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Can an Educational Activity Program Based on Feuerstein's Program and Gardner's Theory Increase Excellence and Creativity in Math in Omani Students?

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Excellence and creativity in mathematics are necessary requirements for the twenty-first century, and some countries have gone to build and develop new curricula for excellence and creativity. We prepared an activity program in mathematics based on Feuerstein's instrumental enrichment program and Gardner's multiple intelligences theory to increase excellence and creativity in mathematics for Omani students. We hypothesized that the success of previous programs based on the same foundations would generalize to Omani students. In an experiment, the experimental group received a special training and the control group did not. We then checked whether the pretest-posttest gain was larger for the experimental group than for the control group. The study sample was comprised of an experimental group of n = 35 8th-grade girl students of class nr. 8/1 in Aesha bent Abu Bakr school in Salalah, Oman, and a control group of n = 36 of 8th-grade girl students of class nr. 8/3 in the same school. The differences in pretest-posttest gains were analyzed using t-tests, significance levels, correlations, and effect sizes. There were large and significant experimental effects in favor of the experimental group, showing these educational outcomes can be generalized to Oman. We note various limitations of the study and give various recommendations.

Keywords**:** educational activity program, instrumental enrichment, multiple intelligences, excellence in math, creativity in math.

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Education in the 21st century faces several challenges, such as preparing learners to use their knowledge gained in school, being able to use technology to control their environment, and being able to face and solve life's problems (Gravemejjer, et al., 2017).Many countries, including Oman, have reorganized and developed curricula and programs with the aim of increasing learners' creativity, so they are better able to face local and global challenges. Some countries have introduced new curricula, known as curricula for excellence, which focus on helping students to reach levels of excellence in achievement, so they are better able to serve their communities (Mintzes & Chiu, 2014); (Forgasz & Hill, 2013). They also relied on the use of modern assessment strategies such as the assessment as learning (AaL) strategy to contribute to raising the level of students' academic performance and raising their self-regulation (Hinduja, et al., 2020).

Excellence in education means that the students have the ability to achieve difficult goals, to show a high level of skills during activities, to have a high level of thinking abilities, and to possess special learning skills, which allow them to serve their society and, more broadly, humanity (Bansal, 2012). This is related to the good teaching style which provides an opportunity to let students of diverse abilities pair with each other to work on academic task in friendly environment (Ullah, et al., 2020). As for creativity, it is a process with successive stages aimed at producing multiple solutions characterized by diversity and novelty, and the various components being balanced (Almufty, 2005).Excellence and creativity are linked.

Learningmathematics is a good way to achieve excellence and creativity for students, because it depends on the use of imagination, mental images, logic, and supplying evidence for positions. Mathematics also has a special nature that can be described as experimental, practical, cumulative, deductive, and synthetic, and, when everything works well, it can be a source of pride and joy to learners (Elsayed, 2015a).

Dascalu (2012) states that achieving excellence and creativity in math helps students to succeed in their jobs later in life; to face practical problems in life; to develop abilities like inquiring, researching, and experimenting; and to increase their personal competences. The National Council of Teachers of Mathematics (NCTM) also states that achieving excellence and creativity in mathematics are essential nowadays, and that the setting of these goals represents a new trend in mathematics education. They also state there is a transformation from concentrating on traditional goals to more contemporary goals (NCTM, 2015), so, teaching mathematics evolved from concentrating on exercises, applications, and procedures to developing excellence and creativity, and increasing a general understanding of math, in addition to developing mathematical thinking and math for life (William, et al., 2009).

To give an example, Scotland presented a pioneering experiment in preparing curricula based on excellence for students from kindergarten to university in all subjects, including mathematics. These curricula focused on four basic goals: successful learners, confident students, responsible citizens, and effective participants (The Scottish Government, 2008).Spain was 1 of the 17 countries that participated in the International Association for the Evaluation of Educational Achievement’s Teacher Education and Development Study in Mathematics (TEDS-M 2008), by organizing the curriculum contents according to four areas of knowledge: school mathematics, advanced mathematics, general education, and physical education science (Cañadas, et al., 2013). Moreover, many conferences and national projects concentrated on developing excellence and creativity, and the importance of providing experiences and activities to train students on practicing these skills. To give some examples, there were two conferences on excellence in The Excellence Research Center in Science and Mathematics Education at King Saud University in Saudi Arabia in 2017 and 2018, respectively, and there were the Conference of Mathematics Education and Developing Creativity in 2003 by the Egyptian Council of Mathematics Education, and the Conference of Curricula and Thinking Development in 2000 by the Egyptian Council of Curricula and Instruction.

A potential for excellence in math and creativity in math needs to be activated and developed using different strategies and approaches, which depend on appropriate enrichment activities (Elsayed, 2015b).

Feuerstein's instrumental enrichment model aims to help students learn and increase their ability to adapt to the environment by changing their cognitive environment and acquiring new cognitive skills (Feuerstein et al., 1985). This model includes educational procedures and fifteen enrichment instruments that allow the opportunity to choose those suitable for math content and its concepts, generalizations, and skills.

