__The Development of Inductive Thinking of Pedagogue Candidates__

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The Barcelona Conference on Education 2023
Official Conference Proceedings

Abstract
The study of inductive, and in particular abstract reasoning has a very extensive literature. However, putting these competencies into the context of dropout research is less typical. The focus of this research is therefore directed to this area. The main objective was to analyse the components of abstract reasoning in terms of students who achieved good results, and the overall sample, and its relationship to time was also examined. Based on the results of the 204 students participating in teacher training at J. Selye University, it can be stated that the time spent on the solution, the division, the course, and the parents' highest education can be formed three well-separable groups in the whole sample, while among the best-performing students, two distinct groups can be classified.

Keywords: Inductive Reasoning, Dropout, Teacher Training, Specific Performance

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Introduction

Inductive thinking can be interpreted from two perspectives. There is one approach that considers the ability of inductive conclusive thinking among the elements of intelligence, along with elements such as (1) the ability to learn from experiences and apply them, (2) the ability to adapt to the expectations of a changing and uncertain world, (3) the ability to motivate oneself and perform challenging tasks effectively.

The other approach interprets inductive thinking as an important method of human cognition. Through it, we are able to extract the essence from complex, abstract things and recognize connections.

Inductive thinking plays an important role in drawing conclusions, making judgments, recognizing laws and legality, that is, in logical thinking, as well as in conceptualization.

Brain imaging studies have provided new evidence that adolescence is a period of continuous neural development (Blakemore, 2012) that may last longer than Piaget's (1972) theory suggests. This has been proven in the study of students' ability to solve simple algebraic equations. The results showed that younger students are less accurate and slower in solving equations with letters and symbols than with numbers. Küchemann (1981) reported that the majority of those under the age of 15 do not know algebraic letters (symbols) as unknown or generalized numbers, which would be expected from official operational thinkers. This difference disappeared in older students (16–17 years), indicating that they reached an abstract level of argumentation (Markovits et al., 2015). A similar conclusion was reached by analysing strategies, suggesting that younger learners mostly used specific strategies, such as inserting numbers, while older students generally followed more abstract, rule-based strategies. Kusmaryono, Suyitno, Dwijanto, and Dwidayati (2018) report that none of the 14-15-year-old students participating in their research on mathematical problem solving has reached the quality stage of inductive, and especially abstract, thinking. These results indicate that the development of algebraic thinking is a process that develops over a long period of time (Susac, 2014).

It is evident from the above that abstract thinking skills play an important role in learning mathematics and natural science subjects. Lawson (1985), however, recommends delaying the teaching of abstract concepts until brain maturation allows for the transition to the stage of formal functioning, especially since the development of students' abstract thinking skills is hampered by cognitive, didactic, psychological, and epistemological barriers (Komala, 2018).

Abstract Reasoning and Logical Thinking

Abstraction means separating essential and irrelevant characteristics, highlighting the essential and ignoring the irrelevant ones. Thus, abstraction, the highlighting of essential features among the recognized general features, in other words differentiation, can be interpreted as one of the thinking operations.

Among other things, man differs from other living beings in that he is able to interpret and know the world around him in a way that goes beyond sensation and perception. Among the more important abstractions, thing (matter), property and relationship should be highlighted. The most common thinking operations are aimed at transforming them into each other. Things have properties, and it is on the basis of these properties that a relationship can be established between things. The same relationship or the same property can occur in different things, and this forms the basis of analogical conclusion, thinking using analogies.

According to Adey Philip and Benő Csapó (2012), some forms of thinking can be characterized by property pairs. Except for one property pair, in the highest level of thinking, the two types appear complementary or depend on the given situation as to which can be applied more effectively. Such dichotomy can be observed in the following ways of thinking: quantitative-qualitative thinking, convergent-divergent thinking, holistic-analytic thinking, deductive-inductive thinking. The exception is concrete-abstract thinking, as the equivalence of the two members is not valid for this pair of concepts, as abstract thinking is more powerful than concrete.

Recently, it has been established (Lermer et al., 2014) that people's thinking style affects their risk-taking behaviour. Those who think abstractly have a higher propensity to take risks than those who think concretely. Later, it was also found (Lermer et al., 2016) that men are generally more willing to take risks than women. Other research findings seeking a link between the functioning of the brain and the thinking process have shown that abstraction is associated with activity in posterior regions associated with visual perception (Gilead, 2014) and concrete thinking is associated with activation in the prefrontal cortex (Giedd & Rapoport, 2010). Known, Lawson (2000) also found that some tests of prefrontal lobe activity are highly correlated with scientific reasoning ability and that of rejecting scientific misconceptions and accepting correct ideas.

Convergent thinking is applied to types of tasks that move towards a single good solution. It is characterized by the ability to draw logical conclusions, to abstract, and to recognize rules. During divergent thinking, creativity, ease and fluency of thinking, the possibility of raising as many ideas as possible, taking new aspects and methods into account, originality and sensing problems come to the forefront. Distinctive and multidirectional thinking is typical when solving tasks, which examines, takes into account and considers many options, but at the same time, the applied strategies play a significant role in problem solving.

According to Adey and Csapó (2012), the purpose of holistic thinking is to review the situation in its complexity and to form a conclusion based on the "whole picture" with details receiving less attention. In contrast, the analytical approach focuses on details and leads to solving the problem step by step.

While inductive thinking is one of the most important tools for acquiring new knowledge, deductive thinking leads to new ones from true knowledge as long as the rules of formal logic are followed. Inductive thinking is primarily needed when we want to use our observations and experiences in new (creative problem solving) or similar (analogous knowledge transfer) situations. In the former case, new knowledge always carries the possibility of uncertainty or error. While deductive thinking is characterized by performing operations and applying logical rules, inductive thinking is characterized by the trial-and-error method, the search for and recognition of rules. Bivalent logic cannot be equated with deductive thinking, but it is in any case of decisive importance in it.

Carroll (1993) refers to inductive and deductive thinking as the "sub-ability" of thinking ability. Sternberg (1986) draws a parallel between deductive and inductive thinking, and states that the difference is primarily in information processing procedures such as selective transcoding, selective comparison and selective combination. While the first two are considered dominant in inductive thinking, the third procedure is considered dominant in deductive thinking.

