

The Difference between Gifted and Ordinary Children in Jordan in their Use of Intuitive Rules "Everything can be divided".

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Abstract
The primary purpose of this study was to examine the difference between gifted and ordinary students in Jordan in their use of intuitive rule "Everything can be divided". Participants of the study consisted of (240) students divided into two groups (120 gifted, and 120 ordinary students), I used a questionnaire including 4 tasks relate to the rule " Everything can be divided". An analysis of variance was carried out for correct responses for intuitive rule " Everything can be divided" with the factors giftedness (ordinary, gifted) and grade level (10^{th} 11^{th} 12^{th} grades). Results indicate that the percentages of the correct responses are similar in the two groups, and also the percentages of correct responses were given by the gifted students to one of the tasks is even lower than that given by the ordinary groups.
Keywords: Gifted, Ordinary Children, Intuitive Rule "Everything can be divided".

Literature Review

The literature review includes two parts: Intuitive rules and giftedness.

Intuitive Rule "Everything can be divided".

In this chapter, I briefly presented the theory of the intuitive rules, relating to its main characteristics. Here I shall first discuss the similarities and the differences between this theory and other, main approaches that are commonly used in mathematics and science education regarding students' ways of thinking.

I shall briefly describe and discuss the intuitive rule: "Everything can be divided"

This rule was observed in responses related to successive division of material and geometrical objects and in seriation tasks. It was found that starting from grade 7 on, a substantial number of students' tended to argue that the process of subdivision can go on regardless of the nature of the object. This assertion is correct for mathematical objects, but not for material objects. Several studies (e.g., Stavy, and Tirosh, 2000) have discussed this rule:

a. Popular drink

A popular drink is a mixture of equal amounts of cola and lemon soda. Dana went with her friends to a restaurant and all of them ordered the drink. Dana tasted it and felt it was too sour. She poured out half of the drink, filled the half-emptied cup with cola, and mixed thoroughly with the remaining drink. She tasted the mixture, and it was still too sour. Therefore she again poured out half of the drink, added cola, mixing everything thoroughly. She repeated this process again and again.

Is it possible that at a certain stage she will have pure cola, with no lemon soda? Explain your answer.

The concentration of lemon soda in the drink could be described by the series 1/2, 1/4, 1/8, etc. However, at a certain stage, due to the particular nature of matter, it is possible that no molecules of lemon soda will be left in the cup. The vast majority of the students (83%, 83%, and 79% in grades 9, 10, and 11, respectively) argued that "lemon soda will always remain in the cup." Typical justifications were that "there is always half of the lemon soda" and that "the lemon soda and the cola are mixed together, and therefore there will always remain lemon soda in the cup." Most students assuming finity simply stated that "the amount of lemon soda is finite, and eventually all of it will be poured out." Only few referred to "particles" or "molecules" of lemon soda.

In this case, the lemon soda spread throughout the entire cup and therefore is halved along with the solvent. Thus, an impression may be created that both cola and lemon soda will always be present in the cup. The characteristics of this serial dilution task possibly trigger responses assuming infinity.

b. Sand

A group of 10^{th} grade students, classified as gifted, were presented with the following problem:

Consider a bucket full of sand. Pour half of it out. Again, pour out half of the sand left in the bucket. Continue, each time pouring out half of the remaining.

Will this process come to an end? Explain your answer?

This problem refers to discrete discontinuous objects (grains of sand). As expected most of the gifted students responded correctly, arguing that the process would come to an end. Most of them argued that "At the end we shall reach one grain, which cannot be divided".

One of the students treated the grains as molecules: “At the end we’ll get one grain, and half grain is not sand any more". Twenty- three percent of the gifted students incorrectly argued that the process will continue without an end with the justification that “Everything can be divided by two” (Stavy & Tirosh, 1996).