Feuerstein's model's importance reflects in converting the learner from a negative recipient to an active producer for new information and producing real motivations of the learners to achieve the task in joy and pleasure, which leads to a positive attitude towards the subject taught. It aims to correct learners' low cognitive performance with weak cognitive functions and produce reflective thinking and insight. Finally, it helps them acquire concepts, realizing relationships, and necessary skills to carry out their cognitive tasks (Bransford et al.,1985).

Gardner's theory is one of the educational theories based on cognitive psychology and growth psychology and revolted against the then reigning general intelligence theory. Gardner’s theory states that human intelligence consists of several mental abilities other than mathematical and linguistic ones, and it describes how people use their multiple intelligences to solve problems (Elsayed, 2010).

The theory enables teachers to determine students' weaknesses and strengths, help their students to overcome their learning disabilities, and use technological tools in the educational process (Susan & Dale, 2004).

1. Literature Review

2.1 Feuerstein’s Model and Gardner’s Theory

Feuerstein's instrumental enrichment model aims to change from teaching with a strong focus on memorization to developing learners' mental skills, using these skills to understand problems in the present and future, and overcoming these problems (Strang & Shayer, 1993). Feuerstein's model is based on the hypothesis that mental functions can be developed through systematic mental challenge, which emphasizes reflection and basic development (Anita, 1997). It also aims to help students in their learning, and increases their abilities to adapt to the environment through changing their cognitive environment and acquiring new cognitive skills (Feuerstein, et al., 1980).

Feuerstein designed the Instrumental Enrichment Program in the early 1980s based on the idea that the mental capabilities of learners with low cognitive performance do not have fixed properties but that these characteristics can be changed and modified using educational programs aimed at bringing about modifications in the cognitive structure of these learners. Feuerstein called this process the concept of cognitive modification, by which learners can be helped to learn, are provided with new cognitive skills, and increase their ability to adapt to the environment (McCollum, 1996).

The Feuerstein program is based on four theoretical foundations. The first is the Mediated Learning Experience Theory. Feuerstein believes that if the learner is exposed to environmental stimuli directly, he may not interact with them because he does not have learning experience that enables him to deal effectively with those stimuli (Ben-Hur, 2000). He can also acquire that experience through a mediator who works on modifying the stimuli and shaping them in a way that makes it easier for him to deal with them while directing him to the correct methods and methods from which he must start, thus enabling him to complete the task facing him successfully (Ben-Hur, 2000; Bransford et al.,1985; Strang & Shayer, 1993).

The second theoretical foundation is the learner's Cognitive Map. Feuerstein proposed a model for analyzing learners' mental performance with low cognitive performance, intending to identify the difficulties they face. Feuerstein called this model a cognitive map, and it includes seven dimensions (Blagg, 1991; Feuerstein et al., 1980, Feuerstein, et al., 1985): 1) The content of the assignment assigned to the student, 2) The means, which is how the mind deals with the task, 3) The process, which refers to the mental formation through which information is processed from simple mental processes to complex operations, 4) The form of mental performance, defined it in three forms: input, processing, and output, 5) Level of complexity, which refers to the quantity and quality of the necessary units of information from which to produce mental performance, 6) Level of abstraction – the more mental performance moves away from the physical events in which it is directed, the more abstract the performance, 7) The level of competence, which expresses the speed and accuracy in completing the tasks of mental performance.

The third part of the theoretical foundation is cognitive modifiability, which means modifying the learner's knowledge structure through an intentional intervention. These modifications are meant for the acquisition of a certain amount of knowledge or skills and the development of the learner's ability to respond and interact with situations that are in constant change (Feuerstein et al., 1980).

The fourth part of the theoretical foundation is the Learning Potential Assessment Device (LPAD).Feuerstein designed the LPAD, a clinical tool that consists of an interconnected set of tools to predict a learner's future ability to learn (Feuerstein et al., 1990; Feuerstein et al., 2003).

Gardner's theory is based on a set of at least fourteen principles, which will be shortly described below (Armstrong,2009;Fariborzi, 2017; Gardner, 1997; Nolen,2003; Shearer, 1997). First, most people can develop each intelligence to an adequate level. Second, the intelligences usually cooperate in a complex fashion. Third, the intelligences are multiple, not singular. Fourth, each person possesses all intelligences, all of which are dynamic, of equal importance, and present in every person, but to varying degrees. Fifth, the intelligences differ in their nature, development, and growth among individuals. Sixth, the intelligences can be defined, described, and measured. Seventh, one type of intelligence can be used to enhance another type of intelligence. Eight, Intelligence is rarely seen abstractly. Ninth, individuals can express each intelligence in more than one way. Tenth, the human race should be described using multiple intelligences, regardless of age or circumstances. Eleventh, evolutionary theory applies to Gardner's theory of multiple intelligences. Twelfth, people learn well if education is matched to their aptitudes. Thirteenth, the cognitive mental abilities, skills, and sub abilities of each type of multiple intelligences can be measured and evaluated. Fourteenth, Gardner's model is only a temporary form, and further research may lead to the discovery of new intelligences.

