students and promoted their abilities in performing assessments. The students were also encouraged to innovatively come up with solutions and downsize rote thinking and traditional approaches. The students were constantly encouraged to develop new ideas and approaches. As a result, they enhanced their critical thinking and problem-solving
As the students were challenged, they improved their self-confidence and competence, which in turn boosted their satisfaction and pushed them to further develop their critical thinking and problem-solving skills.

6.3.1 (d) Generation of Alternatives

Significant statistical differences were observed at a p value of $< 0.01$ in the enhancement of the ability to generate alternatives of the control and experimental groups. The result favors the experimental group (Table 5.14).

The activities of the program challenged the students to generate numerous solutions and alternatives. Such approach helped the students enhance their critical thinking skills, motivation, and self-confidence and promoted their abilities in generating new and alternative solutions and methodologies.

6.3.1 (e) Decision Making

Significant statistical differences were observed at a p value of $< 0.01$ in the enhancement of the decision making of the control and experimental groups. The result favors the experimental group (Table 5.14).

The activities of MTRIZP concentrated on enhancing the decision-making skills of students. The students were challenged to solve problems through the different strategies of MTRIZP.
The improvement of decision-making skills of students effectively promoted their problem-solving skills through engagement in group discussions and fulfillment of the talented students’ need for achievement.

6. 4 Discussion of Findings Related to Hypotheses One and Two

Hypothesis one. No significant difference was observed in the critical thinking and problem-solving skills of the participants in the experimental and control groups in the pre-test.

The result showed no significant difference in the critical thinking and problem-solving skills of the experimental and control groups in the pre-test.

The result did not show significant difference in the critical thinking and problem-solving domains of the experimental and control groups in the pre-test (Tables 5.6 and 5.7).

Hypothesis two: The application of MTRIZP had no significant effect on the critical thinking and problem-solving skills of gifted and talented students.

After intervention with MTRIZP, a significant difference was observed in the critical thinking and problem-solving skills of the experimental and control groups.

The problem solving and critical thinking scores of the experimental group were higher than those of the control group (Table 5.8). A significant difference was found skills in the domains of problem solving for the experimental and control groups. The means and mean ranks of the experimental group was higher than those of the control group (Table 5.12).
The result also showed a significant difference in the critical thinking domains of the experimental and control groups. The means and mean ranks of the experimental group were higher than those of the control group (Table 5.13).

The findings for the second hypothesis were based on the assumption that students trained under MTRIZP achieved higher post-test results than the students who were taught using the regular program. The findings showed that the students who received training under the MTRIZP demonstrated enhanced levels of critical thinking and problem solving compared with students who were taught with the regular program. Thus, the second hypothesis is not supported. The findings show statistically significant differences in the level of critical thinking and problem solving of the students in the experimental and control groups.


These findings show that MTRIZP enhances the critical thinking and problem-solving skills of talented students. Several researchers support this study because of the positive results obtained by the individuals from the program.
The results also indicate that MTRIZP is more effective than the program offered by the Tabuk Center in enhancing the critical thinking and problem-solving skills of talented students. This positive effect of the MTRIZP can be attributed to the fact that the MTRIZP provided the experimental group with an exceptional learning environment. Thus, MTRIZP promoted their critical thinking and problem-solving skills and enabled them to thoroughly express themselves. MTRIZP was also unique in that it offered the students a real opportunity to participate in hands-on activities that promoted their critical thinking and problem-solving skills.

MTRIZP clearly exerted a positive effect on the experimental group as it enhanced their critical thinking and problem-solving skills.

Results also show that MTRIZP developed the critical thinking skills of gifted students, thereby confirming the effectiveness of the TRIZ program and its efficiency in the development of critical thinking skills. Such positive effect of the TRIZ program is attributable to its content and exercises that are connected to and based on the real life of students, as well as its ability to change the rigidity of traditional methods of education. In this program, the student who criticizes the situation and illustrates its advantages and disadvantages can use critical thinking skills through exposure to different situations offered by the program. Critical thinking requires the critical thinker to obtain feedback and consultation from external sources in a democratic environment that is receptive to the culture comprising different views.

This issue was focused on the training sessions of MTRIZP, where ideas were presented and criticized. The strengths and weaknesses of the ideas were recognized,
and the points of view of the majority were respected. These features helped in the
emergence of the positive result. The result can be also be attributed to the fact that
the students at this stage develop the ability to think critically. They are can
recognize more things than they did in the previous stages of their lives and
understand the ideas presented.

In addition, students are not used to thinking critically, as evidenced by their
low critical thinking scores (Norris, 1985). Furthermore, some studies, such as those
of Aldjaafarh and Kharabsheh (2007) and Al-Hadabi & Al-Ashool (2012) reported a
low degree of critical thinking among outstanding students.

The results of the current work confirm the continuity of the effectiveness of
MTRIZP in the development of critical thinking skills. This proven effectiveness can
be attributed to the extended positive impact of the training program as a result of its
richness, its focus on students’ concerns, and its feature of stimulating their
imagination. The program also guides students to explore new areas. These areas
were proven effective in the development of the levels of critical thinking. Therefore,
the results confirm the presence of the effect of training activities on critical thinking
and problem-solving skills.

The school curriculum does not provoke critical thinking because the
traditional classroom focuses on ready-made solutions to problems. In addition,
educational programs do not highlight critical thinking activities. These educational
programs are only concerned about academic topics that should be addressed by the
school for the purpose of examination. In other words, these programs do not
highlight aspects of students’ capabilities and achievement.
Furthermore, students in traditional educational methods are accustomed to receiving information from the teacher. They then memorize this information and retrieve it in achievement tests and final examinations. Course activities are conducted in the same way, wherein only the transmission of information is involved. This traditional method prevents the employment of the capabilities and potential of students and the development of their critical thinking skills.

By contrast, MTRIZP activities allowed students to think critically and recognize problems that others do not see. They realized flaws and deficiencies in the process. Additionally, the activities of MTRIZP facilitate the awareness of students of the vulnerabilities and changes in problems as a necessary step to finding alternatives and solutions. Consequently, the students were able to develop, test, retest, and adapt hypotheses and present the results.

The researcher realized the students’ desires and reactions during the application of MTRIZP. This realization became evident through the students’ enthusiasm in collecting information, engaging in discussions, asking questions, participating in training activities, carrying out the tasks required, and interacting within the groups. These aspects were also observed because the focus of the current research helps in resolving the problems faced by students in their scientific and social life, facilitated the development of critical thinking skills and the use of appropriate principles for problems, along with the possibility of using more than one principle to avoid conventional and unfamiliar solutions.

During the application of MTRIZP, the researcher’s use of various strategies, techniques, and methods assigned the responsibility of learning to the students. In
turn, the students developed their critical thinking skills, which allowed them to
discover and rediscover knowledge using their own styles.

Through MTRIZP, learners can deal with situations in school and the
workplace and solve varied problems. In this work, the strategies of MTRIZP
supported the students’ sense of responsibility for learning tasks that were not
imposed by the school and their teachers. These strategies enabled the students to
understand their positive participation through discussion, discoveries, teacher’s
directions, and presentation of results. These improvements helped the students
achieve their goals.

The results are compatible with the reports of Dixon (2002) who pointed out
that the development of critical thinking among gifted students requires special
training and a specific type of activity. These authors also noticed that the mere
exposure of these students to normal curricula and traditional teaching methods and
unvaried methods of assessment will not help in the development of general and
critical thinking skills. This finding also applies even to talented students who are
willing to develop and practice sophisticated thinking.

Most previous studies that addressed programs based on TRIZ theory merely
focused on the effect of theoretical strategies on innovative and creative thinking,
critical thinking skills, and metacognition. The studies reviewed in the current work
(Mujahid, 2015; Mokhtar, 2015; Sheikh and Al-Qadhi Sobh Al-Lolo, 2015;
Khawaldeh, 2016; Abdel Aal 2013; Said, 2014; Gazem and Rahman, 2014;
Abdullah Mahdi, 2014; Gad Al-Haq, 2014; Gad Al-Mawla, 2013; Arwa Abdul
Karim 2013 Karim, 2016; Nour Hassan (2013); Sabri & Al-Hazmi, 2013; Lathin,
2013; Souchkov, (2016). Raeed, 2013; Al-Khayat, 2012; Turki, 2011; Suleiman,
Sheikh and Al-Qadi (2010) confirmed the importance of TRIZ theory as a creative tool in the development of critical thinking skills in general. Al-Refaai (2012) showed the effectiveness of the principles TRIZ theory in the field of education of gifted students.

The results of the study showed that MTRIZP affected the development of problem-solving skills of gifted students. Moreover, the proposed program helped gifted students recognize such skills, which led to a change in the gifted students’ conceptualization and development of these skills.

The proposed program likewise helped students focus on the interaction with the program so as to enhance their problem-solving skills before developing the skill for identifying problems and before developing the styles to solve problems. Furthermore, the program taught the students to perform decision making, resolve a problem after it had been studied, compile information about the problem, and study alternatives and scrutinize them. The program helped the gifted students to be more positive and enabled them to deal with problems that confused them and negatively affected the clarity of their minds.

Using the principles of the TRIZ program, which are seen as tools for guidance, helped gifted students discover and formulate problems, encouraged them to abandon stereotypes, and trained them to produce unfamiliar new ideas to reach special solutions for various problems. Furthermore, the principles used in the program helped the students check the status of a topic, discover problems, and formulate problems in the form of questions to develop their ability to understand problems. In addition, the principles of the TRIZ program trained students to analyze
problems, use all available sources, and identify resources that could help them reach solutions and resolve contradictions.

These milestones were followed by drafting a new text that could clearly express a given problem. This change helped the students develop their abilities to produce flexible ideas. Training under this program helped the students identify perfect results for a particular problem and offer justifications for taking appropriate and possible directions for the problem. Consequently, their abilities to assess ideas and develop solutions were enhanced.

The activities used in the construction program made encouraged gifted students to play an active role in the educational process by giving them the freedom to put forward their ideas and solutions to problems. This process, in turn, increased their knowledge. The activities enabled the students to examine problems in terms of various aspects to break free from stereotypes and produce new ideas and distinctive solutions to various problems. This result is consistent with Mujahid (2015), Mokhtar (2015), Sayed (2013), Turky (2011), and Louri (2009).

The positive outcome of the current work can be attributed to the fact that the training program designed according to the principles of TRIZ theory was prepared in a dynamic environment where learning and working were based on issues that matched the nature and level of students’ creative skills. The aspects of thinking in such an environment helped students find solutions using TRIZ theory. This setting encouraged the ideas of gifted students and supported their abilities to solve problems and provide feedback on an ongoing basis. The students were also given directions toward the need to deal with the challenges of a problem and view data as chances to develop problem-solving skills.
6. 5 Discussion of Findings Related to Hypothesis Three

**Hypothesis three:** Age, birth order, class, father’s education, and mother’s education did not exert a significant effect on critical thinking skills of gifted and talented students after applying the MTRIZP.

Result showed that age, birth order, and father’s education did not show any significant effect on the problem-solving skills of the gifted and talented students after applying the MTRIZP.

Result showed that class and mother’s education at the university level exerted a significant effect.

- **Age exerted no significant effect on critical thinking after the application of MTRIZP.**

This study showed a significant difference in the students’ critical thinking in the pre-tests based on their age. No significant difference was observed in the post-tests. This result indicates improvement in the critical thinking of the students at certain ages (Table 5.18). The implementation of MTRIZP is not affected by age group, although it is most effective for participants aged 12 years.

A significant difference was found in the assumption that participants aged 12 years recorded the highest means of assumption. Significant improvements in interpretation and inference were found as a result of the non-significant values in the post-tests relative to the pre-tests (Table 5.24).

However, the results of this study are not consistent with Hambar et al. (2002). The researcher believes that this difference is attributed to the metrics used to
measure critical thinking, the variability of methodologies, and/or the size of the study sample. For the current study, the size of the sample was relatively large.

The results can be interpreted in a way that emphasizes the importance of civilizational and cultural development and freely accessible knowledge of information technology. These characteristics transform the world into a small village where information and knowledge can be obtained in less than a second.

- **Birth order exerted no significant effect on critical thinking after applying MTRIZP.**

  This study showed no significant difference in the students’ critical thinking based on their birth order in the pre- and post-tests (Table 5.19).

  No significant difference was found in the students’ critical thinking across all domains in the post-tests (Table 5.26). In other words, the eldest, middle, and youngest children showed improvements in their critical thinking skills after the application of MTRIZP. No difference was observed in the critical thinking skills of the participants with different birth orders. Thus, the general effectiveness of MTRIZP implementation is not affected by birth order.

  The Kruskal Wallis test was used to identify differences in assumption, interpretation, deduction, and inference. The only significant result was found in interpretation, wherein the highest mean ranks were observed among the eldest, followed by the middle and youngest children. One possible explanation is that the
family environment provides opportunities to interact and rich incentives for critical thinking skills.

Another influencing factor is technological advancement, especially with regard to communication. In the past, communication with children was restricted to face-to-face interactions and forms of communication, such as talking with parents or siblings. Communication today is no longer restricted to face-to-face interaction, especially with the advent of social media and video and audio communications. These changes enable children to achieve critical thinking skills without any dependence on direct social interactions.

**Class exerted no significant effect on critical thinking after the application of MTRIZP.**

This study showed a significant difference in the participants’ critical thinking skills. Grade eight students recorded the highest overall score for critical thinking, followed by grade ninth and seventh students (Table 5.20).