One important question, related to the intuitive rules is how to overcome the effect of the intuitive rules on our responses. The intuitive rules theory suggests that with age and/or instruction, schemes, formal rules, and bodies of knowledge related to specific content areas are developed and reinforced. Consequently, in respect to these content areas, the relevant intuitive rule loses its power in the face of competing knowledge. It is also possible that with age and/or instruction, children become aware of the need to examine their initial responses, to consider other factors that might be relevant to the task, and to avoid conflicting arguments. Thus, learners may gradually become aware of the boundaries within which a given intuitive rule is applicable (Stavy and Tirosh, 2000).

In this study I chose to focus on two different groups: gifted students and ordinary students. It is my assumption that the gifted student, due to their rich formal knowledge, skills, schemes and awareness of the need to control their responses would be able to overcome the impact of the intuitive rules at least in some content areas.

Giftedness

This study aims to investigate the differences in performance between gifted students and ordinary students in their use of intuitive rule "Everything can be divided". In the previous section I reviewed the literature on intuitive rules. In this chapter I review the second element in the study regarding talented and ordinary students. More specifically I refer to historical aspects of giftedness, definitions of giftedness and ways to identify gifted students.

Among the many findings, the following ones are of importance. Gifted students have higher ability in performing their school assignments and duties. They are more intellectually developed than their classmates. They do well in all school subjects. The percentage of gifted students who attended graduate studies is higher than the percentage of ordinary students (Davis and Rimm, 1985, pp. 3-14).

Terman, and Odeh, (1959) studies, as well as those of Gallgher (1979) showed that the physical characteristics of gifted children are better than those of their normal peers.

In the mid-1960s, an exciting gifted education movement began in the United States, one which includes federal and state legislation, special funds, new programs, and very high interest and commitment by teachers, administrators and educational researchers (Davis and Rim, 1985, p.15; Anastasi and Foley, 1959). Currently, this field is growing in importance in the education domain, as more and more programs are created to highlight this domain.

Academic coursework was telescoped for bright students. College courses were offered in high schools; foreign languages were taught in elementary schools. Public and private funds were earmarked for training in science and technology. Acceleration and ability grouping were used, and efforts were made to identify gifted and talented minority students. New mathematics and science curricula were developed, most notably the School Mathematics Study Group (SMSG), Physical Science Study Committee (PSSC), and Biological Science Curriculum Study (BSCS). Virtually all large school systems have initiated new programs. Many individual schools and even individual teachers, not waiting for formal district action, initiated special services and training for gifted children. At that time many researchers developed diagnostic tests, ways of evaluating specific programs for gifted students, and many related articles were published (Davis and Rimm, 2004).

The field of gifted education continues to evolve toward the close of the twentieth century. Advancements in education and psychology brought empirical and scientific credibility to this field. Research on mental inheritance, subnormal children, construction of instruments to measure both the sub and super normal, and their realization that graded schools could not adequately meet the needs of all children.

Recently, the National Association for gifted children published a report in which it was claimed that the needs of gifted students are not adequately met (Colangelo, Assouline and Gross, 2004). Consequently, a call was made for additional research on giftedness and support for gifted children.

Definitions of Gifted Children

Several terms are used when refereeing to gifted children. Among them are the terms “gifted”, “superior ”, “creative”, “talented", “able”, “genius”, “prodigy”, “excellent”, “expert”, “competent”. Whatever the term used may be, it refers to a category of exceptional children that lie under the umbrella of special education (Newland, 1976, pp. 62-63; Gold, 1996). Here I shall use the term gifted.

Many definitions appeared to explain what is meant by a gifted child. Some of the definitions concentrated on the mental ability while other definitions concentrated on high academic achievement. Some definitions concentrated on creativity and on personal and mental characteristics. The American psychologist Lewis Terman was the first to use the term “gifted”. Terman (1916, 1925) focused on developing and administering the Stanford-Binet Intelligence Scale, based on the earlier work in France by Binet. Terman offered his well-known premise, which essentially stated that the gifted and talented individuals are those who scored at the top 3% of the population on the Stanford-Binet Scale (Brown, Renzulli, Gubbins, Siegle, Zhang and Chen, 2005).