Many studies have been conducted in mathematics education using Feuerstein's model and Gardner's theory to improve many outcomes, with some of them showing substantial effects. First, Feuerstein et al., (1979) found that instrumental enrichment strategy was effective in developing skills and mental abilities as measured by a mathematical skills test, a self-concept scale, and Thurstone’s Test of Mental Alertness, which assesses one’s ability to problem solve through a variety of levels. Second, Strang and Shayer(1993) found that an instrumental enrichment strategy effectively developed achievement and thinking skills for London high school students. Third, Elbana (2002) studied gifted students with learning disabilities and found that an instrumental enrichment strategy effectively developed achievement in science at the levels of recall, understanding, and application. Fourth, Sohn (2004) found that multiple-intelligences-based teaching helped develop students' multiple-intelligences profiles, contributing to a better understanding of mathematical problems. Fifth, Abdelsamie and Lasheen(2006) reported that multiple-intelligences-based strategies effectively developed students' attitudes towards mathematics and improved their mathematical thinking and abilities in solving mathematical problems. Sixth, Elsayed (2010) showed that a multiple-intelligences-based program effectively develops achievement and reduces mathematics-anxiety for basic education students in Oman. Seventh, Hong et al. (2020)studied the relations between students’ naturalistic, bodily-kinesthetic, spatial, and logical intelligences and their hands-on making self-efficacy reflected in their attitude toward quality improvement in a science, technology, engineering, arts, and mathematics contest. The authors conclude that attitude toward quality improvement was crucial for students to win in the contest, which benefited those students with a high level of the four types of intelligence.

Educational Activity Program: Excellence in Math

Many educational researchers agree that excellence in mathematics is defined as the student's ability to achieve the highest score in performance and academic achievement, and high-level skills in school activities, and different researchers focus on different variables. William (2011) stated that excellence in mathematics refers to learner's possession of a varied set of skills: using imagination and reflection to understand math, performing arithmetic operations rapidly and efficiently, solving non-routine problems and understanding the important role that math plays in supporting technological, social, and natural sciences. In this regard, Farooq and Sayed (2008) stated that excellence in math refers to learner's smart behaviors related to three dimensions: the first represents a learner's cognitive abilities in math; the second focuses on mathematical-operations-related skills, such as communication, inference, and problem solving; and the third deals with learner's attitudes towards math learning. Also, excellence in math refers to the learners' mastering of mathematical knowledge and skills, and their ability to apply them in life, communicate with others, and create new ideas. It means that excellence in math differs from academic achievement, which concentrates on mastering mathematical knowledge and skills only (Elsaeed & Abdelhaye, 2015). Sayuri and Patrick (1998) determined excellence skills in math as follows: acquiring and building mathematical knowledge in different ways; acquiring communication, connection, and deduction skills; building relationships and mathematical representations; and flexibility of mathematical thinking.

In the construction of the present activities program in math, excellence in math is defined as students possessing a set of mathematical skills consisting of being able to reach an integrated understanding, being able to obtain an extreme extent of mathematical knowledge, being able to design a creative product in math, and being able to use math in daily life. The construct of excellence in math is operationalized as the score students receive on a self-created test of excellence in math.

Excellence in math can be achieved by using several approaches. Obeida (2013) developed excellence skills for gifted students at Tabouk University in Saudi Arabia by using an enrichment program based on the associative theory. Waisman, et al., (2014) examined the impact and the interplay of general giftedness (G) and excellence in mathematics (EM) on high school students' mathematical performance associated with translations from graphical to symbolic representations of functions, as reflected in cortical electrical activity (by means of ERP—event-related potentials—methodology).Elkahtany (2105) developed excellence skills for secondary students using a program based on the communicative theory. While Elsaeed (2018) used an integrated multidisciplinary approach to develop academic excellence skills for middle school students in Egypt.

For our Omani students we used an educational activity program that was based on the work of Feuerstein and Gardner; it focused on the students reaching four objectives: integrated understanding, having the maximum mathematical knowledge of no less than 90%, designing a creative product in math, and using math in daily life. The program is described in detail in Method.

2.3 Educational Activity Program: Creativity in Math

The topic of students' creative process in mathematics is increasingly gaining significance in all countries of the world. Researchers often use Multiple Solution Tasks (MSTs) to foster and evaluate students' mathematical creativity (Schindler & Lilienthal, 2019).However, perspectives on creativity in mathematics education research are diverse and there is no single shared definition or even a shared conceptualization of mathematical creativity (Singer, 2018). Yet, research so far predominantly has a product-view and focused on solutions rather than the process leading to creative insights (Schindler & Lilienthal, 2019).

Creativity is characterized as a key component of the ability to find unique and manifold ideas (Guilford, 1967). This ability comprises four aspects: 1) fluency, the number of solutions;2) flexibility, the diversity of produced solutions; 3) originality, the uniqueness of produced solutions; and 4) elaboration, the level of detail of the descriptions.

Creativity is aimed to be investigated through paper and pencil tests. This approach has been transferred to mathematics education research by Leikin (2009), who introduced the concept of Multiple Solution Tasks (MSTs) within the domain of mathematics education. Creativity is evaluated based on the number, variety, and originality of students' solutions (Leikin & Lev, 2013).