According to Klauer (1989), inductive thinking means finding regularities and irregularities by recognizing similarities, differences, as well as similarities and differences that appear together by comparing properties and relations. The ability to recognize and use relational similarities between two situations or events is made possible by the ability to think analogously, which is a type of thinking that is applied between specific examples or cases when we know something about one example and use it to infer new information about the other example. Table 1 lists the scope of operations that can be interpreted in terms of properties and relations, the two large areas of inductive processes, and this table also forms the basis of the tests used in the research.

	Properties	Relations
Similarity	Generalization	Recognizing connections
Difference	Differentiation	Differentiation of connections
Similarity and difference together	Classification	System creation

Table 1: Inductive operations

The Goals, Methods and Tools of the Research

The most important goal of the research was to identify the competencies that can be associated with dropout, on the one hand, and predict dropout, on the other hand, and that is also important for standing up in the world of work.

As we have seen before, abstract thinking is an important form of human cognition. Through it, we are able to extract the essence from complex, abstract things and recognize connections. And this is essential for understanding. Abstract thinking plays an important role in drawing conclusions, making judgments, recognizing laws and legality, that is, in logical thinking, as well as in conceptualization. It is evident from the above that abstract thinking competence plays an important role in learning mathematics and natural science subjects. Since, unfortunately, these subjects are at the forefront of dropouts, we have focused our research on abstract thinking skills.

The question arises how to reliably measure the development of students' inductive, and especially abstract, thinking without specific subject knowledge (e.g. mathematics, physics). There are several available methods for this, from certain intelligence tests to inductive thinking tests to special measuring tools that focus on the given competence component.

In our research, we used the abstract thinking test, one of the measuring tools developed Psychometric Success WikiJob Ltd. (London, United Kingdom), which takes into account the labour market's expectations (Newton & Bristoll, wy). When compiling the test, they based their measurement on single and multi-factor intelligence theories.

Eductive skills refer to logical operations based on inference, through which new knowledge is created from the perceived information by recognizing and understanding the relationships and taking into account the contextual content. Understanding the problem as a whole requires a holistic competence, while solving it requires the ability to recognize the relationships and connections between the parts. Interpreting the problem is more than a comprehensive pattern recognition (Gestalt), it is also necessary to emphasize what is essential and ignore anything that is irrelevant. These are mostly non-verbalizable, so geometric shapes (squares, polygons, circles, etc.) are mostly the measuring tools. The perception of these geometric shapes, the recognition of their characteristic features, and the understanding of the relations between them depends on the existing knowledge on the one hand and certain cultural influences on the other. However, one of the main advantages of the test is that it can be considered culture-independent to some extent.

Based on Raven's eductive ability test, Paul Newton and Helen Bristoll developed an abstract thinking test that takes more into account the aspects of the labour market (Newton & Bristoll, wy). The difficulty of recognizing the logical connections behind the patterns in the tasks is the problem for the test subject to solve. The problems arise from the difficulty of recognizing the change or even repetition of the following characteristics: (1) shape, (2) size, (3) colour, (4) pattern.

The tasks consist of visual patterns that need to be continued by the subject after recognizing the logical connections behind them.

In the research, we used an online test that measured the development of the three components of inductive thinking: abstract, analogical and diagrammatic conclusive thinking. The task examining analogical thinking consisted of 6 items, while the other two of 12 items. Thus, the test consisted of the following types of tasks:

- Examination of abstract thinking: (1) continuation of a one-dimensional series (6 items); (2) recognition of an item that does not fit into a one-dimensional series ("odd one out") (6 items);
- Examination of analogical thinking (6 items);
- Diagrammatic thinking: (1) recognition of regularities – unknown action (6 items); recognition of regularities – known actions (6 items).

Participants in the Research

Approximately 400,000 of the citizens of Slovakia (8% of the total population) belong to the Hungarian ethnic minority. The only Hungarian-language university in the country is János Selye University. A total of 204 first-year pedagogue candidates from the University participated in the research. Below is a summary of the participants' demographic data:

- Distribution by gender: 17.6% (N=36) male, 82.4% (N=168) female;
- Age: M=25.10 years, MOD: 20 years, SD= 8.267 years, 76 people (37.2%) between the ages of 19 and 20, while 49 people (24.0%) between the ages of 21 and 22;
- The highest level of education of the father: primary school 9 people (4.4%), vocational training school 85 people (41.7%), vocational secondary school 72 people (35.3%), high school 18 people (8.8%), higher education 20 people (9.8%);
- The highest level of education of the mother: primary school 17 people (8.3%), vocational training school 47 people (23.0%), vocational secondary school 85 people (41.7%), high school 24 people (11.8%), higher education 31 people (18.2%);
- Residence: city 92 people (45.1%), municipality 112 (54.9%);
- Country of graduation: Slovakia 120 people (58.8%), Hungary 83 people (40.7%);
- Type of secondary school where they passed the graduation exam: 70 people in 4-grade high school (34.3%), 9 people in 8-grade high school (4.4%), 113 people in vocational high school (55.4%) and 12 people in adult education (5.9%);

- The language of education in the secondary school: Hungarian 182 people (89.2%), Slovak 12 people (5.9%), bilingual 10 people (4.9%);
- Training programme: 57 people (27.9%) applied for teacher training, 127 people (62.3%) for kindergarten training, 19 people (9.3%) for pedagogy and public education;
- Type of programme: 145 people full time (71.1%), 59 people correspondence programme (28.9%);
- Residence during the studies: 127 people (62.3%) commute from home, 71 people (34.8%) in dormitories, 6 people (2.9%) in rented apartments;
- Family circumstances: 160 people (78.4%) live with their families, 31 people (15.2%) with their partners and spouses, 7 people (3.4%) live alone, 6 people (2.9%) with their friends.

Based on the above, it can be stated that the majority of the participants in the training programme passed the graduation exam in Hungarian at a vocational secondary school, and the proportion of those who applied to the full-time kindergarten teacher program is high. Among the students, the proportion of graduates from Hungary is high. As for the qualifications of the parents, the proportion of those who graduated from vocational training is high.

