THE IMPACT OF OVERCOMING FIXATION AND GENDER ON DIVERGENT THINKING IN SOLVING MATHS PROBLEMS

Mehmet Ali Kandemir
Balıkesir University, Turkey
kandemir@balikesir.edu.tr

ABSTRACT

The impact of fixation in solving math problems and that of gender on divergent thinking has been studied in this paper. The study was made in the academic year of 2006-2007, Fall Semester, at Necatibey Faculty of Education, Balikesir University. 229 first and second-year students at the Dept of Primary Math Teaching have been participated in the study. 70 % of the prospective mathematics teachers have been found to be fixed in problem solving. There is no meaningful difference between the scores of those with fixation and those without fixation but the scores of those who have fixation in solving problems are slightly higher than the others. The impact of gender has been studied as a factor on divergent thinking but it has not been found to have a meaningful effect. The scores of female prospective mathematics teachers are slightly higher than the male ones. That is based of the fact that the fluency scores of female prospective teachers are higher than male group. The study shows that the prospective math teachers, who should improve their creative divergent thinking, have fixation in problem solving and the study also reveals the fact that teacher training should include creativity.

Keywords: Problem solving, divergent thinking, creativity, mathematics education, prospective mathematics teachers.

INTRODUCTION

A great many writers have improved conceptual frames to determine creativity in mathematics and they have been in an effort to set factors for mathematical creativity (Pioncare, 1948; Hollands, 1972; Tammage, 1979; Haylock, 1987; Sriraman, 2002). The researchers like Torrance (1966) and Guilford (1967) have traditionally used divergent productive tests, which they improved, in evaluating creativity. Torrance (1966) and Guilford (1967) have taken four factors into consideration like originality, flexibility, elaboration and fluency in the tests they have improved to measure creativity. Hollands (1972) has taken five factors into consideration like originality, flexibility, elaboration, fluency and sensitivity in the tests he has improved to measure creativity. According to Hollands, fluency is the factor to show a lot of ideas in short time; flexibility is shown to change the way to solve a problem or it helps the students to present various methods; care is set forth by expanding or improving the methods of solving; originality is that students try new and nonstandard ways in solving problems and sensitivity is students' creative approach to standard methods.

Considering the studies of some researchers about divergent products and means of measurement in Maths, Dunn (1975) has found out that using open ended questions in Mathematics will be a better way to measure divergent thinking. Haylock (1987 discusses creativity in Maths as problem solving. To Haylock, the sign of creative thinking appears in two cases. The first is to overcome functional fixation in problem solving and the second is to have divergent thinking in solving a problem. Silver (1993) emphasizes the significance of using open ended questions to improve students' creativity in Maths.

It is the responsibility of teachers to improve students' creativity in Math education. Here are some of the obstacles to prevent teaching desirable methods (Kandemir, 2006). A great many of Maths teachers do not know how to improve creative thinking. They ask students the type of questions with one way to answer, which deals with single-dimensional thinking. As a result, their students do not improve divergent thinking and apply routine functions to every type of problems. They cannot produce different ways to solve a problem. This is, as Haylock (1987) stated, the first type of fixation. "*Fixation is a very general phenomenon and can occur in a wide variety of cognitive domains, including output interference in retrieval (Rundus, 1973), the tip-of-the-tongue phenomenon (Brown and McNeill,1966), the use of algorithm in problem solving (Lunchins and Lunchins,1959), and creative idea generation (Smith, Ward and Schumacher,1991)*" (Finke, Ward and Smith,1992). The first type of fixation is constant use of a successful algorithm, which will result in failure when applied in the wrong place. This is functional fixation (Haylock, 1987).

Another element emphasized in problem solving is divergent idea. According to Dacey (1989), Divergent thinking is seeking various answers for questions which have more than one correct answer or thinking in different aspects (Dacey, 1989). Discussing divergent thinking in Maths Weisberg (1997) finds out that divergent idea is a cognitive process to give a lot of useful answers to a question and to develop new and unusual answers to a problem. Solving a problem in different ways will increase to reach original and creative ideas. For that reason, divergent idea is the process to open one's mind to a variety of hypotheses, relations and possibility. At the same time, divergent idea as an initial ability is important because a wide net of relations passes through divergent ideas for ability to solve a problem. Experimental studies made by Milgram and Arad (1981), Vertanian, Martindak and Kwiatkowski (2003) show that those who can produce divergent ideas are able to solve problems in a more efficient way. In the study carried with 273 students from the seventh grade of 3 different primary schools, Imai (2000) has investigated the impact of overcoming fixation in Maths problems against divergent thinking in open ended Maths problems. It can be found from the conclusion of the study that the students who have overcome fixation in solving Maths problems have relatively higher scores than those who cannot overcome fixation. The study shows that the students who overcome fixation in problem solving can develop better ideas and ways to solve problems than the others. Evans has developed some problems to determine and evaluate divergent ideas in Maths. He has defined the cases to be called fluency, flexibility and originality in mathematical divergent ideas.

