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THE EFFECTIVENESS OF PEER TUTORING IN THE FIELD OF TEACHING BASIC ASTRONOMICAL CONCEPTS AMONG OLDER PRESCHOOLERS AND YOUNGER PUPILS. A QUANTITATIVE ANALYSIS

Peer tutoring constitutes an attractive form of teaching (Budzyński, 2009). Its basic premise is pairing children so that one of them takes the role of a teacher and the other – a student. In a dyad, the child who knows more shares his or her knowledge with the child who knows less (Foot et al., 1990). The effectiveness of the peer tutoring method depends on a number of variables. These are: the teacher-child's level of knowledge, the particular nature of the discussed content, the relationship between the children in the pair (Brzezińska, Appelt, 2013) and an appropriate level of their social maturity. It has been established that the children who know more will be able to pass their knowledge to the children who have not had the opportunity to acquire knowledge to such an extensive level yet. The effectiveness of peer tutoring is already effective among older preschoolers and younger school pupils (Gruszczyk-Kolczyńska, 2011).

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During tutoring meetings the beliefs are confronted. A student-child, listening to a teacher-child and looking at his or her works can ask questions and present arguments supporting their own beliefs. Whether the teacher-child manages to instill his or her beliefs in the student-child (it will be referred to as the effectiveness of the tutoring method in the paper) will depend on the knowledge resources, the level of their internal relations (structuring), their social skills and how easily they can transmit their knowledge. The process of encouraging someone to accept your convictions usually involves the following steps:

- attempting to understand the other person's point of view;
- confronting the explanation with their internal conviction;
- finding common and distinctive features of each other's beliefs;
- determining the reasons for differences in the student-child's beliefs;
- assessing whether the differences are real or fictitious.

The process usually ends with one of three possible options: (a) formulating counterarguments to confirm your own beliefs; (b) adopting a new, more attractive explanation; or (c) constructing a chimerical explanation as a kind of compromise between the convictions if both seem to be partially true.

Performing the above-mentioned activities by older preschoolers and younger school pupils is best suited to teach scientific content (Schaffer, 2007, p. 234). However, a question arises of **whether the effectiveness of the peer tutoring method will remain on a high level if the subject of teaching will be basic astronomical issues**, and thus: the shape of the Earth, the location of people, clouds and trees on Earth, the phenomenon of day and night. Astronomy belongs to the field of sciences, but its contents are more abstract than other areas of inanimate nature. The abstract nature of the science results from the fact that daily observations lead to erroneous conclusions. The evidence confirming the aforementioned statement is provided by the history of astronomical discoveries. Throughout thousands of years of observation, humanity had difficulty in establishing the shape of the Earth and building a proper model of the Solar System.

Children also find it difficult to build scientific concepts concerning objects and astronomical phenomena (Vosniadou, Brewer, 1994). They create their own explanations on the basis of knowledge acquired in a direct and indirect way (from adults, peers and the media). On the basis of the information obtained, children construct a representation of the surrounding world in their mind (Piaget, 2006). It is very early when they become interested in astronomical objects and phenomena. Even 5-year-olds are able to create explanations similar to the scientific ones (Nobes et al., 2005; Jelinek, 2017). Initially, children's explanations are based solely on direct experiences which suggest a flat representation of the Earth and a geocentric image of the Solar System (Vosniadou, Brewer, 1994; Jelinek, 2017). As we acquire information, the knowledge about the world becomes more complete and internally consistent.

A research carried out among Polish children shows that the children's idea concerning the shape of the Earth as spherical seems to be a concept poorly related with others in their mind. Almost all surveyed children (98.6% out of 444) stated that the Earth is spherical, however only 30.1% of them did not change their mind when asked about the location of people, trees or clouds, about the way objects move on the surface of the planet and finally about the phenomenon of day and night. The children gave up the idea of indicating the Earth as a sphere, referring to the image of a flattened sphere or a disk. With age, the number of responses close to the scientific ones increases. What the children found the most difficult to explain was the phenomenon of day and night (more: Jelinek, 2018).

Among the surveyed children there were five-years-old who had broad knowledge in the field of astronomy, as well as ten-years-old whose knowledge differed significantly from the scientific explanations. A question arose of how the child who knows more about the (above-mentioned) basic astronomical issues is going to teach the one who knows less as far as this area of knowledge is concerned. Below a research is presented, whose main objective was to determine the effectiveness of the peer tutoring method in teaching such a type of astronomical concepts. Due to limited publication possibilities, the paper is limited to presenting a quantitative analysis only.