A significant difference was found in deduction, wherein grade nine students received the highest score, followed by grade eight and seven students. Moreover, a significant difference was found in assumption, wherein grade eight students received the highest mean rank (Table 5.28).

These findings show that class level did not affect the effectiveness of MTRIZP in general, but it effectively improved the deduction skills of ninth graders, as shown in the pre-tests (Table 5.24).
One of the possible explanations is the focus of the new curricula on critical thinking and present the skill of critical thinking daily to the students in all lessons, either through practical application or through course exercises. Thus, students are supported in their development of critical thinking skills through the employment of MTRIZP.

As explained previously, the activities of MTRIZP stimulated the critical thinking skills of students, thereby enabling them to think in a manner beyond traditional, rote thinking.

However, the results of this study are not consistent with the findings of Abdulhameed (2015), Al-Asmary (2014), and Aldjaafarh (2007). The researcher of the present study attributes this difference to the metrics used to measure verbal fluency, the variability of methodologies, and/or the size of the study sample. The size of the sample was relatively large in the current study.

**Fathers’ and mothers’ education exerted no significant effect on critical thinking after the application of MTRIZP.**

This study did not find a significant difference in the participants’ critical thinking based on their fathers’ education in the pre- and post-tests (Table 5.21).

A significant difference was observed for all domains of critical thinking based on fathers’ education in the post-tests (Table 5.30).

A significant difference was observed in the participants’ critical thinking based on their mothers’ education in the pre-tests. The highest mean was found for mothers with postgraduate education. No significant difference was found in the participants’ critical thinking based on their mothers’ education in the post-tests. This
result indicates improvement in the participants’ critical thinking after applying the intervention program (Table 5.22). No significant difference was observed across all domains of critical thinking based on mothers’ education in the post-tests (Table 5.32).

The Kruskal Wallis test uncovered a significant difference in deduction based on mothers’ education. The highest mean rank was observed among the students with mothers who held postgraduate degrees. The levels of parents’ education did not affect the effectiveness of the MTRIZP for the participants, but the deduction scores of the participants were high when the mothers’ levels of education were high.

The father is the leader of the house and serves as a top model for others in the family. Thus, a son may believe that the father is correct in all his decisions, points of view, and confidence amid problems. This conception can be explained by the fact that a child may resort to the adoption of his father’s decisions, points of view, and solutions to problems without thinking about these issues.

By contrast, the effect of mothers’ education was highest for children whose mothers held postgraduate degrees. This result could be attributed to the intimate relationship between mothers and their children. Mothers are the main players when it comes to directing children’s lives and providing them with advice and feedback.

6.6 Discussion of Findings Related to Hypothesis Four

**Hypothesis four:** Age, birth order, class, father’s education, and mother’s education exerts no significant effect on the problem-solving skills of gifted and talented students after the application of MTRIZP.
The result showed that age, birth order, class, and father’s education exerted no significant effect on the problem-solving skills of the gifted and talented students after applying MTRIZP.

The result showed that mothers’ education exerted a significant effect, especially for mothers holding university degrees.

The researcher believes that each category of problem-solving skills can be nurtured and developed independently.

**Age exerted no significant effect on problem solving after the application of MTRIZP.**

This study showed a significant difference in the overall scores of the students’ problem-solving skills and their ages in the pre-tests. In the post-tests, no significant difference was observed in the overall scores of problem-solving skills. This result indicates improvement in the problem-solving skills of students as a result of the application of the intervention program (Table 5.33).

The only significant result was observed in decision making, which is different from the significant result in the pre-tests. Students aged 13 years recorded higher mean ranks in the post-tests than in the pre-tests. This result indicated improvement in the participants’ decision making. Moreover, the result showed no differences in the domains of problem identification and generation of alternatives, wherein students reaped the benefits of the intervention program (Table 5.39).
These results suggest that the effectiveness of the MTRIZP in improving problem-solving skills was not affected by the age group of the participants, especially in the domain of decision making.

Two important features should be considered in the proper interpretation of the results. The first feature is a continuous development in civilization and culture. The second feature is the knowledge and technology that are available and open to everyone. This feature transformed the world into a small village in which information and data can be retrieved rapidly.

The results of this study are not consistent with Hambar et al. (2002). The researcher of the present study attributes this difference to the metrics used to measure problem-solving skills, the variability of methodologies, and/or the size of the study sample. The size of the sample was relatively large in the current study.

**Birth order exerted no significant effect on problem solving after the application of MTRIZP.**

This study showed no significant difference in the participants’ problem-solving skills in the pre- and post-tests (Table 5.34).

The result also showed no significant difference in all domains of problem solving in the post-tests (Table 5.41). This outcome indicated that birth order did not affect the effectiveness of MTRIZP implementation in improving problem-solving skills.

One possible explanation is that the family environment provides opportunities to interact and rich incentives for critical thinking skills.

Another influencing factor is technological advancement, especially with
regard to communication. In the past, communication with children was restricted to face-to-face interactions and forms of communication such as talking with parents or siblings. By contrast, communication at present is no longer restricted to face-to-face interaction, especially with the advent of social media and video and audio communications. These changes enable children to achieve critical thinking skills without any dependence on direct social interactions.

**Class exerted no significant effect on problem solving after the application of MTRIZP.**

This study found no significant difference in the participants’ problem-solving skills based on class in the pre- and post-tests (Table 5.35).

The result also showed no significant difference in all domains of problem solving in the post-tests (Table 5.43). Clearly, class level did not affect the effectiveness of MTRIZP implementation in improving problem-solving skills.

This effect may be attributed to the learning environment and school systems, which grant teachers and administrators full authority in solving problems encountered by the students, thereby preventing students from practicing these skills.

The results of this study are not consistent with Selcuketal (2007), The researcher of the current study attributed this difference to the metrics used to measure problem-solving skills, the variability of methodologies, and/or the size of the study sample. The size of the sample was relatively large in the current study.

**Fathers’ and mothers’ education exerted no significant effect on problem solving after the application of MTRIZP.**
This study found no significant difference in the participants’ problem-solving skills based on their parents’ level of education in the pre- and post-tests (Table 5.36).

The result also showed no significant difference in all domains of problem solving (general attitude, identification of problem, generation of alternatives, and assessment) in the post-tests (Table 5.45).

This study found no significant difference in the participants’ problem-solving skills based on their mothers’ education in the pre- and post-tests (Table 5.37).

The result also showed a significant difference in the domain of decision making based on mothers’ education. Participants whose mothers hold university degrees recorded the highest mean ranks (Table 5.46). The Kruskal Wallis analyses reported a significant difference in the decision-making skills of the participants based on their mothers’ education. Participants whose mothers held university degrees recorded the highest mean ranks.

MTRIZP implementation effectively improved the problem-solving skills of participants regardless of their parents’ level of education. However, participants whose mothers held secondary school degrees or lower recorded the most significant improvement in decision-making skills.

Given that the father is considered as responsible for the family and the leader of the house, the son in such a family environment is expected to conceptualize the views, decisions, and thoughts of his father as the best and the most reliable ones. Such conceptualization of the father by the son may encourage he son to regard his
father’s decisions, views, and ideas as the correct decisions that should be followed strictly even without evaluating them.

The effect of mothers’ education was highest among children whose mothers hold postgraduate education. This result could be attributed to the intimate relationship between mothers and their children. Moreover, mothers are main players in directing their children’s lives and providing them with advice and feedback.

6.7 Recommendations for Future Research

This study inspires future research in the following directions.

1) The employment of MTRIZP for teaching thinking can be enhanced by adding lessons in other academic subjects, such as composition, reading comprehension, science, and social studies.

2) Understanding the causal correlation between creative thinking and verbal fluency may be a good issue to consider because it could uncover relationships among such aspects.

3) The impact and feasibility of MTRIZP should also be investigated at the international level.

4) Similar studies should be conducted to teach other types of thinking, such as inferential, innovative, and critical thinking, for talented students by using the MTRIZP or other thinking programs.

5) Research priority should be given to the implementation of MTRIZP among talented students in other Arab environments.
6) Further studies that focus on various types of gifted students with sufficiently large samples of respondents are recommended. Furthermore, future research may employ quantitative comparison research to examine the efficiency of MTRIZP across various types of gifted students.

7) Another issue that needs to be addressed is the impact of MTRIZP on other variables that relate to gifted students. Among these variables are academic achievement, age, schooling type, social status, and economic environment.

8) Future studies may consider investigating the effect of other variables that may leave a positive or negative influence on gifted students’ creative thinking.

9) Other special educational courses/programs can consider an appropriate adaptation of MTRIZP. When the adaptation of the MTRIZP is considered, researchers may examine its effect on dependent variables related to students.

10) Future studies may consider the implementation of the MTRIZP among gifted students, but examining the effect of this program among ordinary students should not be ignored. In this regard, investigating the effect of the MTRIZP on variables concerning ordinary students can be a good research area.

11) Another rich area worth studying is the effect of emerging educational technologies used in teaching, such as software programs like Flash and PowerPoint, smart boards, and smart phones, on the employment of MTRIZP.

6.8 Implications of the Research

1) The critical thinking skills of gifted students can be improved through the
2) Compared with other existing enrichment programs that are encouraged/offered by the Ministry of Education in KSA, MTRIZP performs better in the development and enhancement of critical thinking in terms of efficiency. The evident superiority of MTRIZP is highlighted by the findings of the current study, which showed that the students in the experimental group outperformed the students in the control group. This study revealed the effectiveness of the MTRIZP in helping students to improve their critical thinking skills. Thus, the Ministry of Education in the KSA may consider adopting this program.

3) The existing studies reviewed in this work and the findings of the current study clearly indicate the feasibility of MTRIZP in enhancing the critical thinking skills of gifted students who possess various capabilities. Therefore, the motivation of students to think can be developed by understanding and applying varied thinking skills. To execute this approach, teachers are encouraged to implement different thinking programs in their lessons. One of the most significant conclusions of this study is that MTRIZ is an effective program for enhancing the critical thinking skills of gifted students.

This important finding is consistent with the most important goal of MTRIZP, which is to teach students thinking skills, especially critical thinking skills. Furthermore, this approach of the MTRIZP is beneficial for the development of critical thinking among gifted students.

4) A revision in the structure of conventional assessment in schools should be
considered. This change should lead to the inclusion of new patterns of assessment that employ thinking as one of the criteria so as to help teachers identify students’ thinking patterns and promote occupational, academic, and technical guidance. One of the advantages of this approach is the identification of students with LDs in various aspects of life.

5) The enhancement of gifted students’ critical thinking may be related to their successful learning attainment, which may, in turn, result in high achievements.

6) Educational authorities in KSA are advised to focus on drastic reforms of educational policies that seek to train students, including gifted ones, to develop critical thinking skills.

7) Given the promising results shown in this work, MTRIZP can be considered as a reference and tool for boosting activities that enhance the level of critical thinking skills of gifted students.

8) Workshops and training seminars should be organized for individuals who deal with gifted students. These individuals include gifted and ordinary teachers, educational supervisors, school principals, and others. In such workshops, the target trainees are provided with the latest updates and methods for teaching thinking skills. Trainees should be given a summary of the findings of the current study, which recommends the implementation of the MTRIZP among gifted students.

9) Programs that are designed for gifted students should include specific lessons on thinking skills. In addition, special exercises should be included and used in the curriculum designed for gifted students. MTRIZP is considered a good choice in conducting these exercises.
6.9 Conclusions and Summary

This study concludes that the use of MTRIZP assisted talented students in significantly enhancing their critical thinking and problem-solving skills. These findings uphold MTRIZP. MTRIZP demonstrated considerable effects on critical thinking and problem-solving skills. In other words, this study shows that MTRIZP effectively enhances the critical thinking and problem-solving skills of talented students.

MTRIZP should be taught independently or be integrated into the curriculum for talented students.

The findings also demonstrate the significant effects of age, class, birth order, and fathers’ and mothers’ education on the post-test scores for critical thinking and problem solving. MTRIZP effectively enhances the critical thinking and problem-solving skills of talented students. Thus, course designers and educators should adopt MTRIZP or incorporate a lesson on thinking skills when developing a curriculum for talented students.

In conclusion, MTRIZP is highly effective in enhancing the critical thinking and problem-solving skills of talented students.
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APPEBDEX

APPENDIX (A)

CRITICAL THINKING TEST

Name: _____________________________________________

Age: _______________________________________________

Birth order: _________________________________________

Mark: ______________________________________________

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Test Instructions

1. Do not turn this page until you are giving instruction to do that.

2. Do not place any markings on this document

3. Only use the answer sheet to place your answers, notes, or markings.

4. This test contains five sections, please follow the directions for each section.

5. Before you answer, make sure to read all instructions pertaining to the section, and make sure that you have read the examples.

6. If you decide to change your answer, make sure that you have erased the older answer.

7. Answer all questions, do not leave any unanswered questions.

8. You have 60 minutes to answer the test
First Test

Recognizing Unstated Assumptions

First Test instructions

1. Each Exercise starts with a statement, which is followed by multiple assumptions. You need to decide the validity of each assumption based on the information given in the statement.

2. Place a check mark in the parenthesis in front of the statement if you decide that the assumption is valid.

Example

If the children are young, then the parents need to forgive the shortcomings of their children.