Spearman used the term “genius” to identify gifted children. He concentrated on mental ability, represented by the IQ (Intelligence Quotient) and considered it the only measure that applies in the definition of the gifted child as it is considered the separating point between gifted and normal children. In the 1950s and 1960s of the 20th century, other definitions for the gifted child had appeared. They emphasized the measure (standard) of mental ability (Newland, 1976, p.14; Stephens & Karnes, 2000).

Most current definitions of giftedness have some common elements:

- General intellectual ability
- Specific academic aptitude
- Creative or productive thinking
- Leadership ability
- Visual and performing arts
- Psychomotor ability

It can be assumed that utilization of these criteria for identification of the gifted and talented will encompass about three to five percent of the school population (Davis, Gary & Colangelo, 1997, p.91).

Currently, there is no one, agreed upon theoretically based definition of giftedness. The definition of giftedness is a central feature of every planned program, and a feature that must be reviewed with great care.

As a final comment on the definition challenge, we repeat that:

1. There is no one agreed upon definition of “giftedness”.
2. The specific, chosen definition will determine the selection of subjects, instruments and procedures.

In the last section of this chapter I shall present the definition of giftedness that was used by the school of the gifted students that participated in my study. In general they adopted a multifaceted approach to the definition of giftedness.

Statement of the Problem

This study is embedded within the Intuitive Rule theory "Everything can be divided", which essentially claims that student responses to given tasks often rely on external, irrelevant features, the importance of critical thinking is evident. In order to overcome the impact of the intuitive rules, students should be able to override their interference. To do that, students should ask themselves questions such as: What are the boundaries within which my response is correct? Does it fit with other things I know? That is, students should critically examine their responses. Research (e.g., Shore & Kanevsky, 1993) indicates that one essential difference between gifted and ordinary students is in their critical thinking (e.g., awareness of their own thinking processes, meta-cognitive abilities, attention and control of reasoning processes). Gifted students were found to have a more developed critical thinking then ordinary students. Accordingly, it is reasonable to expect that gifted students will provide more accurate responses to tasks known to elicit incorrect, intuitive responses in line with the intuitive rule "Everything can be divided". This issue has not been addressed.

This study aims at examining the differences between gifted and ordinary students in Jordan in their use of the intuitive rule" Everything can be divided". The goals of this study are to explore the following questions:

1. Are there significant differences between gifted and ordinary students in their use of the third intuitive rule “Everything can be divided”?

Methodology

Sample:

Students from two schools in the Hashemite Kingdom of Jordan participated in this study. The first school is The Jubilee School for Gifted Students and the second school is Amina Bint Wahab school for ordinary students.

This sample of students consists of 240 students divided as follows: Gifted students: This group consists of 3 grades (10-12), 40 children from each grade. Ordinary students: This group consists of 3 grades (10-12), 40 children from each grade.

Instrument

A questionnaire including 4 tasks related to the intuitive rule" Everything can be divided", was developed for this study.

Procedure

The following steps were taken:

To begin with, the researcher received permission from the Ministry of Education in Jordan, and from the administration of Al-jubilee school for gifted students, and Amina Bint Wahab School for ordinary students to conduct the interviews in the two schools.

The students of the two groups (gifted and ordinary) were told about the nature of the study. Before meeting with the students, the school received permission from the students' parents to participate in this study. This study was implemented during two months, in the second term of the academic year 2000 / 2001. The researcher interviewed each student. Each interview took 30 to 35 minutes. The researcher demonstrated the tasks. The students' answers were audiotaped and transcribed.

Data analysis

After transcribing the interviews, I related to two variables: the judgment, and the justification. I did it for each task.
The judgments were first labeled as correct, incorrect or no response for each task. Then, a more subtle coding was used for the incorrect judgments: Incorrect judgments in-line with the relevant intuitive rule and other, incorrect judgments.