Ediger 2000 emphasizes that Maths teachers should know to think divergently to improve divergent thinking in Maths education. Kandemir (2006) has found that there is difference between genders in perception and implementation of divergent ideas. Torrance 1983 has indicated that the difference in genders in the ability of divergent thinking might change in the course of time. Torrance (1963, 1965) previously found that male students have better performance in originality than female ones while the latter have better performance in verbal creativity and the creativity in care taking than the former group (Torrance,1995).

Flaherty (1989) has studied on the effect of a sample divergent program on individual perception, cognitive and emotional creativity of the third grade primary school students. In the study where experimental and control groups have been used, the girls in experimental group have higher scores than the boys in the same group in making meaning. There is a higher and meaningful increase in total scores of experimental group than those of control group. Tegano and Moran (1989) have found out that girl apt to have higher scores on creativity than boys. Teachers are the people to improve creative thinking among students. However, they should know how to improve it (Sternberg, 1996;Gurol and Tezci,2001; Kandemir, 2006). To be able to improve creativity, Maths teachers and prospective Maths teachers should have divergent ideas and creative ideas (Kandemir, 2006).

The Purpose of the Study

By using the method developed by Evans to evaluate mathematical divergent thinking, the objective of the study is to find out the relation between overcoming fixation in solving Math problems and divergent thinking in Math problems, and to determine the effect of gender on the scores obtained by means of evaluating divergent ideas. The first chapter of the study about the relationship between fixation in problem solving and divergent thinking in problem solving is similar to Imai's study (2000) made on the seventh grade students of primary schools. The same procedures have been applied on prospective Maths teachers, who are the group of people to educate the students in Imai's study. The results of the study have been compared with those obtained in Imai's (2000).

METHOD

This study was carried out in the Academic Year of 2006-2007, in the fall semester. It is a survey. Primary school prospective Maths teachers are on the focal point of the study.

Subjects

The population of the study consists of the first and second year students at the Primary Maths Education Departments of Education faculties in Turkey in the Academic Year of 2006-2007. The sample group has composed of all the prospective teachers at the Primary Maths Education Dept of Necatibey Education Faculty, Balikesir University, Turkey, in the same Academic Year, all of the prospective teachers at the first year (N1=117) and all of the prospective teachers from the second year (N2= 112). The total number of participants have been N= N1+N2= 229. The sampling has been stratified randomly. The population and the subgroups of the the population have been identified and all the prospective Maths teachers at the first and second year of the dept have been assigned randomly (Gay and Airasan, 2000).

Materials

The data have been obtained with two different tests, both of which were used by Haylock (1985;1986). The first is a test comprising from a problem to determine fixation in problem solving (Problem 1). The second is an open ended geometry problem (Problem2) to evaluate divergent thinking in problem solving.

Problem 1:

We have three jugs, A, B and C. Using the amount of water in the jugs the students are asked to find the total amount of water. The sample question below will be helpful.

Jug A Jug B Jug C

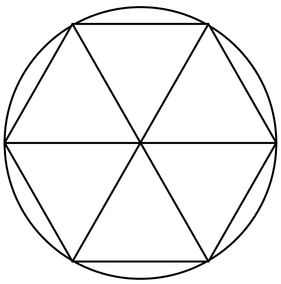
Jug A contains 10 units, jug B, 63 units, and jug C 2 units of water. Let's find 55 units of water.

The answer: B-A+C

Now find the amounts of water in the following problems using the amounts of water in the jugs A, B and C as in the example above.