Suggested assumptions:

a. ( ) The parents are not forgiving

b. (√) Children at young age, do not comprehend the erroneous of their behaviors.

c. ( ) The children do not make mistakes.

Statement 1:

Despite the fact that television is a good learning tool, television is not appropriate for learning all disciplines.
Suggested assumptions:

a. ( ) Television is appropriate for learning all disciplines

b. ( ) There are other learning tools besides television.

c. ( ) The other teaching tools are more beneficial than learning through television.

Statement 2

Some of the human behavior is considered animal behavior.

Suggested assumptions:

a. ( ) Humans and animals share similar behavior.

b. ( ) The animal behavior is considered violent.

c. ( ) The human behavior is considered flexible.

Statement 3

Collaborations means that a group of people work together to fulfill a common goal, as in the case of group of people collaborating to defend themselves or to gain a sustenance.

Suggested assumptions:

a. ( ) Collaboration is an easy task and is widespread.

b. ( ) Collaborations to fulfill an immoral goal is against ethical believes, and thus is considered a negative collaboration.

c. ( ) When multiple people agree on a common goal, then we conclude that such people collaborate effectively.
Statement 4

The relationship between the child and his/her parents lays the foundation for the all future relationships between the child and others.

Suggested assumptions:

a. ( ) Parents play an important role in the health of the child’s social relationships.

b. ( ) The child has an independent personality and forms his/her own relationships.

c. ( ) The parents influence on the child’s future social relationships is minimal.

Statement 5

If a person suffers from psychological disorder, then this person may develop mental illness.

Suggested assumptions:

a. ( ) Humans can only suffer from psychological disorders.

b. ( ) There is a link between psychological disorders and mental illness.

c. ( ) Every person with a mental illness suffered from psychological disorder at an earlier stage.

Statement 6

The relationship between the child and his/her parents lays the foundation for the all future relationships between the child and others.

Suggested assumptions:
a. ( ) Parents play an important role in the health of the child social relationships.

b. ( ) The child has an independent personality and forms his/her own relationships.

c. ( ) The parents influence in the child’s future social relationships is minimal.

Statement 7

If we integrate modern educational system, then we will be assured that we can progress toward technological development.

Suggested assumptions:

a. ( ) We are currently benefiting from technological advancements.

b. ( ) If we do not develop a modern educational system, then we will be at a low level of technology.

c. ( ) If we have modern educational system, then we are guaranteed that we will be at an advanced technological level.

Statement 8

Some of the natural therapies can benefit the treatment of human diseases more than the medicines that are prescribed by the doctors.

Suggested assumptions:

a. ( ) All natural therapies are harmful to the human health.

b. ( ) Doctors are not aware of the natural therapies.
c. ( ) There are other means for treating human diseases other than medicines, which are prescribed by doctors.

Statement 9

Usama did not invite Sami to his party.

Suggested assumptions:

a. ( ) Usama graduated from the university this year.

b. ( ) Currently, Usama does not like Sami.

c. ( ) Usama did not have his party yet.

Statement 10

Ibrahim is lucky in that his work is very close to his residence, and thus, Ibrahim does not have transportation problems.

Suggested assumptions:

a. ( ) Working people do not have transportation problems.

b. ( ) If we follow the system, we will not have any transportation problems.

c. ( ) If the workers’ residences are far away from their work, then they are very unfortunates.

Statement 11

A sensible person is the one who drives his/her car at a reasonable speed.

Suggested assumptions:

a. ( ) The driver of the car has to be sensible to drive the car at a reasonable speed.
b. ( ) A stupid person does not have mental abilities to allow him/her to drive the car at a reasonable speed.

c. ( ) A person who drives the car at 60 km/hour is a sensible person.
Second Test

Reasoning

Second Test directions

1. Each Exercise starts with a statement, which is followed by multiple results. You need to decide the validity of each result based on the information given in the statement.

2. Place a check mark in the parenthesis in front of the statement if you decide that the result is valid.

Example

Ameer received a full mark in the high-school math exam during his studies at King Abdul-Aziz School in Mecca.

Suggested assumptions:

a. (√) All students of King Abdul-Aziz School in Mecca received full mark in the math test.

b. ( ) It is possible that Ameer is a high ranking student in all school subjects.

c. ( ) Ameer is well-liked from all students

Statement 1

In 1980, a report for one country stated that there were 27401 marriages and 321 cases of divorce.

Suggested assumptions:
a. ( ) Getting divorce is an easy process in this country.

b. ( ) If the numbers above are still representative for that country, the ratio of marriages is four times that of divorce.

c. ( ) The divorce rate is very high in this country

**Statement 2**

In the final math test, Sara’s grade was 30 and Amani’s grade was 25, Sara and Amani studied at two different schools.

Suggested assumptions:

a. ( ) It is possible that Sara’s school is better than Amani’s school.

b. ( ) Sara is more intelligent than Amani, thus Sara received a higher grade than Amani

c. ( ) The math teaching methods in Sara’s school is better than the math teaching methods in Amani’s school.

**Statement 3**

Educators in our school are interested in teaching English because it is the only way to study cultures of countries whose language is English.

Suggested assumptions:

( ) **There should be no preference for learning English, but rather all foreign languages should be given the same importance.**

a. ( ) It is not feasible to not learn English.

b. ( ) Arabic language should be taught at the schools of foreign countries as English is taught in our schools.
**Statement 4**

There are many students who passed but do not obtain an acceptable scores in the high school exam that can allow them to enter universities, many students repeat the high school examinations, which result in wasting human resources that can be better utilized.

Suggested assumptions:

a. ( ) Most graduates from high schools do not enter universities.

b. ( ) Some students repeat the high school exam two or three times before obtaining an acceptable score.

c. ( ) Allowing students to retake the high school examination should be reevaluated.

**Statement 5**

The western civilization influenced our youth whom took on some of western civilization cultural aspects. At the same time, the parents of the youth are still grasping on the cultural aspects of the Arabic culture.

Suggested assumptions:

a. ( ) The Arabic culture is better than the western culture.

b. ( ) Parents are at fault because they do not consider the modern western civilization cultural aspects.

c. ( ) The western civilization has its own culture, and we have our own culture.
Statement 6

In 1980, an Egyptian newspaper did a comparative study on the number of accidents by car drivers and train drivers in Alexandria. It was found that 341 accidents were caused by car drivers, while the train drivers only caused 164 accidents.

Suggested assumptions:

a. ( ) Car drivers caused more accidents that train accidents in Alexandria.

b. ( ) The number of car drivers are higher than the train drivers.

c. ( ) The train drivers are better in adhering to driving safety rules than the car drivers in Alexandria.

Statement 7

The October war in 1973 proved that Israelis are cowards, and this guarantees that the Arabs can win any subsequent war.

Suggested assumptions:

a. ( ) The Israelis weapons cannot match the quality of the Arabic weapons.

b. ( ) Arabs should constantly train their army and develop their weapons in preparations for future wars.

c. ( ) Humanity did not progress sufficiently toward enforcing peace as it did in enforcing wars.

Statement 8

Intelligence assessment showed that the students of Alnassar School performed better than the Aloroba School students, but the Alnassar School students did not score as high as the students of Althafer School in the intelligence testing.
Suggested assumptions:

a. (   ) The students of Althafer School scored high in intelligence testing because they are more intelligent by instinct than the Alanssar and Aloroba students.

b. (   ) The families of Althafer students are on average more intelligent than the families of Alanssar and Aloroba students.

c. (   ) The Althafer students receive better education than Alanssar and Aloroba students, and this impacts the results of the testing.

Statement 9

It was shown in a study that the females are better in linguistic fluency while the males are better in mathematical abilities.

Suggested assumptions:

a. (   ) All females are better in language grammar than males.

b. (   ) All males have lower linguistic fluency than females.

c. (   ) There is a correlation between the sex of the child and his/her linguistic fluency and mathematical abilities.

Statement 10

Population scientists showed that the center of the city is usually highly populated and packed with shops, the density of and people and shops decreases with distance from the center of the city. The areas on the peripherally of cities are usually populated with people who moved from the villages and who belong to a low social class.
Suggested assumptions:

a. (   ) All villagers belong to a low social class.

b. (   ) All city inhabitants belong to a high social class.

c. (   ) Some of the people who live in the peripheral of the city belong to a low social class.
Third Test

Discussion Assessment

Third test directions

Each Exercise starts with a question, which is followed by multiple answers. You need to decide the strength of each answer.

- Strong answer: important responses that is directly linked to the question.
- Weak answer: Insignificant responses that is not directly linked to the question.

Place a check mark in the parenthesis in front of the statement if you decide that the response is strong.

Example

Is it necessary for the government to place a law to determine wages between the employer and employees?

a. (✓) Yes, because one duty of the government is to protect the employees.

b. (   ) No, because this should be left for the individuals to decide.

c. (   ) No, because this can be achieved through media and guidance.

Question 1

Can a woman work in the medical field if she had the abilities?

a. (   ) Yes, because a woman can work in all fields.
b. ( ) No, because a woman could have difficulties in the aspects relating to male surgical operations.

c. ( ) No, because a woman's task is the upbringing of her children.

**Question 2**

Is it necessary for students to study according to a set unified schedule?

a. ( ) Yes, because students need to realize that they cannot always apply their own study styles.

b. ( ) Yes, because a student needs to get trained on being punctual and accurate.

c. ( ) No, because there are personal differences between students, students should study according to their styles and personal preferences.

**Question 3**

Is television a better cultural tool than theater?

a. ( ) No, because actors perform live on theater.

( ) No, because television can transmit to the audience things that theater cannot accomplish.

b. ( ) Yes, because watching television is an easy, convenient method of entertainment.

**Question 4**

Do we need to establish charity organizations to collect the donations from the rich and distribute to the poor?
a. ( ) Yes, because without such donations the poor cannot survive.
b. ( ) Yes, because poor people lack many recreational and auxiliary items.
c. ( ) No, because each individual should utilize their own abilities to gain his/her wage.

Question 5

Is it necessary to advance the teaching of females?

a. ( ) No, because teaching females results in the female gaining independence and abilities to argue.
b. ( ) Yes, because a female learns about her living and religious needs from education.
c. ( ) No, because a female will end up being a house-wife.

Question 6

Should we allow the children to discuss their personal issues with their parents without any preservations?

a. ( ) No, because respecting parents is more important than any other issue.
b. ( ) Yes, because the children personality matures during such discussions.
c. ( ) No, because if children are given freedom their personality will be negatively affected.

Question 7

Was education better in previous years than the current time?

a. ( ) No, because educational Programs and methodologies improved a lot in recent years.
b. ( ) Yes, because the subjects were harder in the previous years.

c. ( ) Yes, because students were more obedient to their teachers than the current time.

**Question 8**

It is necessary to modernize the hand-crafted trades by automating them?

a. ( ) Yes, because we need to keep up with modern civilization.

b. ( ) No, because some of the hand-crafted products will lose its value if they are manufactured by a machine.

c. ( ) Yes, because we can save lots of time and effort.

**Question 9**

Is it necessary to develop the secondary education so attending university is not the only option?

a. ( ) No, because an education in a university is required to advance the nations.

b. ( ) Yes, because it is necessary to train qualified technicians and increase the production, which will lead to advancing the countries.

c. ( ) No, because every individual should gain an access to educational opportunities.

**Question 10**

Is teaching the core subjects the only task of schools?

a. ( ) Yes, because without the core subjects schools cannot be established.

b. ( ) No, because schools have other tasks besides teaching the core subjects.
c. ( ) Yes, because the only metric for enrolling in a university is the cumulative score in the core subjects.
Fourth Test

Deduction Assessment

Fourth test directions

1 Each Exercise is comprised of two statements, which is followed by suggested results. You need to consider that the two statements are completely valid even if you disagree with one or both of the given statements.

2 Read each suggested result and decide if the information is a direct conclusion from the statements.

3 Place a check mark in the parenthesis in front of the statement if you decide that the suggested result is a direct conclusion from the statement.

Example

A hero is a person who defend his country. Walid defends his country.

a. ( ) All people like to defend their countries

b. (√) Walid is a hero.

c. ( ) Walid is a coward.

-------------------------------------------------------------

Statements- 1

- Students who are good in physics are hardworking individuals.
- Hamdi is good in physics.
  a. ( ) Hamdi is a hardworking individual.
  b. ( ) Students who are good in physics are high achievers in the school.
c. ( ) Students who are good in math are good in physics.

**Statements- 2**

- All artists are gifted and talented student.
- Some artists do not show off.
  a. ( ) All gifted and talented student people are artists.
  b. ( ) There are no gifted and talented student individuals within people who show off.
  c. ( ) Some gifted and talented student people are artists.

**Statements- 3**

- All high school students study English language.
- Some high school students study German language.
  a. ( ) All students who study English language are high school students.
  b. ( ) Some of the students who study English language study German language.
  c. ( ) All students who study German language do not study English language.

**Statements- 4**

- All individual who like to have fun like watching television.
- Some people do not like to watch television.
  a. ( ) People who do not like to have fun do not like watching television.
  b. ( ) People who like to watch television also like to have fun.
c. (   ) There are no individuals who don’t like to watch television amongst people who like to have fun.

Statements- 5

- All ministers are devoted to their jobs.
- Some ministers work as a university faculty members.
  a. (   ) All university faculty members are devoted to their jobs.
  b. (   ) Some of the individuals who are devoted to their jobs are university faculty members.
  c. (   ) All ministers are originally university faculty members.