Results

First, we compare the results of the students in relation to the tasks. There were 179 students who solved all five types of tasks. As shown in Figure 1, results were well below average. In particular, the students' diagrammatic thinking proved to be undeveloped. The best results were achieved in tasks that required analogical thinking, but the standard deviation was also the greatest here.

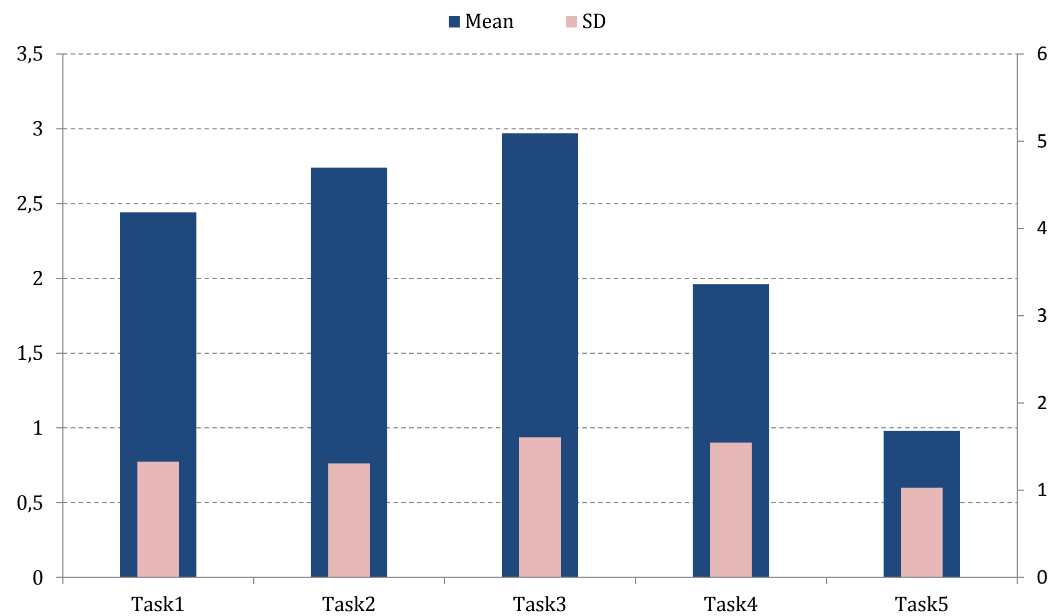


Figure 1: Averages and standard deviations of abstract thinking by task (Own figure)

According to Kolmogorov and Smirnov, the components of abstract thinking are not normally distributed, but due to the permissive conditions (the Kurtosis/Std error of Kurtosis and the Skewness/Std. error of Skewness are less than 2.58) (Rumelhart, 1989), we still accept the first three variables as such.

During the test, the students had 25 minutes to solve the tasks, which in some cases proved to be insufficient. Items could only be solved one after the other. The online system was able to record the time students spent on each item. Analysing these data, two findings can be made.

- Figure 2 shows the average time spent per item, in relation to the students who started to solve the given task item. For task types 4 and 5, it can be clearly seen that the average amount of time spent on the first task is very high compared to the other items. In other words, understanding these two types and recognizing the relationships proved difficult. The high standard deviation value of the tasks also supports this hypothesis.
- We formed 3 categories per task type (low performer: 0-2 points, medium performer: 3-4 points, good performer: 5-6 points). In Figure 3, it can be clearly seen that the rate of those who achieved a low score increases in Task 4.

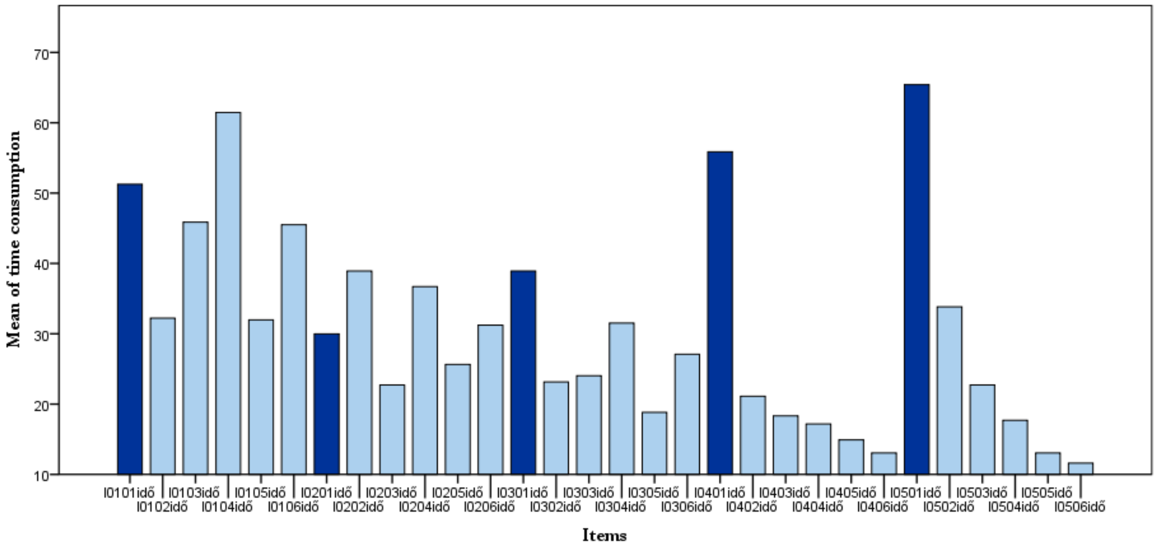


Figure 2: Time spent per item (Own figure)

Now let's focus our attention on those students who achieved a higher total score compared to the group as a whole, that is, they have more advanced abstract, inductive thinking. We found 27 such students. The scores (filled columns) and time spent (empty columns) of these students are given in Figure 4, in order from left to right according to the time spent. For the first six students, it can be clearly seen that even with a relatively low amount of time spent higher scores were obtained. These students reached a value between 16-20 in less than 16 minutes (superficial, but quick-minded). The next category also consists of six students who achieved a similar performance in less than 21 minutes (prudent, smart). The other students almost maximized the available time (24-25 minutes) and achieved a good result (slow, smart).