The justifications were categorized for each task for each student according to previous categorization of these tasks (Stavy and Tirosh, 2000). New types of responses were categorized by me. I then discussed the categorization of these responses and came to an agreement on the few responses that were categorized differently (about 5% of all the data). The frequencies of the judgments and of the related justifications for each task for each group (gifted, ordinary) for each grade level (10^{th}, 11^{th} , 12^{th}) were then calculated (see Tables 3-17 in Results).
The means of correct responses and standard errors for intuitive rule " Everything can be divided". for each group and for each grade level were calculated (see Table 1 in Results). An analysis of variance was carried out for correct responses for this intuitive rule with the factors giftedness (ordinary, gifted) and grade level (10^{th} 11^{th} 12^{th} grades).

Results

The results of the study are addressed by each objective.
Comparison between gifted and ordinary students in different grades. As mentioned before, students from grades 10, 11 and 12 from the two groups (gifted and ordinary) were given various tasks related to the intuitive rule Everything can be divided".

Table 1 provides information about the means and the standard deviation of correct responses by rules and grades of both the gifted and the ordinary students. An analysis of variance was carried out for correct responses for each intuitive rule "Everything can be divided", with the factors giftedness (ordinary, gifted) and grade level (10^{th} 11^{th} 12^{th} grades).

Table 1: Means (and standard errors) of Correct Responses to the Intuitive Rule " Everything can be divided" by Grade and Giftedness (in %).

Giftedness	Ordinary				Gifted			
Grades / Rules	Total	10	11	12	Total	10	11	12
"Everything can be divided".	66 (10.4)	75 (7.5)	55 (15.0)	71 (8.7)	58 (21.2)	53 (26.2)	50 (25.0)	72 (12.5)

Intuitive rule "Everything can be divided " - Results for each task

Four tasks refer to the intuitive rule "Everything can be divided".

In this chapter I shall first provide a general description of the results. Then, I shall describe the results relating to tasks refer to the intuitive rule "Everything can be divided".

Comparison between Gifted and Ordinary Students in different grades

As mentioned before, students from grades 10, 11 and 12 from the two groups (gifted and ordinary) were given various tasks related to the three intuitive rules.

"Everything can be divided" - Results for each task

Four tasks refer to the intuitive rule "Everything can be divided". Two of them (Subdivision of copper wire and successive dilution) are embedded in the material sciences and thus the application of the intuitive rule "Everything can be divided" leads to incorrect responses. The other two tasks (decreasing geometrical series and subdivision of line segments) are mathematical and there the application of the rule results in correct responses.

I will first describe the results of the material sciences tasks and then those of the mathematical tasks.

1. Subdivision of Copper Wire – Material Task

The following task was presented to the students: Consider a copper wire. Divide it into two equal parts. Divide one half into two equal parts. Continue dividing in the same way. Will this process come to an end?.
The correct response to this task: The process will come to an end.

In the case of this task, the frequencies of finite responses given by the students from the two groups were high at all grade levels (See Table 2).

Students gave several justifications for their finite, correct responses. The most common justifications at all grade levels were: "Copper wire is limited" and "Copper wire will be smaller and smaller till you finish it". The last justification, which was given only by a few students, was "There are a starting point and an end point for the copper wire". Interestingly, the particulate nature of matter was not addressed in these responses.
There were three justifications to the incorrect judgment that the process will not end; "You can always divide by two", "There is a new half every time", and "It is an endless process". These responses are in line with the intuitive rule "Everything can be divided".

Table 2: Distribution of Responses (in %) by Group, and by Grade, to the Subdivision of Copper Wire Task

	Ordinary			**Gifted**		
Grades	**10**	**11**	**12**	**10**	**11**	**12**
(n) Responses	(40)	(40)	(40)	(40)	(40)	(40)
*1. **The process will come to an end****	82.5	70	80	80	75	85
1. Copper wire is limited	35	25	42.5	40	45	60
2. Copper wire will be smaller, and smaller till you finish it	35	20	20	30	17.5	12.5
3. There is a starting point, and an end point for the copper wire	12.5	25	17.5	10	12.5	12.5
2. The process will not come to an end	17.5	30	20	20	25	15
1. You can always divide by two	5	17.5	10	7.5	17.5	5
2. There is a new half every time	10	12.5	7.5	---	5	2.5
3. It's an endless process	2.5	---	2.5	12.5	2.5	7.5

* Correct answer

2. Successive Dilution – Material Task

The following task was presented to the students:

A teaspoon of sugar is put into a cup of water and stirred well into it. Half of the sugar water is poured out, and half a cup of water is added to the cup, and is mixed thoroughly with the remaining sugar water. This is done again: Half of the sugar water is poured out, half a cup of water is added, and so forth. This process is repeated.