METHODOLOGY

The research had the following course: first, the EARTH2 test was conducted (Straatemeier et al., 2008) to determine the level of astronomical knowledge of the children. Based on the results of the test, it was possible to determine which of the examined children has the largest, and which the smallest knowledge concerning the shape of the Earth, the location of people on the Earth and the phenomena of day and night. On this basis, the children were paired so that in each pair there was a child who knows more (a teacher-child) and a child who knows less (a student-child). While pairing children, I tried to make sure that children belonging to one pair came from the same class. The tutoring meetings were recorded and the EARTH2 test (Straatemeier et al., 2008) was carried out again at the end of the meeting to determine if there was a change in the children's convictions.

The results described in the article were obtained by carrying out two separate studies. The first research was conducted in April and May 2018. The second analogous research was carried out in October and November 2018. The reason for the research to be continued was a significant number of parents who refused their children's participation in the registered tutoring meeting during the implementation of the first research project.

The present paper analysis is based on the behavior of 56 children forming 28 tutoring pairs. Among the examined children there were 31 boys and 26 girls at the age from 5 to 9 (7 years old on average). The evaluation of the educational effectiveness

of the tutoring method was based on the comparison of the results of the pre-test and the post-test. The time difference between the pre-test and the post-test (carried out right after the tutoring meeting), was – depending on the date of the meeting – from one to five weeks.

A pencil and paper EARTH2 screening test was selected as an objective scale of the belief change evaluation. The authors of the test (Straatemeier et al., 2008) adopted a hierarchical order of concepts (after: Vosniadou, Brewer, 1994) assigning answers with a particular number of points. In the test, it was possible for the pupils to receive from 9 to 36 points. Thanks to the application of the scale, the level of astronomical kowledge of the examined children before and after the tutoring meeting was determined.

RESEARCH RESULTS

The difference in the level of knowledge between peers in a pair and the effectiveness of the tutoring method in teaching astronomical concepts. Among half of the pairs of children (14) the difference in astronomical knowledge ranged from 10 to 19 points, and in the other half it ranged from 4 to 9 points (this differences are presented in table 1).

Table 1. The results of the pre-test and the post-test in tutoring pairs, according to the degree of difference in the astronomical knowledge of the examined children

Pair (number)	Teacher-child (age)	Behavior in the group*	Pretest	Posttest	Result after the meeting**	Student-child (age)	Behavior in the group*	Pretest	Posttest	Result after the meeting**	Pretest result difference
1	KrzyśR (7)	a	35	34	-1	HaniaZ (7)	a	16	24	8	19
2	Hania (5)	w	36	35	-1	Antek (7)	a	17	33	16	19
3	Weronika (8)	w	35	35	0	Natalia (8)	a	17	34	17	18
4	Emilka (7)	a	36	33	-3	Hania (5)	w	18	26	8	18
5	MaciekS (8)	a	36	33	-3	AniaKo (9)	a	19	24	5	17
6	Martynka (8)	a	33	36	3	Konrad (7)	w	17	29	12	16
7	Przemek (6)	w	33	27	-6	Marysia (6)	a	17	19	2	16
8	Adam (7)	a	35	36	1	BartekJ (7)	w	21	28	7	14

9	Filip (7)	a	36	33	-3	Małgosia (7)	w	22	19	-3	14
10	Leon (8)	w	36	36	0	Igor (8)	a	22	34	12	14
11	Kinga (6)	w	33	33	0	KubaK (7)	a	21	32	11	12
12	DariaL (7)	a	33	28	-5	KubaK (8)	w	22	24	2	11
13	WojtekS (8)	a	36	34	-2	ZuziaK (7)	a	25	36	11	11
14	Marcel (7)	a	33	31	-2	Miłosz (8)	a	23	25	2	10
	Total		**486**	**464**	**4 -30**			**277**	**387**	**113 -3**	
15	Franek (6)	a	35	35	0	Nikodem (6)	w	26	23	-3	9
16	JulkaK (7)	a	35	35	0	KonradC (7)	w	26	27	1	9
17	WiktoriaB (7)	a	34	33	-1	WiktoriaCh (7)	w	26	29	3	8
18	JaśZ (7)	a	35	35	0	Piotrek (7)	a	27	25	-2	8
19	AniaP (7)	w	36	35	-1	LenaT (7)	w	28	31	3	8
20	Przemek (7)	w	32	33	1	ZuziaG (7)	a	25	33	8	7
21	Filip (7)	w	34	35	1	Maja (7)	w	27	35	8	7
22	JanG (7)	a	33	33	0	DominikB (7)	w	27	24	-3	6
23	Artur (7)	w	33	30	-3	Marysia (7)	a	27	26	-1	6
24	Amelka (7)	a	34	32	-2	Nikola (7)	w	28	32	4	6
25	Albert (6)	a	33	36	3	Małgosia (7)	a	28	35	7	5
26	AmelkaB (7)	w	32	36	4	AmelkaS (7)	a	28	30	-2	4
27	MajaP (7)	w	32	25	-7	OdetaS (7)	w	28	16	-12	4
28	MaksymB (7)	a	33	32	-1	KubaB (7)	a	29	33	4	4
	Total		**471**	**465**	**9 -15**			**380**	**399**	**38 -23**	