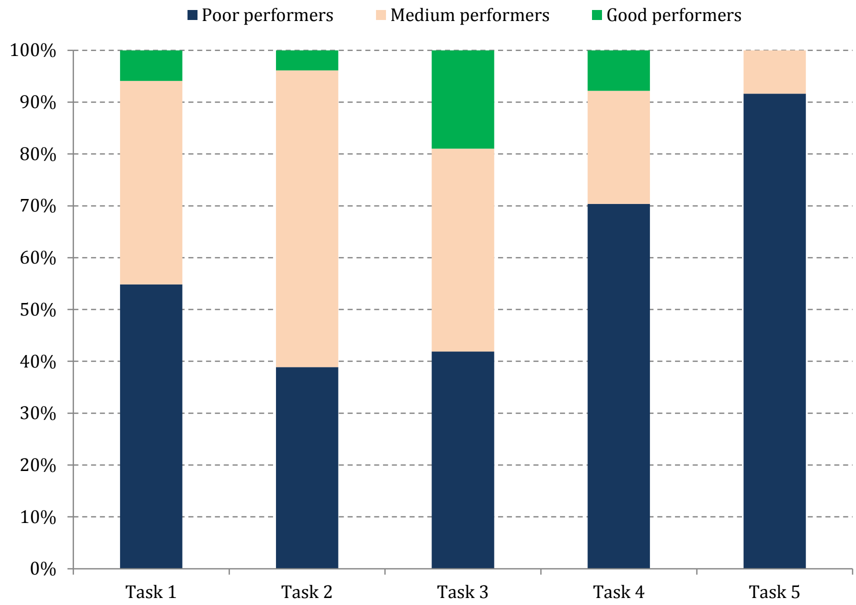
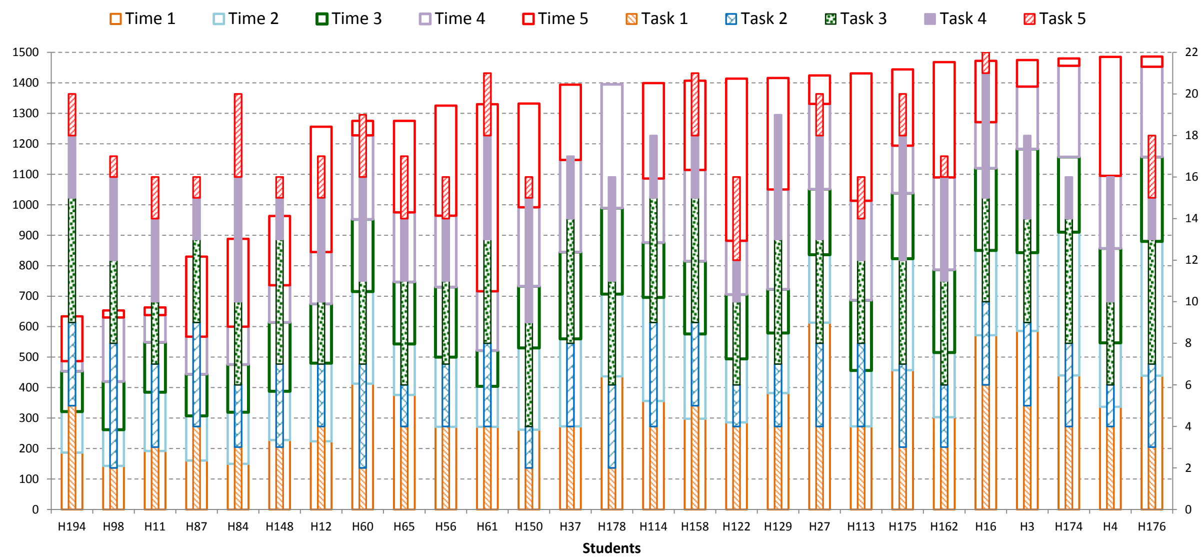


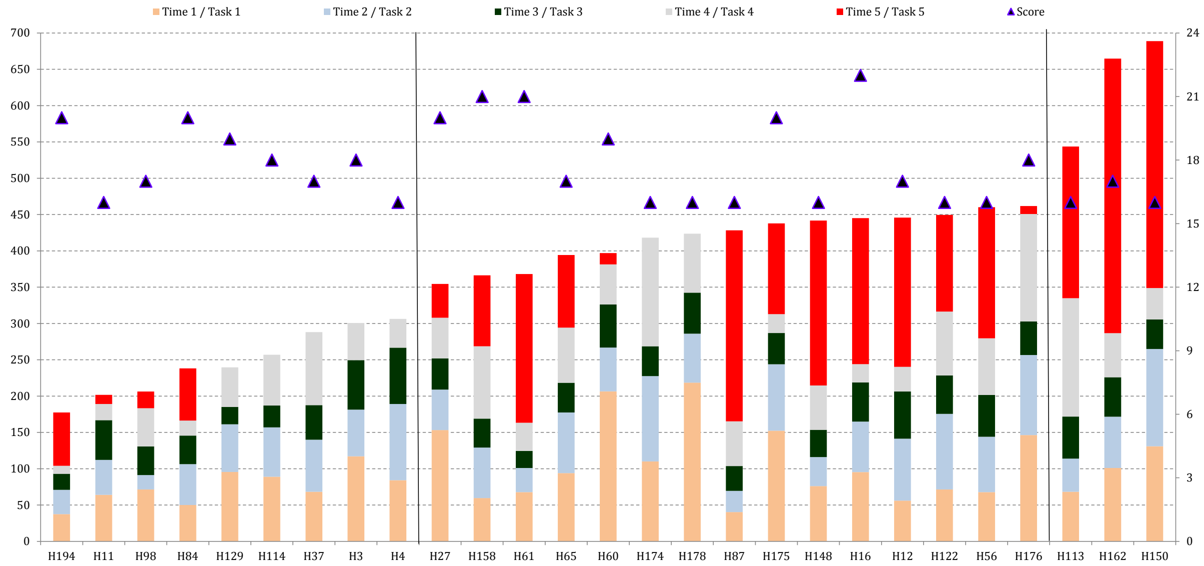
Figure 3: Averages and standard deviations of abstract thinking by task



Note: The left vertical axis indicates the time, and the one on the right the score.