Development of creativity is an aim in many educational programs. Almufti (2005) stated that creative thinking in math is reflected in the learner's ability to introduce non-routine or creative solutions to a problem. For our Omani students we used an educational activity program that was based on the work of Feuerstein and Gardner; it focuses on the students obtaining four skills, which are defined in the following way: 1) Fluency: the ability to find a maximum number of mathematical relationships and ideas related to a certain problem; 2) Flexibility: the ability to produce diverse ideas or methods of proof for a mathematical problem, measured by the diversity of categories of ideas or methods of proof; 3) Authenticity: the ability of giving answers which are unfamiliar in the student community; 4) Sensitivity to problems: the ability of the student to observe problems in specific situations.

Creativity in math can be achieved by using several approaches. Schoevers, et al., (2019) conducted a study to evaluate the effects of the Mathematics, Arts, and Creativity in Education (MACE) program on students' ability in geometry and visual arts in the upper grades of elementary school. The program consisted of a series of lessons for fourth-, fifth-, and sixth-grade students in which geometry and visual arts were integrated, alongside with a professional development program for teachers. Results showed that students who received the MACE lesson series improved more in geometrical aspects perceived in a visual artwork than students who received regular geometry lessons only. Moreover, Kim (2019) conducted a study to investigate how teachers' implementation of innovative curriculum materials specifically designed to support formative assessment practices provides learning opportunities for teachers to become more responsive to student mathematical thinking. The findings discuss precisely how to promote teacher learning and improvement of teaching practices using formative assessment strategies guided by curriculum materials to develop mathematical thinking skills.

For our Omani students we used an educational activity program that was based on the work of Feuerstein and Gardner; it focuses on the students obtaining four skills: fluency, authenticity, flexibility, and sensitivity to problems; the program is described in detail in Method. The activities lead to all student improving their vocabulary and the eight types of intelligences in a balanced way. Many of Feuerstein's enrichment methods were used: Analytical Perception, Illustrations, Comparisons, Family Relations, Numerical Progressions, Syllogisms, Categorization, Instructions, Temporal Relations, and Transitive Relations. Following Gardner's theory and Feuerstein's model, educational activities and tasks were offered to learners organized in small cooperative groups; these activities and tasks were enriched with examples and additional information that allow students to understand information in depth and achieve excellence in achievement – besides, they allowed practicing creative thinking skills while learning.

The teaching strategies used in the program were determined based on the objectives and nature of each lesson, relying mainly on the most important strategies used in Feuerstein's program: introduction, independent work, discussion, summary, and evaluation. A minority of the lessons made use of other strategies from Feuerstein's program: discovery, problem solving, inquiry, use of body language, collective singing, and audio recordings.

2. Study Problem, Question, and Hypotheses

What is the state of affairs concerning learning and creative skills in Oman? Rindermann (2018) analyzes outcomes of international studies on school achievement and shows there are large differences between countries. It is clear that Omani children score below the international mean; for instance, performance indicators of 8th-grade Dhafor students in TIMSS (2015) showed that their mean of 416 points is below the international mean of 500 points (Oman's Ministry of Education, 2018). Another example is a pilot study (Elsayed &A lbarami, 2019)on 250 students in the second stage of Oman's basic education, where the performance on higher-order questions in the final exams in math was clearly weak. So, it is concluded that Oman's basic education students have insufficient math skills and possibly also lower creativity skills.

The first author of the present study has extensive practical experience in supervising students in Oman's basic education schools, and it is clear that most teachers concentrate on traditional teaching methods and use memorization-based evaluation, which is unsuitable to develop excellence and creativity. He is of the opinion that the current mathematics curricula lack multi-level enrichment activities, and that introducing these would enhance math performance. In line with this, Oman's Ministry of Education aims to enhance students' math skills by developing math curricula similar to those used in the Cambridge University system (Oman's Ministry of Education, 2018).

The US Department of Education defined educational activity programs as all programs related to school life and its varied activities related to courses, or social and environmental aspects, which aim to achieve a school's educational goals (Abdelwahab, 1981). Educational activity programs supply learners with opportunities to engage in various activities suited to their interests and needs, which helps them in acquiring new knowledge, skills, and positive attitudes (Urhan & Dost, 2018). These programs also help students to discover facts, concepts, and mathematical generalizations, to develop positive attitudes towards math learning, to support self-dependence, and to increase the ability to discover and innovate (Wille, 2019). Through these activity programs the student can solve both mathematical problems and life problems, which leads to enriching learner's information and academic skills, and excellence and creativity in learning (Mowafy, 2011). Some activity programs are based on Feuerstein's instrumental enrichment model and Gardner's multiple intelligences theory, so we discuss them below. Many educational activity programs in mathematics education based on Feuerstein's instrumental enrichment model and Gardner's multiple intelligences theory were successful in that they yielded substantial increases in math learning and creativity in math in various studies.

The current study focuses on a new educational activity program in mathematics based on the same foundations, namely Feuerstein's model and Gardner's theory.

The Research Question is if its effectiveness in improving excellence and creativity in mathematics for Oman's basic education students is comparable to that of previous educational activity programs based on the same foundations. So, we focus on the question whether the findings from previous research generalize to a new group, namely basic education students in Oman.

We test two hypotheses: Hypothesis 1: The educational activity program has a substantial effect on developing excellence in math skills for Oman's basic education students. Hypothesis 2: The educational activity program has a substantial effect on developing creativity in math skills for Oman's basic education students.