- Problem 1: Jug A contains 10 units, B contains 64 and C contains 1 unit of water. Find 52 units of water.
- Problem 2: Jug A contains 100 units, B contains 124 and C contains 5 unit of water. Find 14 units of water.
- Problem 3: Jug A contains 10 units, B contains 17 and C contains 2 unit of water. Find 3 units of water.
- Problem 4: Jug A contains 21 units, B contains 127 and C contains 3 unit of water. Find 100 units of water.
- Problem 5: Jug A contains 23 units, B contains 49 and C contains 3 unit of water. Find 20 units of water.
- Problem 6: Jug A contains 50 units, B contains 65 and C contains 5 unit of water. Find 5 units of water.

Problem 2:



A hexagon has been inserted into the circle above; each corner comes on the circle. The corners are labeled as A, B, C, D, E and F. The center of circle is O point. Taking the figure above into consideration, write every kind of geometrical features and figures with mathematical symbols and mathematical statements. Do not hesitate to write everything that the figure recalls you, though very simple.

Here are a few sample situations:

- Each corner of the hexagon is on the circle.
- The center of the circle, O point is also the center of the hexagon.

Procedures

The language of the tests is English. The tests were translated from English into Turkish. The translation was checked by specialist teachers of English. After necessary corrections, the Turkish version of the tests was checked by specialist Turkish teachers. After the necessary corrections the tests were printed to be ready to use for students. To see how applicable the tests are, a pilot study was carried applying the tests on 60 seventh grade primary school students and also 33 prospective primary mathematics teachers. The time of application for the second test to measure divergent thinking has been decided to be different for the groups. The advice taken from some specialists has led us to diminish to 7 minutes instead of 9. The statements which the first subjects had difficulty in understanding were changed in accordance with the suggestions made by the first group of participants but the content of the ideas not changed. After all corrections, the tests were applied to the first and second year primary school prospective mathematics teachers.

Data Analysis

The data of the two tests have been analyzed:

Data analysis of Problem 1

According to the answers to Problem 1, subjects have been divided into two groups. If they the answers to the 6 questions are the same, "B-A-2C", the subjects are fixed. They have answered the 5th and 6th questions because the answers to the first 4 questions are the same. They haven't found the shorter and simpler ways to solve to questions. They have been produced ways to solve the problem. The subjects who answered the fifth question as "A-C" and the sixth question as "C" have beeen found to overcome fixation and are were able to think that the following questions might have different ways of solution though the answers are similar.

Data Analysis of Problem 2

There are 3 categories in Imai's evaluation of divergent thinking. However, this stud shows that two categories are enough and the data for divergent thinking have been calculated in two categories. A great many of features have been obtained in the study using two categories so a third category is not needed because the figures and features have been classified for divergent thinking and have been found to enough. Here are the categories:

Divergent Thinking (1): Each correct statement will be given one point.
Divergent Thinking (2): Rarity of correct answers. The rarity of correct answers has been shown in Table 1.

Table 1: the scoring schemata of divergent thinking according to answering percentiles

The rate of subjects giving the same statements.	Scoring
More than 20 %	0
Less than 20 % and more than 10 %	1
Less than 10 % and more than 5 %	2
Less than 5 % and more than 3 %	3
Less than3 %	4

The sections of percentiles in Imai (2000) were wider than this study because this study was carried out on subjects who have higher mathematical skills than his. So there are more original answers in this study. The number of originality has led us to narrow the sections.

The students at primary schools should be evaluated separately from prospective teachers, who are educated to teach the students.

The statements for Problem 2 have been given in Appendices.

Table 2: The scores of divergent thinking for each statement

Percentiles	**Points**	**Items**
Up to 3 %	4	10–14–15–16–17–21–30–32–33–34–40–41–46–50–52–53–54–55–58–59–60–61–62–63–64–65–67–68–69–71–72–73–

RESULTS

With the help of the answers to Problem 1, the number and rates of the individuals who can overcome fixation and who cannot has been found. The figures in general and in the classes have been shown in Table 3, including the number and percentiles of fixation and overcoming fixation in problem solving.

Table 3: Number and rates of the individuals still under fixation and those who have overcome

Level	NS	NSF	RSF	NSOF	RSOF
1.Year	117	81	%69	36	%31
2.Year	112	79	%71	33	%29
Total	229	160	%70	69	%30

NS: Number of Subjects
NSF: Number of Subjects with fixation
RSF: Rate of Subjects with fixation
NSOF: Number of Subjects Overcoming fixation
RSOF: Rate of Subjects Overcoming fixation

Table 3 shows that first and second year prospective Maths teachers have similar rates of fixation in problem solving. The rate of the prospective teachers who can overcome fixation is 30 %.