Statements- 6

- If a child is treated well during his childhood, he/she will most likely treat others well.
- Many people were treated well during their childhood.

(   ) If the individual tends to treat others well, most likely he/she was treated well during his/her childhood.
  a. (   ) Many people tend to treat others well.
  b. (   ) If a child was treated badly then he/she will treat others badly.

Statements- 7

- All private high school students passed their studies.
- Tarik did not pass.
  a. (   ) Tarik did not attend a private high school.
b. ( ) The outcomes of the private high schools is better than the outcomes of Tarik’s schools.

c. ( ) Tarik did attend a private high school.

Statements- 8

- All medical school graduates are very intelligent.
- Ibrahim graduated from a medical school.
  a. ( ) Ibrahim has an average intelligence.
  b. ( ) Some of the medical school graduates have average intelligence.
  c. ( ) Ibrahim is very intelligent.

Statements- 9

- All Arabs are very generous.
- Some Arabs are devoted to their jobs.
  a. ( ) There are no Arabs among stingy people.
  b. ( ) All individuals who are devoted to their jobs are generous.
  c. ( ) some generous individuals are devoted to their jobs.

Statements- 10

- All circles are derived from circular shapes.
- X and Y are derived from a non-circular shape.
  a. ( ) The shape of X is oval.
  b. ( ) The shape of X is rhombus or trapezoid.
  c. ( ) The shape of X is not a circle.
Fifth Test

Inference Assessment

Fifth test directions

1 Each Exercise is comprised of a paragraph, which is followed by suggested inferences. You need to consider that the facts in the paragraph are completely valid even if you disagree with one or both of the given statements.

2 Read each suggested inference and decide if the information is a direct inference from the paragraph. You need to decide on the strength of each inference:

   - Completely valid (5);
   - partially valid (4);
   - incomplete evidence (3);
   - partially erroneous (2);
   - completely erroneous (1).

3 Place the number that corresponds to your answer.in the parenthesis in front of each of the suggested inferences.

Example

1000 freshman from high school students attended a non-obligatory a summit to discuss the relationship between different races and means for implementing world peace because the students felt that these topics are of extreme importance in this current time.

   a. (5) The age of the students is between 19-20 years old.
   b. (2) These students came from different parts of the world.
   c. (1) The students only discussed issues relating to relationships within the employees.
d. (4) The students felt that discussing the race and peace issues are very important tasks.

e. (3) The students who attended the summit care for humanitarian and social issues more than their freshman peers.

Paragraph- 1

A competition was initiated between students for selection of the “ideal student”. Sharif got most of the votes, while other students received substantially less number of votes.

a. ( ) Other students are not well suited for student leadership.

b. ( ) Sharif is very advanced in scientific subjects.

c. ( ) Sharif is well devoted to his peers.

d. ( ) Sharif loves all his family members and his family admires him.

e. ( ) Other students are academically advanced but are not socially advanced.

Paragraph- 2

Creativity assessment was given to a class in one of the high schools. The average score was above average. The analysis of the test also showed that students who acquired high scores in the creativity assessment test were also the highest achievers within their class.

a) ( ) There is a strong correlation between school performance and creativity thinking.

b) ( ) Only creative students can enroll in the high school.
c) (    ) If the creativity assessment was given to an elementary school students, we will obtain the result.

d) (    ) Creative students are intelligent.

e) (    ) Only high-achieving students can enroll in the high school.

Paragraph-3

There are two objectives for the space research missions. The first objective is concerned with the military application, which is considered secretive. The second objective is concerned with the collecting data and information, which is intended for scientific, peaceful applications.

a) (    ) This duplication in the research is unnecessary.

b) (    ) The military research is different from the scientific research.

c) (    ) The military can benefit from the scientific research, but the opposite is untrue.

d) (    ) Collaboration between military and scientific community helps to advance the space mission research.

e) (    ) The military research is only concerned with destruction, and the scientific research is concerned with philanthropy.

Paragraph-4

The pediatric dentists recommends that children should not eat sweets before going to bed because this will prevent teeth decay.

a) (    ) The reduction of eating sweets before bed time has detrimental effects.

b) (    ) The reduction of eating sweets before bed time is a good remedy for teeth decay.
c) ( ) To protect children from teeth decay, it is sufficient to prevent the children from eating sweets.

d) ( ) Eating sweets is the only reason for teeth decay.

e) ( ) There are a big percentage of children who suffer from teeth decay.

**Paragraph-5**

Despite the economic reform in many of the ruler areas, many villagers are still migrating to the cities seeking job opportunities. This results in increasing the housing and transportation challenges in the cities.

a) ( ) There are more job opportunities in the cities compared to that in the villages.

b) ( ) The worker in the city can make more money than the worker in the village.

c) ( ) Only unemployed people migrate to cities.

d) ( ) The employment opportunities are higher in the cities compared to that in the villages.

e) ( ) Increasing employment opportunities in the villages can lead to alleviate the housing and transportation problems in the cities.

**Paragraph-6**

One of the scholars’ duties is to raise the level of literacy among people to meet the level of the scholars’ knowledge. The scholars should not drop the level of their knowledge to the people. The reasons for this are: (1) the people should always be advancing their literacy, and (2) knowledge should always be valued and highly appraised.
a) (   ) What is applied to knowledge, should be applied to philosophy.

b) (   ) One of the main objectives of knowledge is to raise the level of people’s literacy.

c) (   ) Degrading knowledge can degrade the level of people’s literacy.

d) (   ) Maintaining knowledge is more important than people understanding the knowledge.

e) (   ) The higher the level of people’s literature, the higher the level knowledge will be.
APPENDIX (B)

HAPPNAR’S PROBLEM SOLVING ASSESSMENT

Dear student,

The researcher is conducting a doctorate dissertation in special education at University of Science in Malaysia (USM). The title of the study is: The effectiveness of a training Program, which is based on TRIZ theory in the enhancement of critical thinking and solving problems for gifted and talented students in KSA of Saudi Arabia.

It is well appreciated if you respond to the assessment inquiries. The assessment includes a collection of statements, which describes their general use by people in dealing with their daily life-problems. Please read each statement and evaluate its suitability for your personal problem solving style. Place an X in the suitable column next to the statement.

Your cooperation, accuracy, and honesty in responding to this assessment is highly valued. Please note that the information you provide will be used only for this scientific study.

Thank you for your collaboration.

Sincerely,

The researcher
Solving problems assessment

Name: _____________________________________________

Age: _______________________________________________

Mark: _____________________________________________

Birth Order: _______________________________________
## Problem solving assessment

<table>
<thead>
<tr>
<th>No.</th>
<th>Statement</th>
<th>Apply to a high degree</th>
<th>Apply to a medium degree</th>
<th>Apply to a small degree</th>
<th>Does not apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I look at problems as normal phenomena in the humans’ life</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>I collect enough information for each problem that I face.</td>
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<tr>
<td>3</td>
<td>I consider positive and negative consequences for all the suggested options for solving the problem</td>
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<tr>
<td>4</td>
<td>I think of all possible options that can solve the problem that I face</td>
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<tr>
<td>5</td>
<td>I concentrate on the immediate solutions, not long-term solutions</td>
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<tr>
<td>6</td>
<td>I believe that I can face the daily life-problems</td>
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<tr>
<td>7</td>
<td>I try to pinpoint the problem in a clear manner</td>
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<tr>
<td>8</td>
<td>I find it difficult to find multiple solutions to the problem</td>
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<tr>
<td>9</td>
<td>I only focus on the positive sides of the solution that I hope to achieve</td>
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<tr>
<td>10</td>
<td>I choose the easiest solution no matter what the consequences are</td>
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<tr>
<td>11</td>
<td>I utilize a systematic approach for solving my problems</td>
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<tr>
<td>12</td>
<td>When I face a problem, the first thing I do is to identify the problem</td>
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<tr>
<td>13</td>
<td>I find my thinking confined to one solution to the problem</td>
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<tr>
<td>14</td>
<td>I concentrate on the negative consequence of the solution that I do not like</td>
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<tr>
<td>15</td>
<td>I take care to assess the solution after I try it</td>
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<tr>
<td>16</td>
<td>I find it difficult to organize my thoughts when I face a problem</td>
<td></td>
<td></td>
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<tr>
<td>17</td>
<td>I am careful to use suitable statements to describe the problem</td>
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<tr>
<td>No.</td>
<td>Statement</td>
<td>Apply to a high degree</td>
<td>Apply to a medium degree</td>
<td>Apply to a small degree</td>
<td>Does not apply</td>
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<tr>
<td>18</td>
<td>I find myself very emotional to the problem, which inhibits my ability to think</td>
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<tr>
<td>19</td>
<td>I try to foresee the results before I attempt to solve the problem</td>
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<tr>
<td>20</td>
<td>I reevaluate the solutions after their application depending on their effectiveness in solving the problem</td>
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<tr>
<td>21</td>
<td>When I face a problem, I act without thinking about it</td>
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<tr>
<td>22</td>
<td>I investigate the different elements of the situation that is causing the problem</td>
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<tr>
<td>23</td>
<td>I seek other people opinions to explore the possible solutions to the problem</td>
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<tr>
<td>24</td>
<td>I choose the solution that please others, regardless of its effectiveness</td>
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<tr>
<td>25</td>
<td>When the solution is not effective, I try to find the reason for its failure</td>
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<tr>
<td>26</td>
<td>I am careful to postpone thinking about the problems that faces me</td>
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<tr>
<td>27</td>
<td>When I face a problem, I do not know exactly where to start to solve it</td>
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<tr>
<td>28</td>
<td>I have the ability to generate new solutions for any problem</td>
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<tr>
<td>29</td>
<td>I think of the short and long-term solution of the problem</td>
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<tr>
<td>30</td>
<td>I insist on applying the solution that I find even after its failure in solving the problem</td>
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<tr>
<td>31</td>
<td>I avoid discussing the subject that I face the problems with</td>
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<tr>
<td>32</td>
<td>I find it difficult to describe the problem that I face</td>
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<tr>
<td>33</td>
<td>When I face a problem, I think of all possible solutions before adopting one of these solutions</td>
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<tr>
<td>34</td>
<td>I put a plan for implementing the suitable solutions</td>
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<tr>
<td>35</td>
<td>I get angry and irritated when I find that the solution that is not suitable to the problem</td>
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<td></td>
<td>Statement</td>
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<td>36</td>
<td>I feel depressed when I face any problem</td>
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<tr>
<td>37</td>
<td>When I face a problem, I do not know where to start to solve it</td>
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<tr>
<td>38</td>
<td>When I face a problem, I choose the first solution that comes to mind</td>
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<tr>
<td>39</td>
<td>When I face a problem, I choose the solution that is most likely to succeed in solving the problem</td>
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<tr>
<td>40</td>
<td>When I face a problem, I do not get busy in assessing the solutions that I find</td>
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</tbody>
</table>
APPENDIX (C)

MTRIZP

Introduction

The second half of the previous century showed increasing interest in critical thinking and problem solving. Most of the studies, however, concentrated on the theoretical aspects of the critical thinking and problem solving. Despite the presence of few practical, training Programs, which were developed by specialists in the field, there is still a great necessity for the development of more Programs to address the adaptation to various audience and disciplines, especially the field of education.

MTRIZP

The training Program developed in this research, MTRIZP, was developed to bridge the gap between theoretical and practical aspects of critical thinking and problem solving. The MTRIZP aims to design systematic strategies for developing critical thinking and problem solving based on the principles of TRIZ theory, which was developed by Alshuller. The principles of the MTRIZP Program were selected from the 40 principles of TRIZ theory due to their ease of application and suitability for developing critical thinking abilities. The selected 10 TRIZ principles for the MTRIZP Program are:
1. The Segmentation principle
2. The Extraction principle
3. The Merging Principle
4. The inversion principle
5. The self-service principle
6. The changing color and transparency principle
7. The nesting principle
8. The universality principle
9. The Blessing in Disguise principle
10. The copying principle

**The MTRIZP goals**

The MTRIZP Program aims to achieve the following:

1. Assist gifted and talented students in developing critical thinking skills
2. Assist gifted and talented students in developing problem solving skills.
3. Provide gifted and talented students with skills that is covered within the curriculum.
4. Provide gifted and talented students with skills that enable them to portray and embark on real-life problems.
5. Stimulate proactive learning and eagerness for learning.
Target group

The MTRIZP Program is designed for the middle school- seventh, eighth, and ninth-gifted and talented students in Tabuk region in KSA.

General Purpose of the MTRIZP Program

The MTRIZP Program aims at developing critical thinking, with all its components, and problem solving abilities of gifted and talented students. After completing the MTRIZP Program, the following is expected:

1. Enhance the abilities of the trainees in dealing with problems.
2. Encourage the trainees to collaborate and benefit from experiences of others.
3. Providing the trainees to utilize versatile techniques for problem solving.
4. Increase the ability of the trainees to utilize critical thinking in philanthropy.
5. Train trainees on TRIZ principles and their utilization in problem solving.
6. Assist the trainees on understanding the systemic application of TRIZ principles in problem solving.
7. Enhance the ability of trainees in formulating the problem and outlining its contradictions.
9. Application of TRIZ theory to educational problems including curriculum.
10. Encourage trainee to participate in collaborative and team work.
General instructions

(a) Instructions for the teacher

1. Encourage the gifted and talented students to express their ideas and thoughts without any type or degree criticism or offense.