To empirically test our two hypotheses, we carried out an experiment with a pretest-posttest control-group design using two groups of 8th-grade Omani children. The eighth grade was chosen because the content of the mathematics curriculum for this grade includes important and basic topics for learning mathematics in the upper grades, and these topics are compatible with the skills of excellence and creativity to be developed. In addition, the mathematics curriculum for the eighth grade is one of the curricula targeted to be developed at the current stage in Oman according to the philosophy of the Cambridge curricula, which focuses on developing thinking skills, excellence, and creativity among students.

Method

We carried out an experiment where the experimental group received a special training and the control group did not. We then checked whether the pretest-posttest gain was larger for the experimental group than for the control group.

Sample

The study sample comprised an experimental group of n =35 8th-grade girl students (mean age is 13.5 years) of class nr. 8/1 in Aesha bent Abu Bakr school in Salalah, Oman, and a control group of n =36 of 8th grade girl students (mean age is 13.6 years) of class nr. 8/3in the same school. The study was carried out during the first term of the academic year 2018/2019.

Study Materials and Tools

We describe the study materials and the tools used in the study.

Preparing the activity program

The educational activity program was prepared to teach 8^{th}-grade students to develop excellence and creativity skills according to the following four steps.

Analyzing program content and verifying its validity and reliability. The initial learning aspects of the program were listed and this list was presented to three faculty members specialized in math education, and it was modified according to their suggestions. To check the list's reliability, it was re-analyzed after 3 weeks, and the value of the Cooper reliability factor was 91.15 %, which means a high level of reliability (Allam, 2006).

Preparing the program activities. We analyzed the literature on comparable training programs which led to the following choices:

- The activities covered all learning aspects of the program.
- The activities were prepared according to Feuerstein's model and Gardner's theory.
- The activities covered all targeted excellence and creativity skills.
- The activities were put in logic sequence.
- The activities were dependent upon the available equipment and tools of the school.
- The activities were based on the active participation of the students.

Preparing the initial version of the program. The program in its initial version included the following components:

- The program introduction included the program's philosophy, and a theoretical background focusing on Feuerstein's model, Gardner's theory, and excellence and creativity skills. It also included instructions on how the teacher could use this program.
- The program aims are developing excellence and creativity skills for 8^{th}-grade Omani students, operationalized in a set of

behavioral objectives that cover all learning aspects of the activity program.

- The program content consists of a set of activities based on Feuerstein's model and Gardner's theory, and includes the content of the activity program and the excellence and creativity skills.
- The program’s teaching strategies were determined according to the objectives of each lesson, and the excellence and creativity skills in question. These strategies were instrumental enrichment, brain storming, role playing, discussion, discovery, problem solving, inquiry, cooperative learning, and educational scaffolding.
- The educational means and tools were chosen according to each lesson’s objectives and its activities. These tools include white board, smart board, slides, paper cards, figures, photos, graphs papers, PowerPoint presentations, and geometrical tools.
- The program assessment tools were determined according to the aims and learning aspects of each lesson and considering the different program activities. These tools are sets of activities prepared according to Feuerstein's model and Gardner's theory, and also include the excellence and creativity tests.
- The time schedule for the program was prepared in light of the time schedule prepared by Oman's ministry of education for the activity program; the program consisted of 17 lectures.
- The program lessons included the following: lesson number and title, number of classes, learning outcomes, learning aspects, teaching strategies, educational means and activities, lesson procedures, lesson evaluation, and homework.
- Books that the teacher can use.

Verifying the program’s validity, and preparing the final version. The first version of the program was presented to five faculty members specialized in curriculum and mathematics education, and it was modified according to their suggestions of re-designing some activities and eliminating others. So, this led to the final version of the program, which was then applied to the children in the experimental group.

Preparing the test of excellence in mathematics. The test of excellence in math was prepared to measure the level of possession of 8th-grade math skills. This test consists of 22 questions related to the four excellence skills depending on the relative importance of each skill and the number of sub-skills. So, the test consisted of eight essay questions with two questions for each of the four skills, and fourteen multiple-choice questions divided over the four skills as follows:

- 4 questions pertaining to comprehensive understanding of math
- 4 questions pertaining to possessing the extreme extent of mathematical knowledge
- 3 questions pertaining to designing an innovative product in math
- 3 questions pertaining to using math in daily life.

To ensure the validity, this test was presented to six faculty members specialized in curriculum development, teaching methods, and technology, and some items were modified based on their suggestions. The agreement between the specialists was high at 89%. To verify the reliability of the final version of the test, it was taken by a sample of N = 35 8th-grade students of Manbaa Elhekma in Saada school in Salalah, Oman. To gauge the reliability of the test, we computed Cronbach's alpha (Cronbach, 1951), which yielded a value of0.92,which means the test has a high level of reliability. Each multiple-choice question yielded one point for the right answer and zero points for the false one, and each essay question yielded, respectively, 3, 2, or 1 points for the right answer depending on the student's contributions to solving the question, and zero points for a false answer. So, the maximum score on the test was 38 and the minimum score was 0. The children were allowed a maximum of 70 minutes to finish the test.