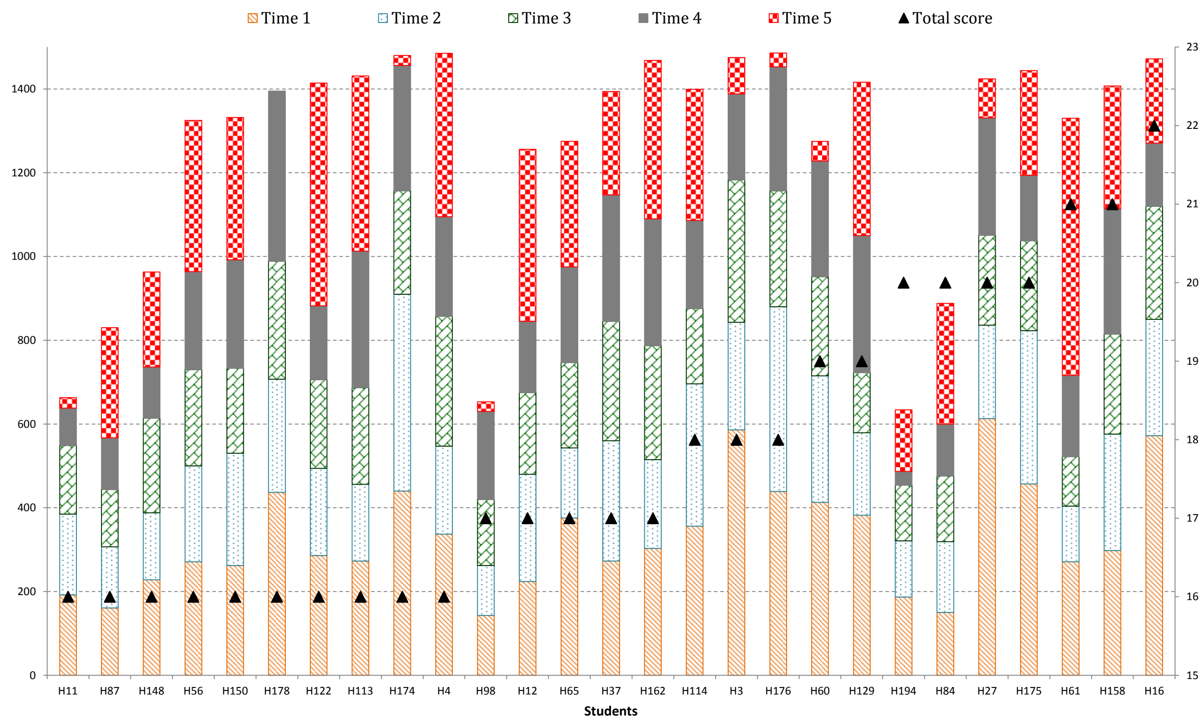
Figure 4: Scores of the 27 best-performing students and their time spent on the solution

In order to demonstrate effectiveness, the concept of specific performance has been introduced. *In the inductive test, the specific performance can be interpreted as the time required to reach the unit score,* which is defined as the ratio of the time spent and the score achieved, per task: $time_x/score_x$, where $time_x$ indicates the time spent on the solution of task x (6 items) in seconds, while $score_x$ indicates the score achieved during this time. We also ranked the students who achieved the highest scores this way (Figure 5). Here, the value of 300 sec/point was considered high specific performance, that is, students achieved a higher score with little time. The values of 300 and 450 sec/point are called medium specific performance, while above this is the low specific performance, that is, a lot of time was required to achieve a unit score.



Note: The left vertical axis indicates the time, and the one on the right the score.

Figure 5: Specific performance of the 27 students



Note: The left vertical axis indicates the time, and the one on the right the score.

Figure 6: Time spent and total score of the 27 students

It can also be clearly seen from Figure 5 that, almost without exception (H60, H174, H178, H176), the last task requiring diagrammatic thinking ruined specific performance.

We ranked the students based on the total score warned on the five task types (Figure 6). It can be clearly seen that the students generally used the available time, but there were one or two students in each score category who achieved a similar result with little time. For example, student H11 or H87 for the-16 point category, H98 for the 17-point, and H194 or H84 for the 20-point category.

In any case, it can be stated that the full use of the available time does not automatically result in a high score, but it can also be observed that all of the students who have achieved more than 20 points have almost fully used the 25 minutes available for the test.

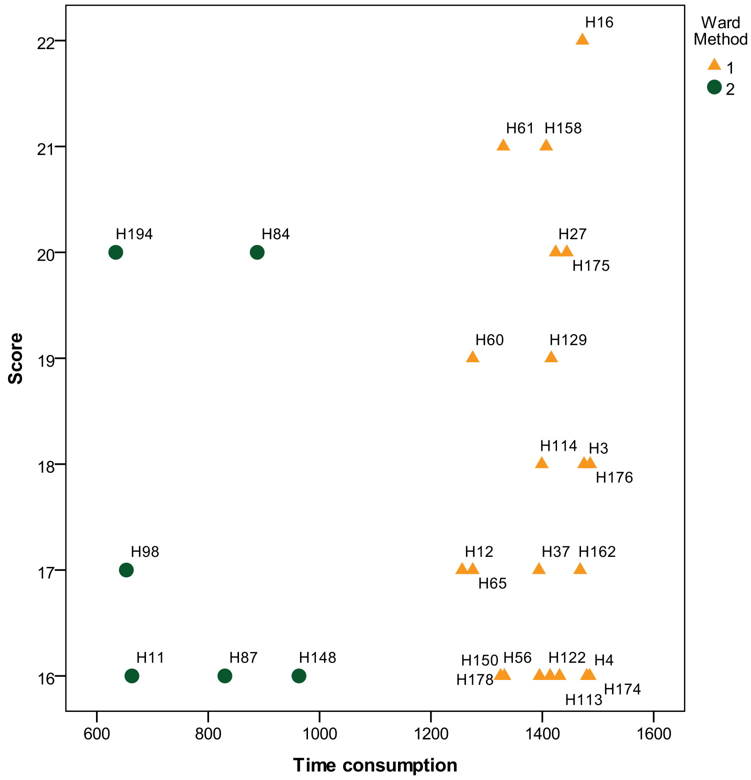


Figure 7: Time spent and total score of the top 27 students separated into 2 clusters