2. Assist the gifted and talented students to express their ideas and assist them in its organization and restructuring.

3. It is crucial that the teacher display seriousness, commitment, and perseverance in order to enable the gifted and talented student to achieve the desired outcomes of the training Program.

4. Insure that the students comprehend the activities and training modules in order to enable student to gain the anticipated benefits.

(b) Instructions for the students

1. Provide ideas about the given problem and be aware of your perception.

2. Reorganize and restructure the ideas given by your peer gifted and talented students in order to maintain continuous training on the application of critical thinking and problem solving.

3. Be proactive; participate in all the activities and discussion.

4. Be supportive to your peer gifted and talented students by providing them with continuous support and feedback.

Duration of the Program
The Program was executed within three months as two 45-minute sessions per week. The Program also included opening and concluding sessions at the beginning and end of the Program, respectively.

**The Methodologies of the Program**

The Program applies versatile educational methodologies, which include:

1. Discussions
2. Dialogue
3. Video presentations
4. PowerPoint presentations
5. Drama-acting roles
6. Stories
7. Brainstorming
8. Small groups
9. Debates

**Evaluation of Program**

The Program was evaluated using the following tools:

1. Watson critical thinking assessment, which will be given before and after administering the Program.
2. Problem Solving Assessment, which will be given before and after administering
   the Program.

3. Interviews, which will include both the trainers and trainees.

The MTRIZP Program content

All of the MTRIZP Program should be conducted in simple, unambiguous vocabulary.
The MTRIZP training Program includes explanation of each of the 10 TRIZ principles
employed in the Program. The training sessions pertaining to each of the TRIZ
principles include examples from the Saudi environment. After that, the gifted and
talented students are provided with activities that prompt the understanding and
application of the TRIZ principles.
## Training Program Schedule

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<td>Twentieth session</td>
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Session A

Opening Session: MTRIZP Program Introduction

Session goals

1. Introducing the teachers
2. Gifted and talented students introducing themselves
3. Presentation of the Program and its goals
4. Determining expectations
5. Participants rights

Session procedures

1. Introduction of the Program and its goals, which include:
   a) Introducing TRIZ theory: Historical and technical summary
   b) Discussing critical thinking and its importance
   c) Discussing Importance of problem solving
   d) Conveying the vision of using TRIZ theory principles to enhance critical thinking and problem solving.
   e) Explain the Program logistics and its schedule, and emphasizing the importance of regular attendance.
   f) Discussing the importance of commitment and fulfilling individual and group roles.
2. Promoting self-confidence of students using games and activities.
3. Promoting team work and collaborations using games and activities.
Session 1 and Session 2

TRIZ Principle: The Segmentation Principle

Educational goals:

At the end of the first and second session, the following are expected:

1. Defining TRIZ Segmentation principle.
2. Introduction of a general problem and the application of the TRIZ Segmentation principle to find possible solutions for it.
3. Give examples on problems that can be solved using the TRIZ Segmentation principle.
4. Application of the TRIZ Segmentation principle on a problem within the school system.

Instructional tools

The following tools will be utilized: Discussions, dialogue, video presentations, PowerPoint presentations, drama-acting roles, stories, brainstorming, small groups, and debates.

Sessions’ content

a) Explanation
The segmentation principle can be applied to problem solving. The logistics of this principle is to divide the system/problem to different independent parts. Each part should be completely isolated from the rest of the system/problem.

b) Examples

* Computers are designed to be divided into several parts that can be disassembled and easily installed and used when needed.

* Manufacturing measuring rulers with different lengths through making them become easy to fold and keep them in a relatively narrow space.

* Manufacturing pipes carrying water or oil so that they consist of relatively small pieces that can be disassembled and installed as well as transported from one place to another easily.

* Furniture made of several Pieces are composed to move them easily from one place to another as well as a single piece of furniture is fragmented into several pieces to easily carry and transfer.
c) Examples on problems that can be solved using the TRIZ Segmentation principle

**Problem 1:** The inability of few individuals of buying a high-value phone-charging card.

**Solution for problem 1:** The creation of different value phone cards: 10, 20, 50, and 100 Riyals. Such cards with segmented values can overcome the difficulty of having insufficient funds, which can allow the individual to accomplish his/her needs.

**Problem 2:** The lack of students’ involvement in the classrooms.

**Solution for problem 2:** Construct students groups.
Problem 3: Many business people own large parcels of land. The large size of the land forces delay or prohibit the selling of the land, or force the owners to sell at low price.

Solution for Problem 3: Divide the parcels for smaller parcel sizes, this removes the negative impact of the size on the ability to sell or the sale price.

d) Application activities

1. The inability of a house wife of completing the high number of house chores.

2. The desire to accomplish a big goal.

3. The inability of students of studying the night of the exam due to the high number of subjects in the curriculum.

e) Homework

1. Elimination of unemployment among high school graduates in Saudi Arabia.

2. Solving the problem of overcrowding in Mina.

3. The problem of women working outside their cities.
**Procedure**

The teacher should provide support, encouragement, and direction to the students throughout the sessions and in all its stages. Teacher should provide critical input on the students’ output but maintain positive support at all times.

1. Divide the students to small groups, each group containing 5 students.
2. Each group utilize critical thinking skills to outline the problem.
3. Formulating the ideal solution for the problem.
4. Provide all steps necessary for solving the problem.
5. Suggesting other possible solutions to solve the problem.
6. Presenting the findings of each group using the blackboard, PowerPoint, or any other means.

Discussing the findings of the groups and evaluating the effectiveness in solving the problem.
Session 3 and Session 4

The TRIZ Extraction Principle

Educational goals:

At the end of the first and second session, the following are expected:

1. Defining TRIZ Extraction principle.
2. Introduction of a general problem and the application of the TRIZ Extraction principle to find possible solutions for it.
3. Give examples on problems that can be solved using the TRIZ Extraction principle.
4. Application of the TRIZ Extraction principle on a problem within the school system.

Instructional tools

The following tools will be utilized: Discussions, dialogue, video presentations, PowerPoint presentations, drama-acting roles, stories, brainstorming, small groups, and debates.

Sessions’ content

a) Explanation

The extraction principle can be applied to problem solving. The logistics of this principle is to identify, retain, and employ the positive components of the system/problem. Similarly, identify and remove components with negative effect.
b) Examples

*Sacking staff that are causing losses to the company.

* Purifying rice from impurities before cooking.

* Separating diet foods from sugars.

* Separating the engine of split air conditioner to reduce inconvenience.

* Recruiting useful people for the company, such as well-known celebrities.

* Attracting doctors who are Nobel Prize winners to universities to raise its status and classification.

* Increasing the amount of the olive oil added to salad to add the best flavor and adding mint to tea and cardamom to coffee.

* Increasing sports quotas to improve the fitness of students physically and mentally.
c) problems that can be solved using the TRIZ Extraction principle

**Problem 1:** The talented face many educational issues in the regular classrooms.

**Solution for problem 1:** Separate the talented students and provide them with enrichment Programs.

**Problem 2:** The school administration discovered that some students have a contagious disease.

**Solution for problem 2:** The sick students should be isolated to prevent the spread of the disease.

**Problem 3:** Many companies suffer from corruption.
Solution for Problem 3: remove the persons who are identified to have participated in corruption, and promote the employees who show high ethical and professional standards to leadership positions.

d) Application activities

1. The spread of obesity.

2. The unsatisfactory level of the school soccer team

3. The need for education development.

e) Homework

1. barriers to learning.

2. Losing weight.

3. Naughty students.

Procedure

The teacher should provide support, encouragement, and direction to the students throughout the sessions and in all its stages. Teacher should provide critical input on the students’ output but maintain positive support at all times.

1. Divide the students to small groups, each group containing 5 students.

2. Each group utilize critical thinking skills to outline the problem.

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3. Formulating the ideal solution for the problem.

4. Provide all steps necessary for solving the problem.

5. Suggesting other possible solutions to solve the problem.

6. Presenting the findings of each group using the blackboard, PowerPoint, or any other means.

7. Discussing the findings of the groups and evaluating the effectiveness in solving the problem.
Session 5 and Session 6
The TRIZ Merging Principle

Educational goals:

At the end of the first and second session, the following are expected:

1. Defining TRIZ Merging principle.
2. Introduction of a general problem and the application of the TRIZ Merging principle to find possible solutions for it.
3. Give examples on problems that can be solved using the TRIZ Merging principle.
4. Application of the TRIZ Merging principle on a problem within the school system.

Instructional tools

The following tools will be utilized: Discussions, dialogue, video presentations, PowerPoint presentations, drama-acting roles, stories, brainstorming, small groups, and debates.

Sessions’ content

a) Explanation
The merging principle can be applied to problem solving. The logistics of this principle is to spatially or temporally interconnect between the similar processes/components of the system/problem. These processes/components are then organized to be spatially close to each other, and that its functions are temporally coordinated.

b) Examples

* Placing government departments that provide similar services to the citizens close to each other so that it becomes easier for citizens to obtain the required services.

* Building complexes containing medical clinics, doctors, and centers for X-rays, medical laboratories and pharmacies to make access to hospital services accessible without patients having to move long distances in search of each of these services.

* Collecting students who possess certain mental, psychological or emotional characteristics or those who suffer from academic or behavioral problems in specific classes which makes it easier for teachers or counselors to deal with them better at a level of efficiency and effectiveness.
c) Problems that can be solved using the TRIZ Merging principle

**Problem 1:** Memory weakness.

**Solution for problem 1:** Organize the data that needs to be recalled, then characterize them and coordinate them within a system that eases their recollection.

**Problem 2:** Family separation due to the spread of family members in a wide geographic area.

**Solution for problem 2:** Determine a suitable time for all family members at which they can Skype or use any other telecommunication tool.

**Problem 3:** The difficulty of making multiple tests for the different class sections.

**Solution for Problem 3:** Make one test for all sections to be administered in one setting at a time that fits all students.
d) Application activities

1. The inability of a student to comprehend the instructions by an instructor, and y.
2. The Crowding during the distribution of students’ allowance at the beginning of every month.
3. The children neglect of their daily prayers.

e) Homework

1. A place for smokers.
2. Organizing football matches at the same time.
3. Pilgrimage time and place restricted.

Procedure

The teacher should provide support, encouragement, and direction to the students throughout the sessions and in all its stages. Teacher should provide critical input on the students’ output but maintain positive support at all times.

1. Divide the students to small groups, each group containing 5 students.
2. Each group utilize critical thinking skills to outline the problem.
3. Formulating the ideal solution for the problem.
4. Provide all steps necessary for solving the problem.
5. Suggesting other possible solutions to solve the problem.
6. Presenting the findings of each group using the blackboard, PowerPoint, or any other means.

7. Discussing the findings of the groups and evaluating the effectiveness in solving the problem.
Session 7 and Session 8

The TRIZ Inversion Principle

Educational goals:

At the end of the first and second session, the following are expected:

1. Defining TRIZ inversion principle.
2. Introduction of a general problem and the application of the TRIZ inversion principle to find possible solutions for it.
3. Give examples on problems that can be solved using the TRIZ inversion principle.
4. Application of the TRIZ inversion principle on a problem within the school system.

Instructional tools

The following tools will be utilized: Discussions, dialogue, video presentations, PowerPoint presentations, drama-acting roles, stories, brainstorming, small groups, and debates.

Sessions’ content

a)Explanation

The inversion principle can be applied to problem solving. The logistics of this principle is to use the opposite of the working processes, which is usually employed. For
example, if the components of the problem is dynamic, it is changed to static. This principle aims to invert the system top to bottom.

**b) Examples**

* When you put the pot inside another with almost the same capacity, they are glued together but still can be separated from each other either by heating the outer container or cooling the inner container by placing pieces of ice in it.

* Medical centers and educational institutions that spread in many areas are visited by people who seek medical help. Using this principle, these centers are transmitted to people in their places of residence to provide them with medical or educational services.

* Instead of having people go to markets for their needs, consumers can go online networks for goods available and their prices, and therefore they get them delivered to their homes without having to move to these markets.
c) Problems that can be solved using the TRIZ inversion principle

**Problem 1:** The construction of wild life habitats where people can see the animals in their natural environment.
Solution for problem 1: Construct the wild life park in which the wild animals are free, and use armor cars for peoples’ transportation.

Problem 2: Difficulty of knowing the status of the governmental applications.

Solution for problem 2: Use the internet to enable individuals to follow the status of their applications.

Problem 3: The long job hours prevent individuals from access to the bank hours.

Solution for Problem 3: Use the ATM machines to do banking transactions.

d) Application activities

1. The need to acquire university degree and the unavailability of a university within the boundaries of residence.

2. The hardship for mothers leaving their children to join a gym.

3. The difficulty of submitting homework

e) Homework

1. Shopping and cannot leave the house.

2. The need to attend a study or course that he cannot go to.

3. Putting laws to students.

Procedure
The teacher should provide support, encouragement, and direction to the students throughout the sessions and in all its stages. Teacher should provide critical input on the students’ output but maintain positive support at all times.

1. Divide the students to small groups, each group containing 5 students.

2. Each group utilize critical thinking skills to outline the problem.

3. Formulating the ideal solution for the problem.

4. Provide all steps necessary for solving the problem.

5. Suggesting other possible solutions to solve the problem.

6. Presenting the findings of each group using the blackboard, PowerPoint, or any other means.

7. Discussing the findings of the groups and evaluating the effectiveness in solving the problem.
Session 9 and Session 10

The TRIZ Self-Service Principle

Educational goals:

At the end of the first and second session, the following are expected:

1. Defining TRIZ self-service principle.

2. Introduction of a general problem and the application of the TRIZ self-service principle to find possible solutions for it.