Preparing the creativity in mathematics test. The test of creativity in math was constructed to measure the level of possession of 8th-grade students' creativity skills. This test consisted of 20 questions related to the four creativity in math skills (authenticity, fluency, flexibility, and sensitivity to problems) depending on the relative importance of each skill and the number of sub-skills. So, the test consisted of five essay questions for each of the four skills. To ensure the validity of the test, it was presented to the same six specialists mentioned above, and some items were modified based on their suggestions. Again, the agreement between the specialists was high at 91%. To gauge the reliability of the test, it was taken by the same sample that also took the excellence in math test described above. The value of Cronbach's alpha was0.90, indicating that the test has a high level of reliability. Each question yielded one or two points for the right answer depending on the student's contributions to solving the question, and zero points for a false one. So, the maximum test score is 40 and the minimum score is 0. The student was allowed a maximum of 80 minutes to take the test.

Study Design

The study variables are the activity program as the independent variable, and the excellence and creativity in mathematics as two dependent variables, as described in Table 1. The study was based on an experimental design, where two parallel groups were assigned at random to the experimental condition and the control condition; the experimental group and the control group both took pre- and post-measurements, as described in Table 2.After selecting the study sample, they were divided randomly into an experimental and a control group. The study was carried out during 6 weeks in a class that met five times a week, so there were 30 lessons in all. The experimental and control groups were pretested, and then only the experimental group was taught the Groups and Relations program by the mathematics teacher (Mrs. Samira Sangour), and the control group was taught the same topics by the same teacher, but now using traditional educational techniques. Knowing that the above mentioned teacher is the senior mathematics teacher in the school, and has extensive experience in teaching mathematics up to eighteen years. At the end of the training period, the students were post-tested in excellence and creativity in mathematics.

Table 1

Independent and dependent variables

Independent Variables Dependent Variables	Activity Program [experimental]	Traditional Education [control]
Excellence in Mathematics	A1	A2
Creativity in Mathematics	A3	A4

Note. A1: Excellence for the group taught by activity program (experimental group)

A2: Excellence for the group taught by traditional education (control group)

A3: Creativity for the group taught by activity program (experimental group).

A4: Creativity for the group taught by traditional education (control group).

Table 2

Design of the study

Experimental	A1	S1	M1	M2
Control	A2	S2	M1	M2
Experimental	A3	S3	M1	M2
Control	A4	S4	M1	M2

Note. S1: Treatment for the experimental group (excellence - activity program)

S2: Treatment for the control group (excellence - traditional education)

S3: Treatment for the experimental group (creativity -activity program)

S4: Treatment for the control group (creativity - traditional education)

M1: Performance on the pretest of (excellence or creativity)

M2: Performance on the posttest of (excellence or creativity)

Statistical Analysis

In this study we employed a pretest-posttest control-group design, and the central measurement is the effectiveness of the activity program, which can be operationalized as the difference between 1) the gain between pretest and posttest of the experimental group and 2) the gain between pretest and posttest of the control group, where it is expected that the experimental group has a larger pretest-posttest gain than the control group. However, when the mean scores on the control group and the experimental group are very similar on the pretest, the experimental effects can be simply computed as the difference of the control group and the experimental group on the posttests. So, we tested whether two groups were equivalent on the pretest, allowing us to use this second approach.

Data were analyzed using means, standard deviations, *t*-tests, significance levels, effect sizes, and η2,employing SPSS version 22.We used *t*-tests to check whether there was a significant difference between the means of the two groups. Statistical significance is the likelihood that the value of a correlation or an effect size is not a coincidence. The significance level is the probability that the hypothesis being tested will be erroneously rejected, and we choose the traditional value of 5%. To arrive at an effect size value, the difference between the experimental group and the control group needs to be divided by the correct standard deviation. In their book on computing effect sizes for research, Grissom and Kim (2012, pp. 90-92) advise to use the pooled *SD* of the pretest for both the control and the experimental group. Pooling the four *SD*s of both pretest and posttest for both the control group and the experimental group is discouraged, as treatment often increases variability, leading to dissimilar values of *SD* for the posttests for the control and experimental group.2η is a two-way correlation between the independent variable and the dependent variable, and it measures the magnitude of the effect of the independent variable on the dependent variable, and hence the actual effect of experimental treatment on search results. It is calculated from the following formula: $2\eta = \frac{2t}{2t+DF}$, DF is the Degree of Freedom (Winer, et al., 1991, p.235). There is a relationship between 2η and the Cohen's effect size as shown in the formula: $d = \frac{2\sqrt{2\eta}}{\sqrt{1-2\eta}}$ (Grissom & Kim, 2012, p. 512).

Results

Equivalence on Pretest for Experimental and Control Group

Tables3 and 4 show the results of the experimental group and the control group on the pretests of excellence skills and creativity skills in mathematics: the differences between the two groups are without exception miniscule and non-significant, so there is strong equivalence of the two groups in excellence and creativity in mathematics. This means we can simplify our analyses, by comparing the scores on the posttests of the experimental group and the control group.