The results of the 27 students who performed well on the test were also examined using cluster analysis (Figure 7). The first group, marked with triangles, consists of the prudent who took advantage of all the available time, while the second group consists of those who are impatient and superficial. Clusters were analysed based on cluster centroids (Table 2). The means were subjected to variance analysis. Not in terms of the scores obtained, but in terms of time expenditure, a significant difference was found between the individual cluster centroids ($F= 222.902$; $p<0.05$). The time spent explains 89.9% of the standard deviation. The reliability of the hierarchical cluster analysis was checked by the K-means procedure, but no significant difference was found between the results obtained.

K		Score on the test	Time spent on task solving
1	M	17.90	1399.19
	N	21	21
	SD	1.947	73.352
2	M	17.50	771.83
	N	6	6
	SD	1.975	140.276
Total	M	17.81	1259.78
	N	27	27
	SD	1.922	280.295

Table 2: Cluster centroids and standard deviations

Regarding the background variables of the 27 students with good results, the following findings can be made:

- their parents are graduates, especially the proportion of graduate mothers is significant compared to the participants in the research,
- the majority of them are kindergarten teachers, who
- graduated from Hungarian-language secondary schools,
- in the correspondence programme.

We separately studied the background variables of the 7 students who achieved the best results (≥20 points). They had a slightly modified (italicized) pattern to the background variables:

- their parents are graduates, especially the proportion of graduate mothers is significant compared to the participants in the research,
- the majority of them pursue their *teaching degree,*
- they graduated from Hungarian-language secondary schools,
- in the *full-time programme*.
- *These students live in the city and*
- *they have work experience, most of them as educators, despite the fact that five out of the seven people are full-time students.*

Regarding the time spent on task solving, two groups can be formed (Figure 7): superficial, but quick-minded (≤1000 sec), prudently thorough (>1000 sec).

As for the superficial but quick-minded (6 people), the pattern features are as follows:

- their parents are not graduates,
- they live in municipalities,
- they studied in Hungarian-language secondary schools,
- they study in the full-time programme,
- pursuing a teaching degree.

Regarding the superficial but quick-minded, it should be noted that in the case of students H84 and H194, rather the latter adjective should be used because the little time spent is paired with a high score (Figure 8).

As for the prudent ones (21 people):

- the majority of parents are graduates, but the proportion of mothers without a high school diploma is high, while the proportion of fathers with a high school diploma is also high,
- they live in the city,
- significantly more of them study in the correspondence programme,
- they pursue a kindergarten teaching degree.

It is also possible to distinguish well among prudent students a group that achieved a good result during the significant time spent (Figure 8, upper right corner) and one that was lower, but the cluster analysis did not confirm this.