* Based on their behavior, the children were divided into two groups: withdrawn (w) and active (a) ones

** The result is the difference between the posttest and the pretest. A positive result means progress, and a negative result stands for regress. The „0" value means no changes

a – active child ; w – withdrawn child

Source: own study.

Taking into account the fact that each child could score up to 36 points in the test, each group (including 14 children) could score 504 points. Based on the comparison of the total score obtained by both groups, it appears that the teacher-children lost many points: -30 in the group with large differences in knowledge, and -15 in the

group with small differences in astronomical knowledge among the children. In the group in which there were no significant differences in knowledge among the children, the value of the student-children's progress could be estimated to 38 points, and the regress was at the level of 23 points. Much more significant progressive changes were observed in student-children (113 points, which constitutes almost 1/4 in relation to the maximum score).

On the basis of the above-mentioned, it is clearly visible that the greater the difference in the astronomical knowledge, the greater (three times) the positive effect of the meeting for the student-child. Among the teacher-children, there is a sort of regression which indicates that they accept some erroneous explanations made by the children-pupils. Perhaps the reason is that these explanations may seem more similar to the phenomena that occur on a daily basis. The observation proves that the effect of the confrontation of beliefs is mixing the views. Whereby it is difficult to refer to a "negative" regression when children give up scientific beliefs. The fact that they previously had a belief similar to the scientific one will make it easier for them to return to this belief in the future. What seems to be the reason why they gave up the scientific conviction is their knowledge not being structured enough. Personally, I do believe that this kind of perturbation in the area of beliefs is "a step back" only in order to take "two steps forward." In other words, regress in the process of confronting beliefs can constitute the basis for progress. This issue requires further empirical elaboration.

Social openness of the children in tutoring pairs, and the effectiveness of the tutoring method in teaching astronomical content. One of the assumptions of the tutoring method is the teacher-children's easiness of establishing social contacts and transferring their knowledge (Tudge, Winterhoff, 1993). While analyzing the previous aspect – the differences in the level of knowledge of the children in pairs – only the test results were compared. At this point, what is going to be compared is how the teacher-children were able to verbalize their inner beliefs in the pencil and paper test.

It should be stated that this issue was not included in the research at the stage of project preparation, but it was the class teachers of the children taking part in the tutoring meetings that pointed it out. The teachers noticed that some of the children who obtained high scores in the test (and were therefore considered to take the role of teachers), were socially "quiet and slightly withdrawn" in the class (quoting the teachers). This issue can turn out to be important as far as the effectiveness of the peer tutoring method is concerned, since the knowledge itself (demonstrated in the test) is one thing, and the ability to transfer it is another. The latter skill requires well-structured astronomical knowledge. It is only a well-organized knowledge that will allow a teacher-child to describe freely how they perceive the world, as well as to solve simple cognitive problems (e.g. to answer a student-child's questions). It is obvious that a number of kindergarten and school children may not think about

such issues as the shape of the Earth, the location of people, clouds and trees on the planet – these questions are not included in the core curriculum of pre-school and early school education (more: Jelinek, 2017). A teacher-child who has not yet considered this issue must define his or her conviction internally and then verbalize it. Moreover, it must be done in a clear way, as he or she talks his peers who play the role of students, after all.

While characterizing the examined children, I divided them into those who were more withdrawn when in pairs, and those who were more active. The indicators that were taken into account to classify pupils as "withdrawn" were: casual way of communication (both verbally and manually in the form of drawings and using plasticine) and being influenced by the other person's initiative. As the assessment was carried out on the basis of a recording analysis, the children were identified as "withdrawn" during the tutoring meetings by comparing the behavior of the pupils in a pair.