Is it possible that there will be a stage at which no sugar at all will be found in the cup? .

This task refers to decreasing concentrations of sugar in solutions. Due to the particular nature of matter, after large number of dilutions, the resulting solution might have a zero concentration of sugar.

Interestingly, the average percentage of correct responses in the ordinary group (grades 10-12) was higher than that of the gifted (56.8 vs. 37.3 respectively). Three types of justifications were given by the students to the correct judgment: "sugar will be less, and less till you get pure water", "concentration will be smaller, and smaller till you finish all the sugar", and "water will replace all the sugar water" (See Table 3). Here much like in the previous task, the particulate nature of matter was not addressed in these responses.

The percentages of incorrect responses, assuming infinity, were higher among the gifted students. Students arguing that sugar will always be in the water claimed that "concentration will be smaller, but sugar will spread in the water, and only half of the sugar will be poured out each time". Some other students explained that "there is a new half every time because everything can be divided".

Table 3: Distribution of Responses (in %) by Group, and by Grade, to the Successive Dilution Task

	Ordinary			Gifted		
Grades	**10**	**11**	**12**	**10**	**11**	**12**
(n) Responses	(40)	(40)	(40)	(40)	(40)	(40)
*1. **No sugar****	67.5	40	62.5	27.5	25	60
1. Sugar will be less, and less till you get pure water	17.5	10	12.5	12.5	17.5	50
2. Concentration will be smaller and smaller till you finish all the sugar	25	20	35	2.5	2.5	5
3. Water will replace all the sugar water	25	10	15	12.5	5	5
2. Will be sugar	32.5	60	37.5	72.5	75	40
1. Concentration will be smaller but sugar will spread in the water, and only half of the sugar will poured out each time	17.5	45	27.5	50	50	20
2. There is a new half every time, because every thing can be divided	12.5	15	7.5	20	25	15
3. **Others**	2.5	---	---	2.5	---	5

*Correct Answer

3 Decreasing Geometrical Series – Mathematical Task

In this task, the students were asked to consider the series 1, ½, ¼ ,…. In this series, each number is half the previous one. They were asked if this process will come to an end.
The correct answer to this task is: The process will not come to an end.
Almost all the students correctly answered this task. High percentages related to the infinite nature of either the group or the process. They claimed that: “the numbers are endless” and “you can always divide by two” (see table 4)
The incorrect responses provided by a small percentage of the ordinary students were that “you will get zero at the end “, and “every thing comes to an end”.

Table 4: Distribution of Responses (in %) by Group, and by Grade, to the Decreasing Geometrical Series Task

	Ordinary			Gifted		
Grades	**10**	**11**	**12**	**10**	**11**	**12**
(n) Responses	(40)	(40)	(40)	(40)	(40)	(40)
*1. **The process will not come to an end****	77.5	92.5	85	97.5	100	100
1. The numbers are endless	75	75	85	97.5	100	100
2. You can always divided by two	2.5	17.5	---	---	---	---
2. The process will come to an end	22.5	7.5	15	2.5	0	0
1. You will get 0 at the end	22.5	7.5	12.5	2.5	---	---
2. Everything comes to an end	---	---	2.5	---	---	---

* Correct Answer

4. Subdivision of Line Segments – Mathematical Task

In this task, the students were asked to consider a line segment, divide it into two equal parts, divide one half into two equal parts, and continue dividing in the same way. They were asked if this process come to an end .

The correct response to this task: The process will not come to an end.

Four main justifications were given for the correct response. Justifications 1 and 2 relate to points and to atoms. Justifications 3 and 4 are in line with the rule everything can be divided: “we can always divide by two” and “every time there is a new half” (see Table 5).