3. Give examples on problems that can be solved using the TRIZ self-service principle.

4. Application of the TRIZ self-service principle on a problem within the school system.

Instructional tools

The following tools will be utilized: Discussions, dialogue, video presentations, PowerPoint presentations, drama-acting roles, stories, brainstorming, small groups, and debates.

Sessions’ content

a) Explanation

The self-service principle can be applied to problem solving. The logistics of this principle is to enable the system to do multiple tasks and utilize all possible resources.
that can benefit the system itself, or improve its function. The idea here is to enhance the performance of the system and enabling it to achieve the desired goals.

b) Examples

* Some hotels and businesses have fire detection devices and when fire starts they immediately start functioning.

* Monetary mechanism enables the customer to perform banking transactions without the need for the bank.

* Adoption of public lighting that depends on the mechanism of operating systems in cities makes it work at the emergence of the dark and stop working at the appearance of the light.

* Opening doors of banks, public institutions and hotels, as soon as someone approaches the door and closing automatically as he sets off.
https://www.youtube.com/watch?v=9FiT4O1BJbg

https://www.google.jo/search?q=%D8%AA%D8%AD%D9%88%D9%8A%D9%84+%D8%A7%D9%84%D8%B6%D8%A7%D8%B1+%D8%A7%D9%84%D9%89+%D9%86%D8%A7%D9%81%D8%B9&biw=1281&bih=625&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjfuZu-m9UAhUFIa8KHbhuCzoQ_AUIBygC#isch&q=%D8%A7%D9%84%D8%AE%D8%AF%D9%85%D8%A9+%D8%A7%D9%84%D8%B0%D8%A7%D8%AA%D9%8A%D8%A9&imgrc=XmAhuhQ9WoxHM%3A

https://www.google.jo/search?q=%D8%AA%D8%AD%D9%88%D9%8A%D9%84+%D8%A7%D9%84%D8%B6%D8%A7%D8%B1+%D8%A7%D9%84%D9%89+%D9%86%D8%A7%D9%81%D8%B9&biw=1281&bih=625&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjfuZu-m9UAhUFIa8KHbhuCzoQ_AUIBygC#isch&q=%D8%B3%D8%AD%D8%A8+%D8%A7%D9%84%D8%B9%D8%B5%D9%8A%D8%B1+%D9%85%D9%86+%D8%A7%D9%84%D8%AB%D9%84%D8%A7%D8%AC%D8%A9+%D8%AE%D8%AF%D9%85%D8%A9+%D8%B0%D8%A7%D8%AA%D9%8A%D8%A9&imgrc=HSxG9l-BJb8g5M%3A
c) problems that can be solved using the TRIZ self-service principle

**Problem 1:** The high usage of doors in institutions, banks, and hotels.

**Solution for problem 1:** Use of automatic doors that functions without the need to manually operate it.

**Problem 2:** The dangerous missions for pilots.

**Solution for problem 2:** Use of drones.

**Problem 3:** The difficulty of cleaning in the fast-food restaurants.

**Solution for Problem 3:** Establishment of self-service cleaning by customers.

d) Application activities

1. The short lifetime of the phone battery.

2. The electricity disconnection during the night.

3. The high risk of fires in some public locations.

e) Homework

1. Short-term validity of the phone's battery.

2. The power cuts during the night.

3. The big risk of fires in some public places.
Procedure

The teacher should provide support, encouragement, and direction to the students throughout the sessions and in all its stages. Teacher should provide critical input on the students’ output but maintain positive support at all times.

1. Divide the students to small groups, each group containing 5 students.

2. Each group utilize critical thinking skills to outline the problem.

3. Formulating the ideal solution for the problem.

4. Provide all steps necessary for solving the problem.

5. Suggesting other possible solutions to solve the problem.

6. Presenting the findings of each group using the blackboard, PowerPoint, or any other means.

7. Discussing the findings of the groups and evaluating the effectiveness in solving the problem.
Session 11 and Session 12

The TRIZ Changing Color and Transparency Principle

Educational goals:

At the end of the first and second session, the following are expected:

1. Defining TRIZ changing color and transparency principle.

2. Introduction of a general problem and the application of the TRIZ changing color and transparency principle to find possible solutions for it.

3. Give examples on problems that can be solved using the TRIZ changing color and transparency principle.

4. Application of the TRIZ changing color and transparency principle on a problem within the school system.

Instructional tools

The following tools will be utilized: Discussions, dialogue, video presentations, PowerPoint presentations, drama-acting roles, stories, brainstorming, small groups, and debates.

Sessions’ content

a) Explanation

The changing color and transparency can be applied to problem solving. The logistics of this principle is to change the color or transparency of the system or its surroundings.

b) Examples
*Distinguishing different professions with certain uniform colors to wear at work times which helps the public to deal with them.

* In chemistry there are many tests and interactions that have a significant color change like litmus paper that changes its color when put in acid.

* Traffic lights have 3 colors and each color has a certain significance.

* gold medals, silver and bronze.
https://www.youtube.com/watch?v=SQggDnScsvl

https://www.youtube.com/watch?v=pUsWrxcZCCw

https://www.google.jo/search?q=%D8%AA%D8%AD%D9%88%D9%8A%D9%84+%D8%A7%D9%84%D8%B6%D8%A7%D8%B1+%D8%A7%D9%84%D9%89+%D9%86%D8%A7%D9%81%D8%B9&biw=1281&bih=625&source=lnms&tbm=isch&ved=0ahUKEwjfuZu-m9UAhUFlhbuCzoQ_AUIBygC#tbm=isch&q=%D8%AA%D8%BA%D9%8A%D8%B1+%D8%A7%D9%84%D9%84%D9%88%D9%86+%D8%A7%D9%88+%D8%A7%D9%84%D8%A8%D9%8A%D8%A6%D8%A9+%D8%A7%D8%A8%D8%AF%D8%A7%D8%B9&imgc=c1uKZHS9nCkQgM%3A

https://www.google.jo/search?noj=1&tbm=isch&sa=1&q=%D8%A7%D9%84%D8%AA%D9%85%D9%88%D9%8A%D9%87+%D8%A7%D9%84%D8%A8%D9%8A%D8%A6%D8%A9+%D8%A7%D9%84%D9%88%D9%86&oq=%D8%A7%D9%84%D8%AA%D9%85%D9%88%D9%8A%D8%A6%D8%A9+%D8%A7%D9%84%D9%88%D9%86&gs_l=img.3...2254.2936.0.3221.6.6.0.0.0.0.0.0....0...1c.1.64.img..6.0.0.O5AiK41-0l#imgrc=P2ecYu1p_c2yoM%3A

c) problems that can be solved using the TRIZ changing color and transparency principle
**Problem 1:** Individuals going to hospitals and wasting time in finding the right department/room.

**Solution for problem 1:** Color coding of the department to ease their identification.

**Problem 2:** The ease of locating the army forces by the enemy.

**Solution for problem 2:** Use of uniforms that allow the army forces to blend in within the environments of the locations. For example, soldiers in desert wearing sandy-color uniforms.

**Problem 3:** It is difficult to differentiate between some chemicals due to the similarities in color and texture.

**Solution for Problem 3:** Color coding of the chemical containers to reflect its dangerous level. For example, using red containers for dangerous chemicals.

d) Application activities

1. The difficulty for the new students in finding their classes.

2. The confusion in getting on the right bus.

3. The difficulty in differentiating between students at different academic level

e) Homework

1. Difficulty faced by students in finding their classrooms.

2. Confusion that occurs in boarding the right bus.
3. The difficulty of distinguishing between students at different academic levels.

**Procedure**

The teacher should provide support, encouragement, and direction to the students throughout the sessions and in all its stages. Teacher should provide critical input on the students’ output but maintain positive support at all times.

1. Divide the students to small groups, each group containing 5 students.
2. Each group utilize critical thinking skills to outline the problem.
3. Formulating the ideal solution for the problem.
4. Provide all steps necessary for solving the problem.
5. Suggesting other possible solutions to solve the problem.
6. Presenting the findings of each group using the blackboard, PowerPoint, or any other means.
7. Discussing the findings of the groups and evaluating the effectiveness in solving the problem.
Session 13 and Session 14

The TRIZ Nesting Principle

Educational goals:

At the end of the first and second session, the following are expected:

1. Defining TRIZ nesting principle.
2. Introduction of a general problem and the application of the TRIZ nesting principle to find possible solutions for it.
3. Give examples on problems that can be solved using the TRIZ nesting principle.
4. Application of the TRIZ nesting principle on a problem within the school system.

Instructional tools

The following tools will be utilized: Discussions, dialogue, video presentations, PowerPoint presentations, drama-acting roles, stories, brainstorming, small groups, and debates.

Sessions’ content

a)Explanation

The nesting principle can be applied to problem solving. The logistics of this principle is to include one component of the system within a second. If needed, the nested components can further be placed within a third component, and so on.
b) Examples

*plastic chairs take up much storage space. When using the principle of containment, chairs will be manufactured in a manner where they can be placed above each other.

*The place of the seat belt.

* Placing new devices inside Flynn to protect them.

*Putting pots inside each other.
c) problems that can be solved using the TRIZ nesting principle

**Problem 1:** The difficulty in storing plastic chairs due to small storage places.
Solution for problem 1: Manufacture the chairs to allow their stacking.

Problem 2: The long length of the safety built in the cars.

Solution for problem 2: Use of retractable design.

Problem 3: The high number of parked cars in the streets.

Solution for Problem 3: Requiring building to design parking floors (on roofs or underground).

d) Application activities

1. The pilgrimages sitting under the sun.

2. The guest food tables occupy a lot of space.

3. The cluttering in the kitchen.

e) Homework

1. Modules.

2. Naughty students.

3. Food.
Procedure

The teacher should provide support, encouragement, and direction to the students throughout the sessions and in all its stages. Teacher should provide critical input on the students’ output but maintain positive support at all times.

1. Divide the students to small groups, each group containing 5 students.

2. Each group utilize critical thinking skills to outline the problem.

3. Formulating the ideal solution for the problem.

4. Provide all steps necessary for solving the problem.

5. Suggesting other possible solutions to solve the problem.

6. Presenting the findings of each group using the blackboard, PowerPoint, or any other means.

7. Discussing the findings of the groups and evaluating the effectiveness in solving the problem.
Session 15 and Session 16

The TRIZ Universality Principle

Educational goals:

At the end of the first and second session, the following are expected:

1. Defining TRIZ universality principle.
2. Introduction of a general problem and the application of the TRIZ universality principle to find possible solutions for it.
3. Give examples on problems that can be solved using the TRIZ universality principle.
4. Application of the TRIZ universality principle on a problem within the school system.

Instructional tools

The following tools will be utilized: Discussions, dialogue, video presentations, PowerPoint presentations, drama-acting roles, stories, brainstorming, small groups, and debates.

Sessions’ content

a)Explanation

The universality principle can be applied to problem solving. The logistics of this principle is to allow the systems’ component to multitask. This results in requiring less system.
b) Examples

* Pharmacies sell drugs and to increase sales, they also sell perfumes and cosmetics.

* Mobile are for making calls and for promotion they added imaging functions, messages ..etc.

* Using the data obtained to continue construction plans for the development of the school.

* The development of a multi-system tools and resources to legalize the expectations from students regarding performance and behavior.
c) problems that can be solved using the TRIZ universality principle

**Problem 1:** The disposition of chocolate metal boxes.
Solution for problem 1: use the boxes to store children toys, organize little items, and use for charity purposes.

Problem 2: The coffee shop started losing business.

Solution for problem 2: Include internet, newspapers, and fresh juices.

Problem 3: The need to carry many personal items in the handbag.

Solution for Problem 3: use of cell phone to replace, diary, notebook, and calculator.

d) Application activities

1. How to efficiently use the building roofs?.

2. Expand the sales of the pharmacy.

3. A tool to detect water leakage

e) Homework

1. Exams in the Arab world.

2. grades in schools.

3. university courses.
Procedure

The teacher should provide support, encouragement, and direction to the students throughout the sessions and in all its stages. Teacher should provide critical input on the students’ output but maintain positive support at all times.

1. Divide the students to small groups, each group containing 5 students.
2. Each group utilize critical thinking skills to outline the problem.
3. Formulating the ideal solution for the problem.
4. Provide all steps necessary for solving the problem.
5. Suggesting other possible solutions to solve the problem.
6. Presenting the findings of each group using the blackboard, PowerPoint, or any other means.
7. Discussing the findings of the groups and evaluating the effectiveness in solving the problem.
Session 17 and Session 18
The TRIZ Blessing in Disguise Principle

Educational goals:

At the end of the first and second session, the following are expected:

1. Defining TRIZ Blessing in Disguise principle.
2. Introduction of a general problem and the application of the TRIZ Blessing in Disguise principle to find possible solutions for it.
3. Give examples on problems that can be solved using the TRIZ Blessing in Disguise principle.
4. Application of the TRIZ Blessing in Disguise principle on a problem within the school system.

Instructional tools

The following tools will be utilized: Discussions, dialogue, video presentations, PowerPoint presentations, drama-acting roles, stories, brainstorming, small groups, and debates.