Using the aforementioned division, four types of tutoring pairs were obtained: (1) an active teacher-child vs a withdrawn student-child; (2) an active teacher-child vs an active student-child; (3) a withdrawn teacher-child vs an active student-child; (4) a withdrawn teacher-child vs a withdrawn student-child. In table 1 the behavior of each child has been marked (using the "w" and "a" symbols).

A withdrawn teacher-child vs an active student-child relationship (8 pairs). It turned out that many teacher-children were reluctant to communicate, they spoke in a casual way and were influenced by the initiative of the more active student-children. They used drawing and plasticine only when they were encouraged to. During the study, it was the active student-child who, when silence occurred, undertook activities to take the initiative of joint learning. As a result, they presented their naive (incorrect) beliefs. The teacher-child, having heard a misconception, often laughed, but did not criticize it. It was considered a joke or good fun as, when asked by the researcher if it was true what the other child had said, they nodded with a smile. It seems that the child perceived the situation as funny or realized that it was different, but they we not able to describe how it really was. As a consequence, some teacher--children (Przemek and Artur) who did not have well-structured astronomical knowledge, adopted the naive explanation of the student-child, which is confirmed by a relatively large decrease in their scores (10) in the post-test. Despite that, as far as the effectiveness of the peer tutoring method is concerned, it turned out to be the highest, as the student-children scored the most points (66, which is 8.25 of the difference in average differences).

However, it should be added that during the meeting in which the teacher-child was not willing to speak and did not respond to the first instruction of the researcher, he asked additional questions that were to stimulate the child to start teaching. Perhaps the form of interference was the reason why this type of relationship between children turned out to be the most effective.

An active teacher-child vs an active student-child relationship (9 pairs). In the pairs in which both children felt comfortable, in the sense of being afraid of neither the research situation, nor the contact with the researcher and each other, the teacher-child expressed his or her convictions freely. When the arguments were confronted, the teacher-child smiled hearing the wrong explanation made by the student-child and patiently explained his or her conviction. In such situations (but not always), the student-child accepted the scientific explanation. It happened, however, that the views of the teacher-child were not fully scientific and, as a result of the confrontation of beliefs, they accepted the student-child's explanation. In such pairs, the effectiveness of the peer tutoring method proved to be the second most effective form of relationship. Progress among some students taking the post-test was close to 10 points (Zuzia, Hania, Małgosia).

An active teacher-child vs a withdrawn student-child relationship (8 pairs) constituted the third most effective relationship as regards peer tutoring. In such relations, the teacher-child explained his or her opinions confidently (sometimes building up their explanations on the spur of the moment). Also, they confidently opposed the erroneous explanations made by the student-children. A meaningful explanation of their beliefs resulted in the student-child readily accepting the explanation conveyed in a comprehensible way. In such pairs, the effectiveness of the peer tutoring method turned out to be high (but not as high as in the case of pairs in which the teacher-child and the student-child relation was reversed, so the teacher-child was withdrawn and the student-child was active). This difference is due to the fact that the active teacher-children probably absorbed too much of the student-children's attention, not allowing them to formulate their own explanations. Their teaching style was like: "I speak, you listen." The relationships in which the teacher-child allowed the student-child to speak out, corrected them as they could, proved to be more effective.

A withdrawn teacher-child vs a withdrawn student-child relationship (3 couples) turned out to be the least effective in terms of the peer tutoring method. It was a situation in which both children remained silent when asked to explain basic astronomical issues. Since neither the teacher-children nor the student-children could explain their beliefs, the interlocutor did not have the chance to become acquainted with the other person's conviction. It was the researcher who played a significant role in such situations, as his task was to ask open questions (such as: What is the shape of the Earth? Where do people on Earth live?) trying to obtain their beliefs from both children. Additionally, in order to activate the children, the researcher took the role of a person who adopts primitive beliefs (e.g. believing that the Earth is flat and that people live only at its top). Most frequently, the children smiled at each other and began to respond in a casual way. They denied the researcher's naive explanation in short sentences. Nevertheless, the children rarely expressed their own internal beliefs. In such pairs, the effectiveness of the peer tutoring method turned out to be

the lowest, and in the case of Odeta, who received 12 points, it seemed that she had adopted the researcher's naive explanations as her own.

Among all the surveyed forms of relationship, it turned out that the most effective method of peer tutoring was the relationship in which the astronomical knowledge of the teacher-child seemed well-structured (allowing to solve simple problems) and when the pupil was able to transfer it well (an appropriate level of communication and social skills). Both of these indicators make the teacher-child act as an expert.

