DATA HANDLING AND STATISTICS IN EXTERNAL ASSESSMENTS

Mojca Suban Ambrož, Sonja Rajh and Jerneja Bone
The National Education Institute, Slovenia
mojca.suban@zrss.si

The paper presents a selection of data handling and statistics tasks at elementary and secondary level of education. These tasks were used on the national external examinations in mathematics in elementary school, high school and vocational schools in the years 2007, 2008 and 2009. In most cases we give the goals to the task of examining, classification of tasks in the appropriate taxonomic level (Gagne's taxonomic classification), the index of difficulty and discrimination index. In addition, we present findings of a qualitative analysis of the students' work in the example of two examination tasks. The analysis studies students' task-solving strategies, peculiarities in completing the tasks as well as typical and repeated errors students have made. The paper concludes with some findings regarding the representation of data handling and statistics on the external examinations, the students' performance and a list of terminology used.

In Slovenia students' math knowledge is tested at the external national tests; the elementary school students are tested at the national level exams, the high school students are assessed at the general matura-exams, while the vocational school students are assessed at the specialized vocational matura-exam level.

THE NATIONAL KNOWLEDGE EXAMINATION AND DATA HANDLING

In the elementary school, the math knowledge is tested at the end of the sixth class (second period) and at the end of the ninth class (third period), which means that such testing encompasses students aged from twelve to fifteen years. When creating the tests, the subjects expert panels give special attention to the representation of individual contents and to the taxonomic levels. The portion of contents on data handling is about 15 % at the end of the sixth and at the end of the ninth class testing. Gagne's taxonomic classification was used in this paper: I. knowledge and terms and facts understanding, II. routine procedures performance, III. the complex procedures usage, IV. problem solving and research.

Data handling exercises at the end of the second period

There were three exercises from the data handling included in the examination in the period from 2007 to 2009. The first exercise is presented in whole (Ric, 2009).

The sixth class students wrote out the heights above the sea level of certain places in Slovenia from Veliki družinski atlas-The Big Family Atlas.

Place	Height above the sea level	Place	Height above the sea level
Celje	244 m	Novo mesto	220 m
Črnomelj	196m	Portorož	92 m
Ilirska Bistrica	414 m	Postojna	533 m
Javorje nad Poljanami	695 m	Rateče	864 m
Kočevje	461 m	Rogaška Slatina	235 m
Lendava	195 m	Stari Vrh	1210 m
Lesce	515 m	Šmartno pri Sl. Gradcu	452 m
Ljubljana	299 m	Tolmin	180 m
Maribor	275 m	Velenje	420 m
Murska Sobota	184 m	Vojsko	1070 m

a) Fill in the spreadsheet with the number of places for an individual class regarding the height above the sea level.

Class	Height above the sea level in metres	The number of places
1.	0 - 249	
2.	250 - 499	
3.	500 - 749	
4.	750 - 999	
5.	1000 - 1249	

Answer the questions:

a) To which class does Novo mesto belong regarding the height above the sea level?
b) Which places belong to the 5th class?
c) Write down the heights above the sea level of places, belonging to the 3rd class.
d) Find out the greatest difference in heights above the sea level between two places.

In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8, July, 2010), Ljubljana, Slovenia*. Voorburg, The Netherlands: International Statistical Institute. www.stat.auckland.ac.nz/~iase/publications.php [© 2010 ISI/IASE]

The goal was to find out, whether the students were able to make out the spreadsheet data, to classify them into the correct rank, and to represent all data in a given spreadsheet, to read the appropriate data from the spreadsheet and to seek out the data regarding a given relation. The exercise was classified into the first and into the third taxonomic level. The difficulty index was 0,82 while the discrimination index was 0,46. At the close scrutiny of students' tests, a special emphasis was given to the strategies used in counting of places at a specific height above the sea level. Thus in one third of cases in the sample, the students helped themselves by using a variety of different signs, e.g. lines, various symbols, numbers. When counting, one fifth of the students in the sample used the same sign for each place counted, e.g. a tick, cross, a small dot. In this way they were able to check, whether they had taken all place names into account. In cases of certain spreadsheets, it is possible to notice the sum of all the frequencies inscribed or just the sum itself - 20, meaning, that the students checked, whether they had captured all the places in the spreadsheet.