After the prospective teachers with and without fixation have been found in Table 3, they are divided into two groups and accepted to be two different groups. Then, the scores of the two groups about divergent thinking have been calculated in accordance with category of testing divergent thinking and Table 2. In order to determine if there is a meaningful difference between divergent thinking scores of the both group, an independent T-test has been applied to take the mean scores of the groups. The results of the T-tests have been given in Table 4.

		75–76–77–80–81–82–83–84–85–86–87–88–89–90–91–92–93–95–97–98–100–101–102–103–105–106–107–108–109–110–111–112–113–114–115–116–117–118–119–120–121–122
3–5 %	3	11–13–18–20–37–38–39–44–51–56–57–66–70–74–78–79–96–104
5–10 %	2	1–12–23–24–25–28–31–36–42–43–45–48–49–94
10–20 %	1	6- 9–19–26–29–35–47–99
Over 20 %	0	2–3–4–5–7–8–22–27

Table 4: Independent t Test to compare divergent thinking scores of the group with fixation and the group without fixation

Groups	N	$\bar{X}$	SS	Sd	t	p
Those Fixed	160	16.28	8.96	227	-1.41	.15
Those not fixed	69	18.1	8.93			

As p = .15>.05 in Table 4, there is no meaningful relationship between those fixed and those overcome it. However, the divergent thinking scores of those fixed at problem solving is relatively higher that those who have overcome it. The difference shows that fixation in problem solving has an impact on divergent thinking, though slightly and the individuals who can overcome fixation in problem solving have a broader perspective of thinking in Maths.

The divergent thinking scores of male and female prospective Maths teachers have been calculated to determine the effect of gender on divergent thinking. Again a t Test has been used to determine if there is a meaningful relationship between the divergent thinking scores of both groups. The results of the t tests have been given in Table 5.

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Table 5: The results of t Tests about the impact of gender on the scores of divergent thinking

Groups	N	$\bar{X}$	SS	Sd	t	P
Male Pro. Teachers	134	17.02	8.34	227	.38	.7
Female Pro. Teachers	95	16.55	9.82			

As p = .7>.05 in Table 5, there is no meaningful relationship between divergent thinking scores of male prospective teachers and divergent thinking scores of female prospective teachers. It can be observed, when examined in details, that divergent thinking scores of female prospective teachers are slightly higher than divergent thinking scores of male prospective teachers when mean scores are taken. This is found to be resulted from the higher scores of female prospective teachers in fluency. That’s, they can write more correct items in a short time that their male counterparts.

DISCUSSION

The majority (70 %) of prospective Maths teachers, who will improve creativity among students in Maths education and will therefore have to implement various teaching techniques together with divergent thinking activities (Ediger, 2000; Kandemir, 2006), and who should have divergent and flexible ideas (Sternberg, 1996;2003), have been found to have functional fixation in problem solving. The result shows that they are educated in a system that does not improve their ability to figure out but a system where they only memorize and aim to achieve their own goals, graduating. The study, which is a repetition of the study made by Imai (2000) among the seventh grade students of primary schools with a different perspective, shows how significant creativity is in teacher training. The Maths teachers, who are almost the primary group to improve students' creative thinking, should have appropriate thinking styles to achieve this objective. The focal point of the issue is university education. The main issue is that the prospective Maths teachers have ceased to show or reveal their own creative ideas. A way to overcome the issue might be to supplement creative courses or the courses that prospective teachers can improve their own creative ideas.

The study also shows that the prospective teachers who overcome fixation in problem solving have higher divergent scores. Haylock (1987) takes creativity of students in Maths education as overcoming fixation and as divergent thinking. The fact that the prospective Maths teachers who overcome fixation have higher divergent thinking scores than those who cannot overcome it shows that the conceptual frame is not mistaken. Besides, the education system should be flexible enough for students to improve their viewpoints instead of inflexible, settled standards. The new point should cover the education system as a whole not only university education. Thinking, creative, flexible teachers, open to differences and innovations, will change the direction of primary school education in the desired way. People will start creativity at very early ages and they will not be fixed with certain thinking standards.