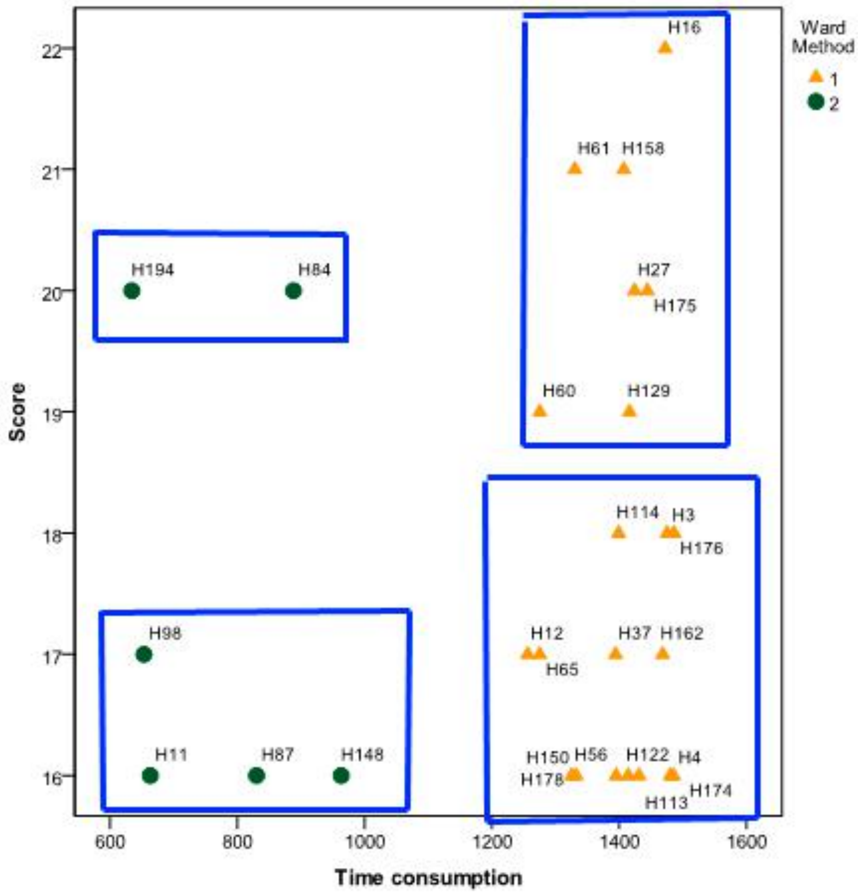


Figure 8: Time spent and total score of 27 students divided into 4 groups

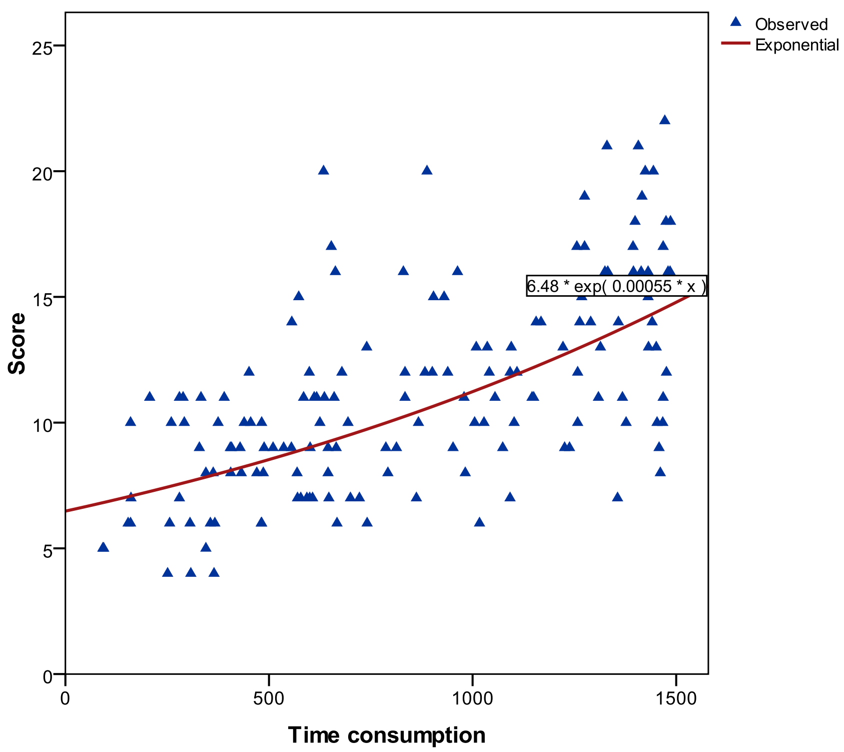


Figure 9: Relationship between the time spent on the whole sample and the total score

The relationship between the time spent and the score obtained was also examined for the whole sample (Figure 9). An exponential function describes the relationship in an acceptable way:

$$Score = 6.48 * \exp(0.00055 * Time\ spent)$$

The model explains 39.9% of all variance. The ANOVA study indicates a significant regression relationship ($F=100.318$; $p<0.05$).

Finally, we performed the cluster analysis on the whole sample. We reached similar conclusions as those of the best-performing students, that is, clusters can be formed on the basis of the time spent on problem-solving. In this case, three groups can be formed (Figure 10):

- the careless, superficial,
- the prudent, but not persistent enough,
- the persistent, the diligent.

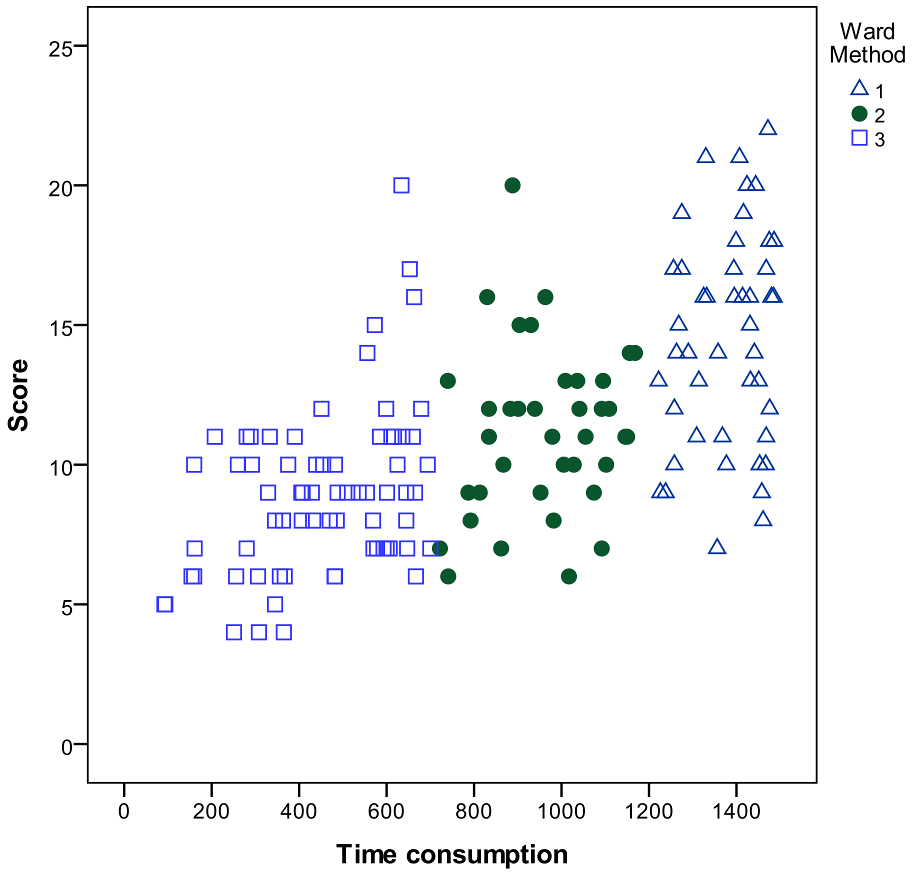


Figure 10: Clusters formed for the whole sample

There are also students with low and high scores in all three groups, but the trend is still what the regression study describes.

Reliability was checked by the K-means procedure here as well and found to be correct. The data for cluster centroids are summarized in Table 3.

K		Score on the test	Time spent on task solving
1	M	1378.36	14.51
	N	45	45
	SD	84.658	3.841
2	M	961.000	11.21
	N	38	38
	SD	128.830	3.024
3	M	455.79	8.93
	N	70	70
	SD	166.251	2.994
Total	M	852.61	11.14
	N	153	153
	SD	419.463	4.023