The goals that the second exercise followed were as follows: to use the data from the bar chart and to calculate with them, to compare the bar chart data, to logically deduce, to find out the logical redistributions and to describe a redistribution. This exercise type was classified into the first and into the third taxonomic level. The difficulty index was 0,79 while the discrimination index was 0,49. The goal of the third exercise was to see, whether the students could solve the practical, from the everyday life taken type of exercise by using the data handling knowledge: to read the data on the circular diagram, to calculate the portions, to show the data in the spreadsheet, to select the appropriate problem-solving strategy, to calculate the whole and to write the required answer. This exercise type was classified into the third and into the fourth taxonomic level. The difficulty index was 0,80 and the discrimination index was 0,49.

Data handling exercises at the end of the third period

There were three exercises from the data handling included in the examination in the period from 2007 to 2009. The goals of the first exercise were to see, whether a student was able to read the data in the bar chart, to connect and analyse the data, to correctly write them down and show them in a given circular diagram and to assume a critical attitude towards the data gathered. The exercise was put into the first, second and fourth taxonomic level. The difficulty level was 0,29 while the discrimination index was 0,51. The second exercise checked, whether the students understood and, furthermore, were able to read the data on the pie chart, whether they were able to manifest parts of the whole in a fraction and whether they were able to use the percentage calculus in a text exercise. The exercise encompassed all four Gagne's taxonomic levels. The difficulty index was 0,78 while the discrimination index was 0,40. In the third exercise the students showed, whether they were able to read and analyse the scattered diagram, to define all possible solutions and solutions with a given additional condition as well. The difficulty index was 0,69 while the discrimination index was 0,36.

GENERAL MATURA EXAM

After the successful completion of the 4-year high school education, the students are required to take the general matura exam. Only one exercise from data handling and statistics was included in the exams and is represented in full (Ric, 2009).

The ski jumper Marko made four jumps during the training sessions, achieving the following distances: 94 m, 100 m, 94 m, 96 m. Calculate his ski jumps average length. How many meters should he have jumped in his fifth training attempt to increase his average to 98 m?

This exercise checked, whether the students were able to calculate the arithmetic mean to the given data and to find out the missing information for a given arithmetic mean. The results, achieved on a basic level, were 4,66 points on average out of total five. The difficulty index was 0,93 while the discrimination index was 0,22. The results for the students on a higher level were 4,92 points on average. The difficulty level was 0,98.

VOCATIONAL MATURA EXAM

Students at the secondary vocational and vocational-technical school programs at the end of their education take the vocational matura exam in four subjects. The data handling contents are often represented in examination papers; in the following, the exercise examples are shown, as well as the success data rates.

The first exercise checked, whether the students were able to understand and read the data from a structured circle, to calculate the portions in separate categories, to calculate the average value of the given data and to calculate the angles, belonging to a given category. The exercise could be classified in the second taxonomic level. The exercise belonged among those from the second part (structured exercises), where a candidate is faced with multiple options to choose from. Out of a 354 candidates sample, this exercise was selected by 326 candidates, representing 92 %. The difficulty index was 0,72. Two thirds of candidates had used cross-shaped calculus in order to calculate the absolute frequencies. It is obvious that this method is present and regularly used during maths classes at these schools. A markedly lower number of candidates had used the percentage calculus or proportionality.

In the second exercise, the chart showed the number of baskets, having been scored by the leading scorer at a basketball tournament at six games. The candidates had to calculate the average number of baskets, having been scored by the leading scorer at these six games. The exercise goals were to read the data from a given graphic representation and to calculate the arithmetic mean of the data read. The exercise could be classified into the second taxonomic level. 471 out of 594 candidates successfully solved the exercise in full. It had the difficulty index 0,84 which was the highest in this examination paper, while the discrimination index was 0,31. As the mistakes are concerned, a certain number of erroneously read data was observed, but the main reason was in the arithmetic mean term misunderstanding, illustrated by the next example: a candidate multiplied the number of baskets, having been scored at the first game, with the number one, … , the number of baskets, having been scored at the sixth game, with the number six. The multiplication sum was then divided with the sum of all the baskets scored.

The third exercise is presented in whole (Ric, 2008).

The spreadsheet with the temperatures measured at 13:00 for every day of the week.

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
T[°]	20	20	18	19	22	22	24

Calculate the average temperature for this week. Round off the result precisely to one decimal place.

With this exercise, we wanted to check, whether the students were able to read the spreadsheet data, to calculate their arithmetic mean and to make an appropriate average result. This exercise could be classified into the second taxonomic level. On the basis of a 179 candidates sample, it was concluded, that the exercise had been correctly solved by 126 candidates, the difficulty index was 0,84 and was the highest on this exam paper, while the discrimination index was 0,37. It is interesting that some of the candidates tried to use the time-13 in their calculations, as they thought that they should use all the given numbers in the exercise.