Table 3

Difference between the means of the experimental and control groups on the excellence in mathematics pretest

Skills	Group	*N*	Mean	*SD*	*t-value*	value-*p*
Comprehensive	Experimental	35	1.65	0.90	1.24	0.901
Understanding of Math	Control	36	1.67	1.33		
Possessing extreme extent	Experimental	35	1.66	0.93	1.22	0.900
of mathematical Knowledge	Control	36	1.69	1.33		
Designing an innovative	Experimental	35	1.64	0.91	1.23	0.902
product in Math	Control	36	1.68	1.35		
Using Math in daily life	Experimental	35	1.63	0.92	1.23	0.903
	Control	36	1.67	1.33		
The whole test	Experimental	35	6.58	2.19	0.94	0.363
	Control	36	6.71	2.42		

Table 4

Difference between the means of the experimental and control groups on the creativity in mathematics pretest

Skills	Group	*N*	Mean	*SD*	*t*-value	value-*p*
Fluency	Experimental	35	1.68	0.91	1.25	0.902
	Control	36	1.69	1.30		
Authenticity	Experimental	35	1.70	0.96	1.24	0.905
	Control	36	1.69	1.33		
Flexibility	Experimental	35	1.67	0.90	1.23	0.903
	Control	36	1.71	1.34		
Sensitivity for problems	Experimental	35	1.66	0.95	1.24	0.901
	Control	36	1.65	1.29		
The whole test	Experimental	35	6.71	2.19	0.92	0.365
	Control	36	6.74	2.42		

Effectiveness of the Program

What is the effectiveness of the activity program in developing excellence skills and creativity for Omani pupils? The first hypothesis states that when the activity program has a substantial effect on developing excellence in math skills there should be a substantially higher scores for the experimental group. Table 5 shows that the effect sizes vary from *d* = 2.26 to *d* = 3.77 and 2varies from 0.56 to 0.78, soηthere are substantial differences on all dimensions, and also on the total score; the *t*-values and the *p*-values show that all the difference scores are highly statistically significant. Overall math skills showed a very large effect, and there were also very large effects for all the individual skills. So, the first hypothesis is clearly supported.

Table 5

Difference between the means of the experimental and control groups on the excellence in mathematics posttest

Skills	Group	*N*	Mean	*SD*	*t-value*	*p*	2η	ES
Comprehensive Understanding of Math	Experimental	35	8.07	2.42	13.27	0.000	0.72	3.20
	Control	36	2.28	1.58				
Possessing extreme extent of mathematical Knowledge	Experimental	35	8.9	2.86	10.42	0.001	0.61	2.50
	Control	36	3.1	1.74				
Designing an innovative product in Math	Experimental	35	9.52	2.71	11.64	0.001	0.66	2.79
	Control	36	2.34	1.32				
Using Math in daily life	Experimental	35	7.52	1.98	9.29	0.002	0.56	2.26
	Control	36	2.9	1.57				
The whole test	Experimental	35	34.0	3.69	15.56	0.000	0.78	3.77
	Control	36	10.62	2.93				

Note. ES = Effect size

The second hypothesis states that the activity program has a substantial effect on developing creativity in math skills, so there should be a substantially higher posttest score for the experimental group. Table 6 shows that the effect sizes vary from *d* = 2.17 to *d* = 3.29 and 2η varies from 0.54 to 0.73, so there are very large effects on all dimensions, and also the effect on the total score is very large; the *t*-values and *p*-values show that all the difference scores are highly statistically significant, so there is clear support for the second hypothesis.

Table6

Difference between the means of the experimental and control groups in the creativity in mathematics posttest

Skills	Group	*N*	Mean	*SD*	*t*-value	*p*	2η	ES
Fluency	Experimental	35	8.17	2.40	8.91	0.003	0.54	2.17
	Control	36	3.14	1.67				
Authenticity	Experimental	35	8.88	2.90	9.1	0.002	0.55	2.21
	Control	36	2.93	2.00				
Flexibility	Experimental	35	9.49	2.69	10.28	0.001	0.60	2.45
	Control	36	2.86	2.14				
Sensitivity for problems	Experimental	35	7.54	1.99	11.5	0.001	0.66	2.79
	Control	36	2.36	1.34				
The whole test	Experimental	35	34.15	3.71	13.55	0.000	0.73	3.29
	Control	36	11.29	2.50				

Note. ES = Effect size

Discussion

Various educational activity programs in mathematics were based on Howard Gardner's multiple intelligences theory and Reuven Feuerstein's instrumental enrichment model and yielded substantial improvements in educational outcomes. We tested whether the math scores of Omani children could also be improved by applying an educational activity program based on the same foundations. So, we focused on the question of whether the findings from previous research generalize to Omani school children. The first hypothesis that the activity program has a substantial effect on developing excellence in math skills was strongly confirmed: the group that received the special training scored much better on the posttest of excellence in math; the effect was very large. The second hypothesis was that the activity program has a substantial effect on developing creativity in math and it was also strongly confirmed: the group that received the special training scored much better on the posttest of creativity in math. So, in both cases effects of the training that can only be described as very strong. The strong, experimental design increases the faith we have in these conclusions.