The table shows that the percentages of correct responses given by both groups were high. Students used three types of justifications to the incorrect response that the process of halving the line segment would come to an end: “it is a limited process”, “everything come to an end”, and “there is a start point, and an end point in this line segment". These responses are similar top those provided to the subdivision of the copper wire task. This implies that some students did not differentiate between mathematical and material objects.

Table 5: Distribution of Responses (in %) by Group, and by Grade, to the Subdivision of Line Segment Task

	Ordinary			Gifted		
Grades	**10**	**11**	**12**	**10**	**11**	**12**
(n) Responses	(40)	(40)	(40)	(40)	(40)	(40)
1. The process will not come to an end*	35	70	32.5	70	72.5	55
1. There is endless number of points in this line segment	25	32.5	5	25	40	5
2. We will get an atom; you will never finish this process	---	7.5	10	20	15	35
3. We can always divide by two	5	12.5	17.5	12.5	7.5	10
4. Every time there is a new half	5	17.5	---	12.5	10	5
2. The process will come to an end	65	30	67.5	30	27.5	45
1. It's a limited process	40	22.5	50	10	10	27.5
2. Every thing will come to an end	20	2.5	5	7.5	7.5	2.5
3. There is a start point and an end point in this line segment	5	5	12.5	12.5	10	15

* Correct answer

Rule 3: Summary of results

The most striking finding related to this rule is that unlike in the other cases, the percentages of correct responses are similar in the two groups and that the percentages of correct responses provided by the gifted students to one of the tasks is even lower than that given by the ordinary group. This behavior could result from the stronger development of the idea of infinity in the gifted group, which competes with their learned knowledge about the particulate nature of matter.

The incorrect responses to the mathematical tasks and the correct responses to the material tasks were supported by the same kind of concrete justifications. Thus, correct responses to the material tasks were not supported by the particulate nature of matter. Such responses are typically given by young children who had not yet acquired the concept of infinity.

Discussion

This study is embedded within the intuitive rule theory "Everything can be divided". This is the first study, within this framework that attempts to identify the differences between gifted and ordinary students in their use of the intuitive rule "Everything can be divided" . The study was carried out in Jordan.

In respect to the this study intuitive rule "Everything can be divided", I referred to two types of tasks: material tasks in which the repeated processes of halving come to an end when they reach the atomic level and mathematical tasks in which these processes are endless. In the latter case, the correct response is in line with the intuitive rule. When regarding students' responses to the mathematical tasks it is notable that almost all students at all grade levels provided correct responses. Yet, the students in grade 10 provided finite, incorrect responses to the subdivision of the line segment task. This finding is in accordance with previous observations that students who had not yet developed the abstract idea that processes might be infinite. It was found that young students' responses to repeated halving problems are often that these processes are finite (Fischbein, Tirosh, and Hess, 1979; Piaget and Inhelder, 1963). With respect to the material tasks it is noticeable that the percentages of correct responses provided by the gifted students to one of these tasks (the successive dilution task) are lower than that given by the ordinary group.

However, the judgment provided to correct responses by the ordinary students were not based on the particulate theory of matter but on concrete considerations, and therefore these arguments were not scientifically based. The incorrect responses of the gifted students reflected their abstract reasoning related to infinite processes. Yet the gifted students did not differentiate between mathematical and material objects and considered the sugar as if it was continuous quantity. The high percentages of responses assuming infinity to this task indicate the strong effect to the intuitive rule "Everything can be divided".

In this study it seems that the students kept applying this intuitive rule at more or less the same extent during their years of studies in high school. This suggests that a special intervention is needed to increase students' awareness of the impact of the intuitive rule on their thinking.

In the rest of the discussion, I shall suggest some educational implications that could be drawn from this study to mathematics and science education. I suggest that each of these interventions should be followed by related formal explanations, definitions and other aspects of the relevant scientific framework. Such formal knowledge may help the students in controlling the effects of intuitive rules theory.

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