In the fifth exercise the picture showed the oil barrel prices around the world. Students had to read the prices and put them in the spreadsheet, calculate the average price of oil ranging from the 12th January to the 19th of January and to do some more calculations not connected with data handling. With this exercise, we wanted to check, whether the students were able to read the data from a given graphic representation and to calculate their arithmetic mean. This goal checked the knowledge on the second taxonomic level. Other goals were connected with the contents, surmounting the data handling. There is no information on the solution success.

The sixth exercise is presented in whole (Ric, 2007).

At the 100 meters sprint class competition the following results were achieved (in seconds): 12, 12, 13, 13, 13, 13, 14, 14, 14, 14, 14, 14, 15, 15, 16, 16, 16, 16, 16, and 16. Calculate the average result. Calculate the percentage of competitors, having achieved a better result than the average.

The exercise wanted to check, whether the students were able to, from the data collected and assorted by value, calculate the arithmetic mean and to correctly use the percentage calculus. This goal checked the knowledge on the second taxonomic level. This exercise had been correctly solved in full (five points) by 9,5 % candidates and 60,4 % candidates achieved three or four points. The difficulty index was 0,69 and was the highest among all exercises in this examination paper. The discrimination index was 0,49.

CONCLUSION

The contents representation in the external examinations in '07, '08 , '09

The data handling exercises in the national external examination in elementary schools are represented according to the agreed shares. At the general matura exam, the statistics exercises are very rare, as the mentioned contents were represented in one exercise only. At the vocational matura exam, the statistics exercise was present in five cases in the examination papers checked in seven examination periods.

The Solution Success

The difficulty indexes regarding the data handling at the national knowledge examination show that these exercise types were either among the exercises with the best or with the worst results achieved. The reasons can be found in the fact that besides the goals regarding the data handling, other contents goals, e.g. numbers, were also checked.

The only statistics exercise at the general matura exam was solved with a very high degree of success on the basic and on the higher level.

At the vocational matura exam, the information concerning the difficulty index for all exercises in the examination papers is available for three out of five cases. It is our finding that in all cases, the statistics exercises were the exercises solved the most successfully among all, which can probably be attributed to the fact, that this subject is dealt with in the last class, making it relatively very close to the candidates. Another thing must also be added, namely, the exercises were classified on the second taxonomic level, where only the simple routine knowledge is checked - so called type-like exercises, which the candidates become familiar with during the vocational matura preparations. We should reconsider the use of exercises at a higher taxonomic level in the class and at the matura exam as well.

Terminology

The terminology usage problems must also be mentioned. We expose various terminology of the data graph circle display: the pie chart in the math curriculum in the elementary school and high school, the circular diagram in the aforementioned exercise at the national examinations, the circular diagram in the knowledge catalogues in the secondary vocational and vocational-technical programmes, the frequency cake or the structured circle at the vocational matura. We should reconsider the terminology unification for the whole school math curriculum.

REFERENCES

DPK SM (2009). Interno gradivo./Internal material.

Letna poročila o izvedbi nacionalnega preverjanja znanja v šolskih letih 2006/2007, 2007/2008, 2008/2009/Annual reports on implementation of the national knowledge examination in the school years 2006/2007, 2007/2008, 2008/2009. Državni izpitni center. Ljubljana. Accessed, 17. 3. 2010, http://www.ric.si/.

Nacionalno preverjanje znanja. Matematika. Preizkusi znanja./ The national knowledge examination. Mathematical tests. Accessed, 17. 3. 2010, http://www.ric.si/.

Poklicna matura. Izpitna pola. Matematika./ Vocational matura. Examination papers. Accessed, 16. 3. 2010, http://www.ric.si/.

Pavlišič, J. (2009). *Poklicna matura-matematika, junij 2008*. Gradivo za študijska srečanja učiteljev matematike. Online.

Pavlišič, J. (2008). *Poklicna matura 2008-matematika, avgust 2008*. Gradivo za študijska srečanja učiteljev matematike. Online.

Pavlišič, J. (2008). *Poklicna matura 2007-matematika*. Gradivo za študijska srečanja učiteljev matematike. Online.

Splošna matura. Izpitna pola 1-osnovna raven. Matematika./ General matura. Examination papers. Accessed, 16. 3. 2010, http://www.ric.si/.