Sessions’ content

a) Explanation

The blessing in disguise principle can be applied to problem solving. The logistics of this principle is to use adverse factors and apply them to a system to reverse their nature.
In addition, this principle utilizes the elimination of negative factors by adding one negative factor to another.

b) Examples

* The toxins produced by snakes inherently harmful and could lead to human death, but it can be used in the production of medical drugs that are used to give children or adults immune against the risk of snake bites and other poisonous insects.

* Heavy rains and what can be caused by the flooding are considered factors that lead to natural disasters, which result in heavy losses of life and property, but this flooding could be taken advantage of to increase the water inventory in the ground, and raise the water level in dams, and help State to detect deficiencies in the systems prepared for disasters to develop and improve their performance together.

* The prevalence of diseases is one of the risks that threaten the lives of the people of all countries who seek to avoid their occurrence. However, when disease happens, it can lead to the discovery of prescription drugs to overcome this disease, as it leads to the development of health awareness among citizens, and to take preventive measures to improve the level of health services in the state to reduce the possibility of its spread in the future.

* Nations in the stages of their lives are exposed to military and political severe defeats that are risky on the present and future of these nations. However, living nations can be turn these defeats to a starting point to deepen the sense of patriotism and self-review and draw lessons for the advancement of a new nation.
c) problems that can be solved using the TRIZ Blessing in Disguise principle

Problem 1: The snake venoms are very toxic and can result in death.

Solution for problem 1: use of the venoms in pharmaceutical to manufacture medicines an anti-venom.

Problem 2: The rise of wasting food.

Solution for problem 2: Use the leftover food to feed the poor and needy.

Problem 3: Salt slows the degradation of food.

Solution for Problem 3: Use salt to preserve food.

d) Application activities

1. Increase in the gray water.
2. Some mountains receive high amounts of snow.

3. Some bacteria degrade petroleum.

e) Homework

1. Increasing the water in remote areas.

2. Some of the mountains receive large amounts of snow.

3. Some bacteria spoil in the oil.

Procedure

The teacher should provide support, encouragement, and direction to the students throughout the sessions and in all its stages. Teacher should provide critical input on the students' output but maintain positive support at all times.

1. Divide the students to small groups, each group containing 5 students.

2. Each group utilize critical thinking skills to outline the problem.

3. Formulating the ideal solution for the problem.

4. Provide all steps necessary for solving the problem.

5. Suggesting other possible solutions to solve the problem.

6. Presenting the findings of each group using the blackboard, PowerPoint, or any other means.

7. Discussing the findings of the groups and evaluating the effectiveness in solving the problem.
Session 19 and Session 20
The TRIZ Copying Principle

Educational goals:

At the end of the first and second session, the following are expected:

1. Defining TRIZ copying principle.
2. Introduction of a general problem and the application of the TRIZ copying principle to find possible solutions for it.
3. Give examples on problems that can be solved using the TRIZ copying principle.
4. Application of the TRIZ copying principle on a problem within the school system.

Instructional tools

The following tools will be utilized: Discussions, dialogue, video presentations, PowerPoint presentations, drama-acting roles, stories, brainstorming, small groups, and debates.

Sessions’ content

a) Explanation

The copying principle can be applied to problem solving. The logistics of this principle is to use simple and cost effective model/alternative for the system instead of using the
complex, expensive original system. The model/alternative also gives an idea on how to shrink or expand the system.

b) Examples

* Engineering buildings models

* Teaching doctors surgery on a non-human.

* Students as well as teachers cannot deal with some experiences that can cause them damage or injury as a measure of some dangerous chemical experiments that include interactions of chemical results that are not guaranteed, or to identify the characteristics of some forest animals like elephants, lions or tigers, so they replace them with pictures or picture-run movies of chemical experiments or animals that cannot be dealt with directly.

* measuring the height of high-rise buildings or tall trees or the minarets of mosques can be difficult with the simple available tools, but this might become possible through using the principle of copying the lengths of these things to measure them with minimal effort by measuring the shadows.
https://www.youtube.com/watch?v=OstcQsi6krs

https://www.google.jo/search?q=%D8%AA%D8%AD%D9%88%D9%8A%D9%84+%D8%A7%D9%84%D8%B6%D8%A7%D8%B1+%D8%A7%D9%84%D9%89+%D9%86%D8%A7%D9%81%D8%B9&biw=1281&bih=625&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjfuZum9LJAhUFIa8KHzhuCzoQ_AUIBygC#q=%D8%A7%D8%B3%D8%AA%D8%A8%D8%AF%D8%A7%D9%84+%D8%A7%D8%B4%D9%8A%D8%A7%D8%A1+%D8%A8%D8%A7%D8%B4%D9%8A%D8%A7%D8%A1+%D8%A8%D8%B3%D9%8A%D8%B7%D8%A9+&imgdii=o2FjkqwEl2pOnM%3A%3Bo2FjkqwEl2pOnM%3A%3BlxzsD8NB_6VG9M%3A&imgrc=o2FjkqwEl2pOnM%3A

https://www.google.jo/search?q=%D8%AA%D8%AD%D9%88%D9%8A%D9%84+%D8%A7%D9%84%D8%B6%D8%A7%D8%B1+%D8%A7%D9%84%D9%89+%D9%86%D8%A7%D9%81%D8%B9&biw=1281&bih=625&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjfuZum9LJAhUFIa8KHzhuCzoQ_AUIBygC#q=%D8%A7%D8%B3%D8%AA%D8%A8%D8%AF%D8%A7%D9%84+%D8%A7%D8%B4%D9%8A%D8%A7%D8%A1+%D8%A8%D8%A7%D8%B4%D9%8A%D8%A7%D8%A1+%D8%A8%D8%B3%D9%8A%D8%B7%D8%A9+&imgdii=o2FjkqwEl2pOnM%3A%3Bo2FjkqwEl2pOnM%3A%3BZxAY8-3rxx5UFM%3A&imgrc=o2FjkqwEl2pOnM%3A

c) problems that can be solved using the TRIZ copying principle

Problem 1: The makeup is expensive.

Solution for problem 1: Use of cheaper brands

Problem 2: The requirement or the grass for large quantities of water.

Solution for problem 2: Use synthetic grass.
Problem 3: Wasting of paper.

Solution for Problem 3: Use soft copies instead of paper.

d) Application activities

1. The lack of educational tools in your school.

2. The need for recreational parks in your area.

3. The sacristy of icon, model personalities

e) Homework

1. shortage or lack of means of education in your school.

2. The need to recreational parks in your area.

3. Iconic fitting room and typical figures.

Procedure

The teacher should provide support, encouragement, and direction to the students throughout the sessions and in all its stages. Teacher should provide critical input on the students’ output but maintain positive support at all times.

1. Divide the students to small groups, each group containing 5 students.

2. Each group utilize critical thinking skills to outline the problem.

3. Formulating the ideal solution for the problem.

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5. Suggesting other possible solutions to solve the problem.
6. Presenting the findings of each group using the blackboard, PowerPoint, or any other means.

7. Discussing the findings of the groups and evaluating the effectiveness in solving the problem.

APPEBDEX (D)

INTERVIEW

1- What is the opinion of the effect of applying the MTRIZP Program on
Gifted and Talented student?

2- Do you think that the activities in the MTRIZP Program are suitable for gifted and talented student?

3- Do you think that the activities in the MTRIZP Program can improve talent solving problem performance? if yes how ?if no why.

4- Do you think that the activities in the MTRIZP Program can improve talent critical thinking performance? if yes how ?if no why.

5- What are your suggestions to improve MTRIZP Program.

The first question: What is your opinion on the impact of TRIZ program?

"this program, he stressed that is helped him to find ways to deal with life differently" (p6).

"the program helped them to solve every day" (p3).

"the program is a useful for the gifted students" (p2).

"therefore it can be beneficial to sort-out every day's problems though some of its applications" (p4).

"an excellent program" (p1).

Another participant stated, fingered out the excellency of this program to support talented students (p9).

,"that it is a strong program"(p7).
The Second question:
"that activities gave him motivation for the study(p7).
"that these activities gave him aspiration(p6).
The first student would like the program to have more of these activities" (p1).
"that activities were fun"(p3).
"that activities were exciting"(p4).
"they presented in funny and humorous ways"(p5).
"they were not formal manner"(P8).

The third question
"activities that they suitable with the outstanding students and they help to raise their critical thinking"(p4).
"that future training in this side can develop this way of thinking for those students"(p1).
"felt that the activities elevated their critical thinking, and made them to know exactly what it means by phrase critical thinking"(p7).
"felt that he knows now the importance of critical thinking role in life"(p10).

The Fourth question:
For example, one participant stated, "the activities have contributed to improve their brainstorming skill in innovative way" (p6).

The second code: Learn skills. For example, one participant stated," this program should be implemented to improve problem-solving skills" (p10).

"this program gave him the ability to solve old problems with his brothers and friends" (p9).

"It helps him to deal with new problems and even he was able to solve problems of other students and in general he became more self-confident" (p2).

**The fifth question:**

"they thought that student should participate to design and should be used by all students and not only the talented ones" (p1).

"he was lacking for a such program" (p8).

"increase their number and preferably partially division to fix in their minds of students." (p9).

"proposed to pay attention to increase the principles of the program" (p7).
# APPEBDEX (E)

## NORMALITY TESTS

Tests of Normality

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\(^*\). This is a lower bound of the true significance.

\(^a\). Lilliefors Significance Correction
### Tests of Normality

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a. Lilliefors Significance Correction
APPEBDEX ( F )

PERMISSION TO USE THE INSTRUMENT

From: ata21221@hotmail.com

Transmission date: 12 / Ramadan / 1436 07:04:58 PM

To: nazhamdi@ju.edu.jo

To Prof. Dr. / Mohammed Hamdy impartial God save

Peace, mercy and blessings of God

I Atallah Mohammad Atwi student in the doctoral phase in Universiti Sains Malaysia Faculty of Education and conducted research on solving problems and I want to use the scale you've adapted it to the Arab environment.

So we ask you to approve using the problem-solving scale.

Researcher / Mohamed Atallah Atawi
APPEBDEX ( G )

PERMISSION TO USE THE INSTRUMENT

From: Nazeih Hamdi (nazhamdi@ju.edu.jo)

Transmission date: 27 / October / 1436 01:26:41 PM

To: ATALLAH ALATWI (ata21221@hotmail.com)

Mr. Atallah Atawi Esquire

I wish to inform you agreeing to your use problem-solving scale

best wishes

Hamdi Mohammed Nazih
APPEBDEX (H)

PERMISSION TO USE THE INSTRUMENT

From: ATALLAH ALATWI (ata21221@hotmail.com)

Transmission date: 12 / Ramadan / 1436 08:04:08 PM

To: mamdouh2122@hotmail.com.uk

To Prof. Dr. / Mamdouh Suleiman, may God protect him

Peace, mercy and blessings of God

I Atallah Mohammad Atwi student in the doctoral phase in Universiti Sains Malaysia Faculty of Education and conducted research for critical thinking and I want to use the scale you've adapted it to the Saudi environment.

So we ask you to approve the use of critical thinking scale, Tfezltm and attach the scale and key correction as your sincere thanks.

Researcher / Atallah Mohammed Alatawi

Saudi Arabia
From: daifallah alkarni (d.alkarni@gmail.com)

Transmission date: 19 / October / 1436 06:35:21 PM

To: ATALLAH ALATWI (ata21221@hotmail.com)

In the name of Allah the Merciful

My dear brother / Atallah Atawi guided God

Peace be upon you and God's mercy and blessings be upon you

Thank you good do you think my

Read the questionnaire and made some remarks which are considered typographical mistake. I ask God Almighty to help and guide you.

Brother Deif Allah Ali Al-Qarni

Director of the Center for Gifted Tabuk
APPEBDEX (J)

A LETTER FROM USM TO THE SAUDI MINISTRY OF EDUCATION
TO WHOM IT MAY CONCERN

RE: ALATAWI, ATALLAH MOHAMMED S.
Student Registration Number: P-PD0069/12(R)

This is to inform that the above named is a full time PhD student at the School of Educational Studies, University Sains Malaysia (USM), under the supervision of Dr. Mohd Zuri Ghani and Dr. Aswati Hamzah.

His thesis title is "The Effectiveness Of A Training Program Based On A Modified Triz Program In Developing Critical Thinking And Problem Solving Skills Of Gifted And Talented Students In Saudi Arabia" in Tabuk, Saudi Arabia. Alatawi, Atallah Mohammed S. has completed and passed his research proposal and now intend to conduct interview to complete his thesis.

Therefore, we seek your assistance in giving permission for Alatawi, Atallah Mohammed S. to conduct interview in selected schools in Tabuk, Saudi Arabia. Kindly contact the School of Educational Studies, Universiti Sains Malaysia (USM) if you need additional information.

Thank you.

[ASSOCIATE PROFESSOR DR. ABDUL RASHID MOHAMAD]
Deputy Dean
(Research)

APPEBDEX (K)
A LETTER FROM THE SAUDI MINISTRY OF EDUCATION, MALAYSIA, TO

TEACH TABUK APPLY THE STUDY
From: ata21221@hotmail.com

Transmission date: 17 / October / 1436 08:15:34 p.