CONCLUSIONS AND DISCUSSION

The tutoring method cannot be considered as a substitute form of teaching influence. However, it can be employed in particular situations as a complementation to a teacher's work (Brzezińska, Appelt, 2013). The use of this method requires the teacher to be aware of its limitations. As the method is relatively unknown, in the present study I attempted to determine its effectiveness in the context of teaching basic astronomical concepts.

The research allowed to determine that the greater the gap in knowledge between the teacher-child and the student-child, the greater is the educational effectiveness of the peer tutoring method in the context of teaching such abstract concepts as astronomical issues. The aforementioned conclusion confirms Jerome Bruner's theorem (1974, pp. 20-46), according to which a non-expert child would not provide such experiences to the student-child so that they can structure his or her knowledge in an appropriate way.

The research has shown that a number of children playing the role of the teacher are referred to as "a mouseburger" in the class (the term used by one of the class teachers). The analysis of the relations of both active and withdrawn children in a pair has led to the conclusion that what turned out to be the most effective method of peer tutoring was the relationship of a withdrawn teacher-child and an active student-child. The reason why this particular relationship was the most fruitful one is the fact that the student-children had the opportunity to express their opinions and as soon as the teacher-children denied them and was able to explain their close-to-scientific beliefs, the student-children accepted the convictions as their own.

The research has shown that there is a minor difference in knowledge between boys and girls, in favor of the boys (Jelinek, 2018). Whereas the comparison of teaching methods in relation to gender shows that it is the girls who turn out to be better teachers.

In the paper, the author attempted to analyze the effectiveness of teaching abstract astronomical concepts, such as the shape of the Earth, the location of people, clouds and trees, and the phenomenon of day and night. Although the generalization power of the study is not significant, it can be assumed that astronomical concepts,

despite being abstract to a large extent, seemed to be relatively well transferred by the teacher-children, and the overall effectiveness of the method turned out to be relatively high, although it depends on the variable level of difference in knowledge, the degree of children's "social openness" and their gender.

The tutoring method has been still little explored (Schaffer, 2007). It seems important to determine whether a confrontation with student-children's more naive convictions over a longer period of time results in a better structuralization of teacher-children's knowledge. Moreover, it seems significant to determine other areas of the content of teaching (apart from the inanimate nature) in which the peer tutoring method might turn out to be effective.

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THE EFFECTIVENESS OF PEER TUTORING IN THE FIELD OF TEACHING BASIC ASTRONOMICAL CONCEPTS AMONG OLDER PRESCHOOLERS AND YOUNGER PUPILS. A QUANTITATIVE ANALYSIS

Keywords: peer tutoring, pre-school children, younger school children, astronomy, the shape of the Earth, a location of people living on Earth, day and night phenomenon

Abstract: Peer tutoring as an educational method requires an appropriate application. Teachers need to know strengths and weaknesses of it. In the article, the effectiveness of this method in the context of teaching basic astronomical content (N = 28 pairs of children) was analyzed. The analysis took into account the difference in knowledge levels between children in a tutoring pair and social openness. Studies have shown that the most effective were those couples in which the difference in astronomical knowledge was greater, as well as the relationship between children, in which the teacher-child is withdrawn, and the child-pupil is more active.

SKUTECZNOŚĆ TUTORINGU RÓWIEŚNICZEGO W ZAKRESIE NAUCZANIA PODSTAWOWYCH TREŚCI ASTRONOMICZNYCH U STARSZYCH PRZEDSZKOLAKÓW I MŁODSZYCH UCZNIÓW. ANALIZA ILOŚCIOWA

Słowa kluczowe: tutoring rówieśniczy, dzieci przedszkolne, uczniowie w młodszym wieku szkolnym, astronomia, kształt Ziemi, lokalizacja ludzi żyjących na Ziemi, zjawisko dnia i nocy
Streszczenie: Tutoring rówieśniczy jako metoda edukacyjna wymaga odpowiedniego stosowania. Nauczyciele muszą znać jego silne i słabe strony. W artykule została zanalizowana skuteczność tej metody w kontekście nauczania podstawowych treści astronomicznych (N = 28 par dzieci). W analizie uwzględniono różnicę poziomów wiedzy między dziećmi w parze tutoringowej oraz otwartość społeczną. Badania wykazały, że najbardziej skuteczne okazały się te pary, w których różnica w zakresie wiedzy astronomicznej była większa, a także taka relacja między dziećmi, w której dziecko-nauczyciel jest wycofane, a dziecko-uczeń bardziej aktywne.