The similar results of divergent thinking about gender show that both sexes are affected in similar ways from Maths programs implemented at universities. The education programs prepared for universities to educate innovative, creative and flexible Maths teachers will help to solve and eliminate the problems deep rooted at primary and secondary schools.

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APPENDIX

1. The hexagon ABCDEFG is a regular hexagon (8%)
2. A hexagon consists of 6 triangles (49%)
3. Triangles are equilateral (52%)
4. Diagonals of the hexagon are the diameter of the circle (34%)
5. IABI=IBCI=ICDI=IDEI=IEFI=IFAI .(%33)
6. A side length of the triangle is also radius of the circle. (19%)
7. A side length of hexagon is radius of the circle. (20%)
8. IOAI=IOBI=…=IOFI=r .(25%)
9. IADI=IBEI=ICFI .(%19)
10. The perimeter of the circle is $2\prod r$.(2,6%)
11. The perimeter of the hexagon is 6r .(3,9%)
12. The area of the hexagon is $6(r^2\sqrt{3})/4$.(6,9%)
13. The perimeter of triangle is 3r .(3%)
14. The area of circle is $\prod r^2$.(0,8%)
15. The area of triangle is $(r^2\sqrt{3})/4$.(2,1%)
16. The area of triangle is $(r^2 \mathrm{Sin}60^0)/2$.(0,8%)
17. The are of hexagon $6x(r^2 \mathrm{Sin}60^0)$.(0,4)
18. A circle is circular of the hexagon (3%)
19. The each inner angle of hexagon is 120^0 .(11%)
20. The total of inner angles of hexagon is 720^0 (4,3%)
21. The total of external angles of hexagon is 360^0 dir .(0,7%)
22. m(AOB)=…=m(AOF)=60^0 .(23%)
23. [AB]//[FC]//[ED] . (8,2%)
24. [AF]//[BE]//[CD] .(6,9%)
25. [BC]//[AD]//[FE] .(6,1%)
26. I$\overset{\frown}{AB}$I=…=I$\overset{\frown}{FA}$I .(19%)
27. m($\overset{\frown}{AB}$) = … = m($\overset{\frown}{FA}$) .(26%)
28. $\overset{\frown}{AB}$ = … = $\overset{\frown}{FA}$.(7,4%)

29. [AD], [BE], [CF] are diameters. .(10,9%)
30. The pieces of lines [AD], [BE], [CF] are linear. (1,3%)
31. The sides of hexagon make six equal circular chords. (6,1%)
32. There are six sectoral points between circle and hexagon. (2,6%)
33. Another hexagon can be drawn by means of the strong points of triangles (0,4%)
34. Another triangle can be drawn by means of strong point of triangles (0,8%)
35. Triangles are equal and similar. (11,3%)
36. The sectoral point of the triangles is the center of circle. .(5,2%)
37. IFCI=2IABI=2IEDI .(4,4%)
38. IBEI=2ICDI=2IAFI .(3%)
39. IADI=2IBCI=2IEFI .(3%)
40. The points B to E, F to C, A to D are symmetrical to O point. (0,8%)
41. There are nine chords of the circle. (2,1%)
42. [AD], [BE], [FC] are diagonals.(5,7%)
43. m(FAB)= … = m(ABC) .(5,2%)
44. The O point is strong point of circle and hexagon.(3,5%)
45. The diagonals are crossed at O point. (5,2%)
46. The perimeter and area of circle is bigger then that of hexagonal.(1,7%)
47. There are 6 equilateral quadrangles .(13%)
48. There are 6 parallelograms .(6,5%)
49. There are 6 isosceles trapezoids.(8,2%)
50. ABCO quadrangle is parallelogram .(0,8%)
51. The hexagon consist of two isosceles trapezoids. (4,8%)
52. There are 6 deltoid (0,4%)
53. There are 6 hemicircles. .(0,8%)
54. [AD], [BE], [FC] are symmetrical axis of hexagon.(0,8%)
55. The height of hexagon is $r\sqrt{3}$.(0,4%)
56. Diameter of the circle/Diagonals are bisector to inner angles of hexagon.(3%)
57. Center Angle is equal with value of the arc it looks. (4,8%).
58. External angle is equal with half of the value of the arc it looks. (1,3%)
59. m(AFC) = m(AC)/2=60^0 .(1,3%)
60. The external angle is equal with half of central angle.(0,4%)
61. The equatorial quadrangle consists of two triangles. (1,7%)
62. The equilateral trapezoid consists of 3 triangles. (1,7%)
63. [AE] and [BD] lines pieces make AEDB quadrangle .(0,4%)
64. Each of two corners of triangle is on circle. .(0,8%)
65. The figure resembles a sphere when looked spatially.(0,4%)
66. The six areas between circle and hexagon are equal. (3,9%)
67. The diameter consists of cross between two mutual corners. (1,3%)
68. Sectors are equal to each other. (1,7%)
69. The height of triangle is $(r\sqrt{3})/2$.(1,3%)
70. Equilateral trapezoids are equal. (3,9%)
71. Corners of trapezoids are on circle. (0,8%)
72. Circle has three diameters .(1,3%)
73. Each line of hexagon is equal. (0,8%)
74. Perimeters and areas of triangles are equal. .(4,4%)
75. The line from F corner to B corner makes a right triangle of 30^0-60^0-90^0 (0,4%)
76. The diameter of circle is twice as a side of hexagon. (1,3%)
77. The angles between circular sectors are 60^0 .(0,4%)
78. The hexagon divides circular arc into six equal sectors. (3,5%)
79. The area of hexagon is six times bigger than the area of hexagon. (3%)
80. External angles of hexagon are equal and 60^0 .(1,7%)
81. The height of the triangle is equal to median and bisector. (0,4%)
82. When hexagon is divided with diagonal, two chord quadrangles appear. (0,8%)
83. The length of circular arc is $\Pi r/3$.(0,8%)
84. The intersection of ABFC and CDEF trapezoids is [FC].(0,4%)
85. The intersection of BCAD and DEFA trapezoids is [AD].(0,4%)
86. The intersection of ABEF and BCDE is [BE] .(0,4%)
87. The total of inner angles are 180^0 .(0,8%)
88. m(FC) = m(AD) =m(BE)=180^0 .(1,3%)