Table 3: Cluster centroids and standard deviations

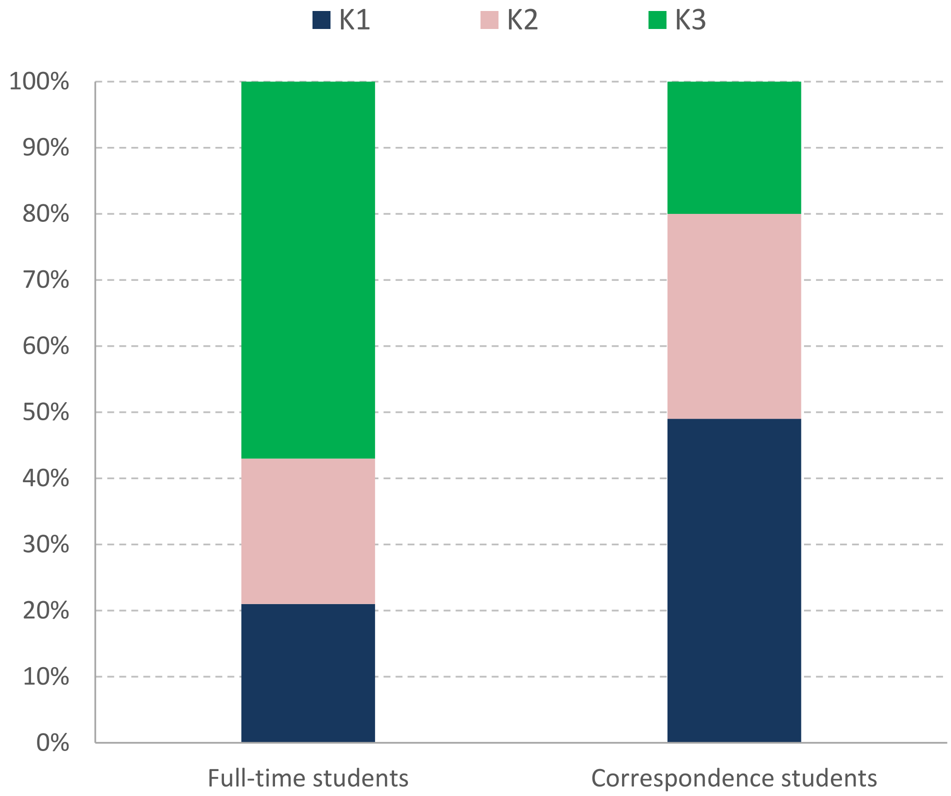


Figure 11: Belonging to clusters by programme type

We examined the composition of the clusters according to the background variables for the whole sample. A higher proportion of full-time students belong to the K3 cluster, while those in the correspondence programme belong to the K1 cluster (Figure 11). The majority of teaching majors are K3, pedagogy and public education majors are K2, while kindergarten teachers are mostly belong to K1 and K3 (Figure 12). Using the Chi-square test, we proved that there is a significant relationship between the programme type and cluster membership ($F= 18.473$; $p<0.05$), and between the major cluster membership ($F= 15.138$; $p<0.05$). Summarizing these, the interpretation of the clusters is shown in Table 4.

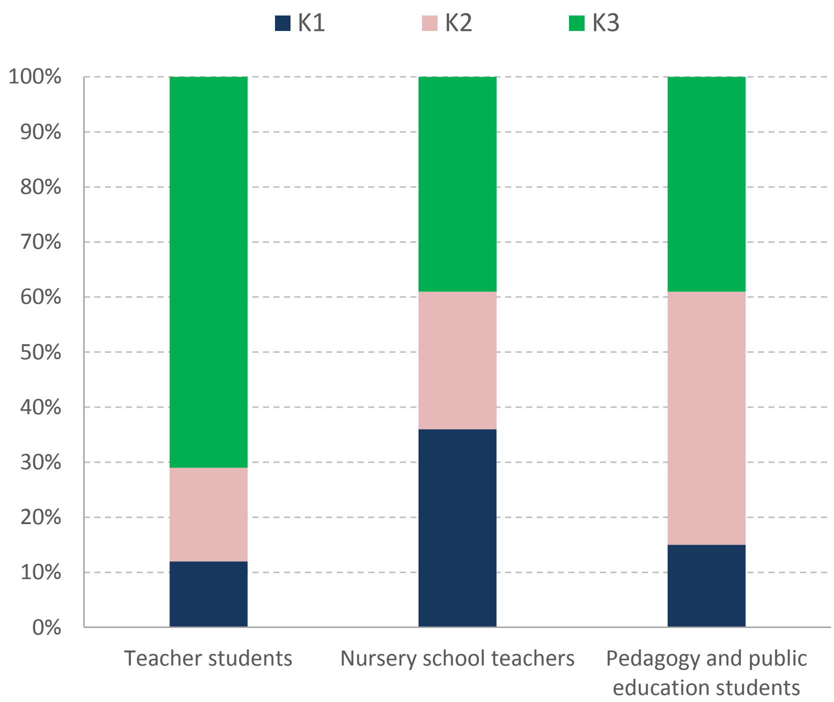


Figure 12: Cluster membership by major

	K1	K2	K3
Time spent on task solving	less	medium	more
Score	5-20 points	6-20 points	7-22 points
Programme type	correspondence	full-time and correspondence	full-time
Major	kindergarten pedagogy	pedagogy and public education	teaching, kindergarten pedagogy

Table 4: Interpretation of clusters

Conclusion

Our research goal was to analyse the components of inductive thinking, and especially abstract thinking in terms of students with good results and for the whole sample, and we also examined its relationship with time expenditure. In addition to descriptive statistics, cross-tabulation and cluster analysis, we used regression analysis to establish correlations. Summarizing the results, the following findings can be made:

- The students achieved the best result in the task of finding analogical and “odd one out” sequence elements, with the lowest average time expenditure, that is, they have more advanced analogical thinking and rule induction skills. At the same time, their diagrammatic thinking is less developed, which is not a particular problem in teacher training, compared to engineering, for example.

- We introduced the notion of specific performance, which was interpreted as the time required to reach the unit score on the inductive test. Using this concept, we found that the best-performing students are teaching majors, full-time students, city residents, and their parents are graduates.

- One of the prerequisites for a good result on the inductive test is to fully use the available time. However, it should be noted that high time expenditure does not automatically result in a high score, and also that some students achieved good results in less time.

- Regarding the entire sample and considering the task-solving time, three groups (the careless and superficial; the prudent but not persistent enough; the persistent and diligent) can be formed, while two groups (superficial and not persistent enough; persistent and diligent) can be formed among those who achieved good results.

- Knowing the student's programme type and major help to interpret the clusters.

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