These results are consistent with the results of several studies using the strategies and approaches based on Feuerstein's instrumental enrichment model and Gardner's multiple intelligences theory, such as Nolen (2003), Bender et al. (2002), Gardner (1997), Shearer (1997), Anita (1997), Kenney (1984), and Feuerstein et al. (1979). So, we can therefore answer the research question positively: an educational activity program based on Feuerstein's and Gardner's work not only leads to increases in learning in Western countries but can also be generalized to a country in the Arab world.

The present study has at least two added values. The first is that use was made of an experiment, which means that we present a strong research design allowing strong conclusions based on relatively simple statistical analyses. This contrasts with a study with a weak research design, often requiring complex statistical analyses and yielding weak conclusions. The second added value is that the overwhelming majority of studies are carried out in Western countries, but that we present a study from a culturally and historically very different country, namely Oman, and that we use samples from one of its least-developed regions. In this way, we offer a unique way of testing for generalizability. This may be due to the activities included in the program and the great interest of the Omani society to advance mathematics education in recent years.

In both posttests, the *SD*s are clearly larger for the experimental group, specifically for the scores on the whole test. This means that both distributions were highly skewed, and that there were some students in the experimental group who did not manage so well. Indeed, it is a well-established fact that experimental groups generally have larger *SD*s than control groups and that is a reason why the *SD* of the pretest is often used when computing effect sizes in a study with a pretest-posttest design (see: Grissom and Kim, 2012, pp. 90-92).

Explaining the Effects

How to explain the very strong effects of the educational activity program? We can think of five reasons. First, the students built their own knowledge through their participation in several enrichment activities related to their different intelligences, which made their learning meaningful. Theirfull understanding of what they learned, lead to a deepening of their knowledge, an ability to relate their knowledge to other information, and its use in daily life. Second, the program included a variety of enrichment activities, covering a wide number of excellence in math skills and math creativity skills, and was based on students' multiple intelligences, which helped the students to go the extra mile in mastering all skills. So, the excellence and creativity skills were developed as a result. Third, the students in the experimental group were split into small collaborative groups during the activities, which lead to the creation of a suitable educational environment, which helped them in understanding the information, applying it in new situations, analyzing it, synthesizing it, and finally assessing it. Fourth, each lesson in the program and in each enrichment activity included one or more of the excellence in math and math creativity skills, which helped the students to master the program content, excellence skills, and creative skills in an integrated way, which suggests the program has its maximum effect in developing excellence and creativity skills as a whole, even more than its strong effects in developing individual skills. Five, providing instant feedback to the students during their participation in the program helped the teacher to discover their weak points and to start working on improving them instantly, while at the same time discovering their strengths and enhancing them. Providing instant feedback also helped in stimulating the children’s enthusiasm and encouraging them to participate in the lessons continuously, which influenced their excellence and creativity skills positively.

Limitations of the Study

The study has several limitations. First, the sample size was limited, with 35 children in the experimental group. Limited sample sizes are quite common in the literature on educational programs, but to be able to draw strong conclusions it is necessary to have larger sample sizes. Having said that, the effect sizes in the present study are very large. Second, the sample was from Dhoar region which is located in the south of Oman, and it would have been good to have a second sample from a more developed part of the country, for instance from the capital. However, the sample was representative of eighth-grade female students in the Dhofar community, because the sample was randomly selected from one of the schools in the city of Salalah, a city with different demographics representing the entire Dhofar region. The teacher of the experimental and control groups was an Omani teacher. She was the school's senior mathematics teacher, and had extensive experience teaching mathematics up to eighteen years. It would also be nice to have studies from various other countries, in various states of economic development, to see whether the results are stable across the various settings. The study was conducted on only one teaching program, namely the Groups and Relationships program, but this could be the beginning of a research program trying to apply programs with similar foundations to other mathematics education areas.

Finally, the testing was carried out with self-developed instruments, but what would have happened to the effect sizes if standardized tests would have been applied? Low reliability of an instrument is known to lead to smaller differences (Schmidt & Hunter, 2015). We tested for internal consistency, which was very good, but we did not empirically establish the test-retest reliabilities' value. A high-quality standardized test could be expected to have excellent test-retest reliability, arguably better than of a self-developed test. Suppose the tests measure the same construct to the same degree, then a more reliable standardized test would yield larger effect sizes than a self-developed test. We add that in this kind of research it is quite rare to see standardized tests being used, as researchers differ substantially in the variables they focus on, leading to an abundance of self-developed instruments.

Recommendations

We finish the paper with five recommendations. First, we should work on developing the math curriculum to develop all excellence and creativity skills rather than concentrating on lower-order thinking skills. Second, we should provide a suitable educational environment based on stimulation, encouragement, searching, and accepting different opinions and ideas, in order to develop creativity. Third, we should train mathematics teachers to use approaches and strategies of active learning by providing several enrichment activities related to multiple intelligences, which will lead the students to be self-reliant when working as individuals or in teams making use of their various mental abilities and interests. Fourth, we should train the students to use their thinking skills in their practical life, and creating a habit of using questions with the goal of raising their thinking level, such as "What if …..?" , "Is it possible that ….?" , "What happens if …..?", etc. Fifth, we should be conducting studies similar to the current study, focusing on using other approaches and strategies based on an active-learning philosophy to develop other aspects and variables for students in different educational stages.

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