89. m(AC)= m(BD)= m(CE)=…=120^0 .(0,4%)
90. O €[FC] .(0,4%)
91. There are 15 lines in the figure. (0,4%)
92. A circle is drawn by turning 360^0 around a point .(0,8%)
93. The diametric diagonals are divided into two parts at O point. (2,1%)
94. The diametric diagonals divide hexagon/circle to equal sectors.(8,2%)
95. The diameter cuts hexagon into symmetrical sectors.(0,8%)
96. The angle O consists of six equal parts of pieces ı 60^0(4,4%)
97. AOF and DOC triangles are symmetric to the center. (1,3%)
98. Circle is divided into sections at O point. (2,6%)
99. The diametric diagonals divide the circle and hexagon into 6 equal sections. (19%)
100. A(AOB)= The area of hexagon / 6 .(0,8%)
101. IADI / IABI = IBEI / IEDI .(0,8%)
102. [AD], [FC], [BE] lines chords. (1,3%)
103. m(BED) = m(AFO)= … = 60^0 .(1,7%)
104. As triangle are equilateral, the inner angles are 60^0 (3,9%)
105. The triangles made in hexagon is isosceles .(1,3%)
106. The bottom angles of isosceles trapezoid are 60^0 .(0,4%)
107. The top angles of isosceles trapezoid are 120^0 .(0,4%)
108. Each of central angles of a circle looks equal sections. (0,4%)
109. Area of circle – Area of hexagon = $\prod r^2$- [(6$r^2\sqrt{3}$)/4] .(0,4%)
110. One Third of hexagon is equilateral quadrangle (0,4%)
111. The sides of parallelograms are equal .(0,4%)
112. The diagonals of parallelogram are equal to perimeter of circle. (0,4%)
113. Two half circles are unified. (1,7%)
114. Intersectional diagonals are longest chords. .(0,8%)
115. BAO and ODE angles are equal. (0,8%)
116. Half of the circle is divided into three equal sections. (0,4%)
117. Diagonals of equilateral quadrangles are perimeters. (0,4%)
118. A parallelogram consists of two triangles. (0,4%)
119. m(ABC) = m(BCD)= … = m(FAB) .(0,4%)
120. F, O, C points are linear (0,4%)
    A, O, F points are linear.
    B, O, E points are linear
121. The sides of hexagon divided circular arc to equal pieces. (0,4%)
122. Diametric diagonals are twice as long as perimeter of circle. (2,1%)