To: S.abujado@unrwa.org (s.abujado@unrwa.org)

Dr., Saleh bin Mohammed Abu Gado

Peace, mercy and blessings of God

I want to choose the ten universal principles for the training of talented students out as part of a search in the doctoral phase. Given the experience in the big training Therese theory. I want to cite your opinion that I have consulted with senior coaches about choosing appropriate Ten Principles, which is a pilot study and critical thinking Astkhm Scale (Watson) and scale to solve problems (Hbnr). With the hope that we went to change Matrunch appropriate principles or any observations it deems appropriate.

And you my sincere thanks and appreciation.

1. division and retail   2-separation and extraction   3-integration and connectivity
4-heart and vice versa   5-Self-Service   6-color change   7-nesting
8-sheet or totalitarianism   9-converting harmful to wholesome   10-copies

Student in the doctoral / Atallah Mohammad Atwi stage
Mr. Atallah Esquire:

After Greetings:

Therese principles in theory all of which can be used, and the principles listed below is suitable for use,

I wish you success
PREDICTION OF OVERALL SCORES

Prediction of Overall Scores and Domains of the Critical Thinking And Problem-Solving Skills of the Experimental Group in the Post-tests

Several assumptions were needed in predicting the variables that affected the outcomes of the current study. These assumptions were used to determine the final model of the outcomes based on significant results mentioned previously. The assumptions of each model are described in this section, followed by the final model. The dummy method and linear regression model were used to determine the predictors.

Predictors of Overall Score of Critical Thinking

1- Assumption 1 states that dependent variables should be continuous: The overall score of critical thinking was continuous.

2- Assumption 2 states that two or more independent variables (numerical, ordinal, or categorical): Three factors of class (seven, eight, and nine), were obtained using the dummy method to predict the outcomes. Class eight served as the reference for the other factors.

3- Assumption 3 pertains to the independence of observations or independence of residuals: The assumption was verified with the Durbin–Watson test. An acceptable results must be in the range of 1–3 or close to 2. The value of the Durbin–Watson test for the overall score of critical thinking was 2.782, which is acceptable.
4- **Assumption 4 suggests a linear relationship between the dependent and independent variable(s):** Difference tests such as ANOVA can be employed given the categorical nature of independent variables. Significant differences were found in class, and such differences were accepted in the current assumption.

5- **Assumption 5 suggests that data must show homoscedasticity:** This assumption was verified using a scatter plot. Result was deemed acceptable when the dots were homogenous and the same in distance along the linear fit line, as shown in the figure below.

![Scatterplot](image.png)

**Figure 1 Homoscedasticity of overall score of critical thinking**

6- **Assumption 6 suggests that data must not show multicollinearity:** This assumption was verified using collinearity diagnostics, wherein the VIP results must not
be less than 2. An ideal result must be close to 1. The result for the current study was 1.286 for both class seven and nine. Thus, the assumption was accepted.

**7- Assumption 7 suggests the absence of significant outliers:** No outliers were found outside 3, which is considered as standard limit (Figure 1).

**8- Assumption 8 suggests that the residuals must be normally distributed:** The residuals of critical thinking were normally distributed. Results are shown in Figure 2.

![Normal Q-Q Plot of Studentized Residual](image)

**Figure 2 Normal distribution for overall critical thinking**

After accepting all assumptions for the overall score of critical thinking, the final model for the predictors of critical thinking is shown in Table 1.

<table>
<thead>
<tr>
<th>B</th>
<th>SE</th>
<th>Beta</th>
<th>T</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
</table>

Table 1
Final model for the overall score of critical thinking in the post-tests of the experimental group
<table>
<thead>
<tr>
<th></th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>19.943</td>
<td>20.532</td>
</tr>
<tr>
<td>Class seven</td>
<td>-1.230</td>
<td>-0.423</td>
</tr>
<tr>
<td>Class nine</td>
<td>-0.763</td>
<td>0.150</td>
</tr>
</tbody>
</table>

Linear regression (Enter): regression model \( p \) value = 0.014, \( R = 0.454 \), \( R \) square = 0.206 (adjusted \( R \) square = 0.163).

In comparison with the class eight students, the class seven students showed significantly lower overall scores for critical thinking. However, no significant relationship was found between the overall score of critical thinking and the class nine students.

**Predictors of the Assumption of Critical Thinking**

Ordinal regression was used with the assumption of critical thinking because the results were ordinals. The expected assumptions for ordinal regression to determine the predictors are as follows:

1- **Assumption 1** suggests that the dependent variable must be non-parametric **ordinal results**: The critical thinking assumption was a non-parametric variable. This assumption was accepted.

2- **Assumption 2** suggests that the independent variables must be continuous, **ordinal, or categorical**: The independent variable involved age (12, 13, and 14 years) and class (class seven, eight, and nine). This assumption was accepted.
3- Assumption 3 suggests lack of multicollinearity: This assumption was verified using collinearity diagnostics, wherein VIP results must not be less than 2. An ideal result must be close to 1. The results of the current study were 1.312–1.366 for class and 1.246–1.249 for age.

These assumptions for critical thinking were accepted. The final model is shown in Table 2.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Estimate</th>
<th>SE</th>
<th>OR</th>
<th>95% CI</th>
<th>Lower</th>
<th>Upper</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years</td>
<td>0.900</td>
<td>0.754</td>
<td>2.459</td>
<td>0.561–10.784</td>
<td>0.233</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 years</td>
<td>−1.000</td>
<td>0.713</td>
<td>0.368</td>
<td>0.091–1.488</td>
<td>0.161</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 years</td>
<td>0</td>
<td>.</td>
<td>1.000</td>
<td></td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>Class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seven</td>
<td>2.365</td>
<td>0.805</td>
<td>10.646</td>
<td>2.197–51.578</td>
<td>0.003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eight</td>
<td>2.226</td>
<td>0.829</td>
<td>9.267</td>
<td>1.826–47.031</td>
<td>0.007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nine</td>
<td>0</td>
<td>.</td>
<td>1.000</td>
<td></td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
</tbody>
</table>

Ordinal regression (logit): chi-square = 18.022, df = 4, p value = 0.001. Cox and Snell = 0.363, Nagelkerke = 0.367

A significant relationship was found between class and the assumption of critical thinking. The scores of students in class seven and eight for the assumption of critical thinking were 10.646 and 9.267 times greater than the scores of the class nine students, respectively. Age showed no significant effect on the critical thinking assumption, as shown in Table 2.
Predictors of Deduction

1- Assumption 1 suggests that dependent variables should be continuous: The overall score of deduction was continuous.

2- Assumption 2 suggests the presence of two or more independent variables (numerical, ordinal, or categorical): The dummy method used to predict the outcomes. Three factors of class (seven, eight, and nine) were obtained, wherein class eight served as the reference for the other factors.

3- Assumption 3 suggests independence of observations or independence of residuals: This assumption was verified using the Durbin–Watson test. An acceptable result must be in the range of 1-3 or close to 2. The value of the Durbin–Watson test for the overall score of general attitude was 1.575, which was considered acceptable.

4- Assumption 4 suggests a linear relationship between the dependent and independent variable(s): Difference tests such as ANOVA, can be employed given the categorical nature of independent variables. Significant differences were found in class, and such differences were accepted in the current assumption.

5- Assumption 5 suggests that data must show homoscedasticity: This assumption was verified using scatter plot. Result was deemed acceptable when the dots were homogenous and the same in distance along the linear fit line, as shown in the figure below.
6- Assumption 6 suggests that data must not show multicollinearity: This assumption was verified using collinearity diagnostics, wherein VIP results must not be less than 2. An ideal result should be close to 1. The result for the current study was 1.286 for both class seven and nine. Thus, the assumption was accepted.

7- Assumption 7 suggests that lack of significant outliers: No outliers were found outside 3, which is considered as a standard limit (Figure 3).

8- Assumption 8 suggests that the residuals must be normally distributed: The residuals of deduction were normally distributed, as shown in Figure 4.
The final model of the predictors of deduction is shown in Table 3 after accepting all assumptions for deduction.

**Table 3**  
*Final model for deduction in the post-tests of the experimental group*

<table>
<thead>
<tr>
<th>Class</th>
<th>B</th>
<th>SE</th>
<th>Beta</th>
<th>T</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower bound</td>
<td>Upper bound</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>bound</td>
<td>bound</td>
</tr>
<tr>
<td>Constant</td>
<td>20.786</td>
<td>0.538</td>
<td>38.632</td>
<td>19.696</td>
<td>21.876</td>
<td>0.000</td>
</tr>
<tr>
<td>Seven</td>
<td>−2.786</td>
<td>0.737</td>
<td>−0.576</td>
<td>−3.781</td>
<td>−4.279</td>
<td>−1.293</td>
</tr>
<tr>
<td>Nine</td>
<td>0.014</td>
<td>0.834</td>
<td>0.003</td>
<td>0.017</td>
<td>−1.675</td>
<td>1.703</td>
</tr>
</tbody>
</table>

Linear regression (Enter): regression model (p value = 0.001), R = 0.577, R square = 0.333 (adjusted R square = 0.297)
Class seven students showed significantly lower overall scores for deduction compared with the class eight students. However, no significant relationship was found between critical thinking deduction and class nine students, as shown in Table 4.58.

**Predictors of General Attitude**

1- **Assumption 1 suggests that dependent variables should be continuous:** The overall score of general attitude was continuous.

2- **Assumption 2 suggests that two or more independent variables (numerical, ordinal, or categorical):** Dummy method was used to predict the outcomes. Three factors of mothers’ education (secondary school or lower, bachelor’s, and postgraduate) were obtained. Bachelor’s degree served as reference for other factors.

3- **Assumption 3 suggests independence of observations or independence of residuals:** The assumption was verified with the Durbin–Watson test. An acceptable result must be in the range of 1–3 or close to 2. The value of the Durbin–Watson test for the overall score of general attitude was 2.105, which was acceptable.

4- **Assumption 4 suggests a linear relationship between the dependent and independent variable(s):** Difference tests such as ANOVA can be employed given the categorical nature of independent variables. Significant differences were found in the factors of mothers’ educations. Such differences were accepted in the current assumption.
5- Assumption 5 suggests that data must show homoscedasticity: This assumption was verified using a scatter plot. Result was deemed acceptable when the dots were homogenous and the same in distance along the linear fit line, as shown in the figure below.

6- Assumption 6 suggests that data must not show multicollinearity: This assumption was verified using collinearity diagnostics, wherein VIP results must not be less than 2. An ideal result should be close to 1. The result for the current study was 1.105 for both secondary school (or lower) and postgraduate education; thus, the assumption was accepted.
7- **Assumption 7 suggests lack of significant outliers:** No outliers were found outside 3, which is considered as the standard limit (Figure 5).

8- **Assumption 8 suggests that the residuals must be normally distributed:** The residuals of general attitude were normally distributed, as shown in Figure 6.

![Normal Q-Q Plot of Studentized Residual](image)

**Figure 6. Normal distribution for general attitude**

After accepting all assumptions for general attitude, the final model of the predictors of general attitude is shown in Table 4.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>Beta (95% CI)</th>
<th>t</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>2.788</td>
<td>0.123</td>
<td>$22.75 / 4$</td>
<td>2.540</td>
<td>2.036</td>
<td>0.000</td>
</tr>
</tbody>
</table>

*Table 4: Final model for general attitude in the post-tests of the experimental group.*
<table>
<thead>
<tr>
<th>Secondary school or lower</th>
<th>0.323</th>
<th>0.151</th>
<th>0.371</th>
<th>2.137</th>
<th>0.017</th>
<th>0.630</th>
<th>0.039</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postgraduate</td>
<td>0.545</td>
<td>0.189</td>
<td>0.501</td>
<td>2.889</td>
<td>0.163</td>
<td>0.928</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Linear regression (Enter): regression model ($p$ value = 0.019), $R= 0.440$, $R$ square = 0.193 (adjusted $R$ square = 0.150)

Mothers’ education (secondary school and postgraduate) showed a significantly positive relationship with general attitude. Postgraduate factor showed a more significant relationship with general attitude than the factor of secondary school. Both significant results indicated the strong relationship between mothers’ education and general attitude.

**Predictors of Decision Making**

Ordinal regression was used for the domain of decision making because the results were ordinals. The assumptions for ordinal regression to determine the predictors of decision making are as follows:

1- **Assumption 1 suggests that the dependent variables must be non-parametric ordinal results:** Decision making is a non-parametric variable. This assumption was accepted.

2- **Assumption 2 suggests that independent variables must be continuous, ordinal, or categorical:** The independent variable involved age (12, 13, and 14 years). This assumption was accepted.

3- **Assumption 3 suggests lack of multicollinearity:** This assumption was verified using collinearity diagnostics, wherein VIP results must not be less than 2. An ideal result should be close to 1. The result for the current study was 1.194.
These assumptions were accepted for the decision making domain of problem-solving skills. The final model is shown in Table 5.

Table 5.
Final model of decision making

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>SE</th>
<th>OR</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 years</td>
<td>−1.258</td>
<td>0.763</td>
<td>0.284</td>
<td>0.064</td>
<td>1.268</td>
<td>0.099</td>
</tr>
<tr>
<td>13 years</td>
<td>0.412</td>
<td>0.688</td>
<td>1.510</td>
<td>0.392</td>
<td>5.822</td>
<td>0.549</td>
</tr>
<tr>
<td>14 years</td>
<td>0</td>
<td>1.000</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ordinal regression (logit): chi-square = 6.387, df = 2, p value = 0.041. Cox and Snell = 0.148, Nagelkerke = 0.151

Significant differences were observed in decision making in terms of age, but no significant result was found in the ordinal regression.