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PRIMARY AND SECONDARY SCHOOL STUDENTS' KNOWLEDGE RELATED TO RENEWABLE ENERGY AND SOME OF ITS INFLUENCING FACTORS

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Abstract. *Shaping attitude related to renewable energy resources is the task of the entire society and in the case of students of different ages it is realized via education in and outside schools. This research concerns the analysis of the knowledge of students related to renewable energy resources, exploring the differences in the case of students in different grades and also the identification of correlations between the knowledge for renewable energy and some of its influencing factors. The research was carried out in spring 2018 with 4th (N=466) and 7th (N=529) graders in primary school and also with 11th graders (N=328) in secondary school in Hungary. Association and selection tasks applied in the research were related to knowledge of renewable energy resources and three questions concerned influencing factors. Assessment was performed based on the word association test. Results indicate poor and less stable knowledge in the case of every grade. The knowledge structure of the grades is similar, solar, water and wind are the most well-known renewable energy resources. Regarding knowledge, the type of the settlement of residence, education level of parents, school curriculum, textbook, theme weeks, project work, media and internet were important among influencing factors.*

Keywords: *project work, renewable energy knowledge, school curriculum, theme work, word association.*

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Introduction

Utilization of renewable energy (RE) resources and their wide application became a key issue in fighting against global climate change as they could significantly contribute to reducing greenhouse gas emission (Ito, 2017; Jordaan et al., 2017; Szabó et al, 2014). RE resources are increasingly available for residents as systems with increasing efficiency with shorter return periods which can be found on the market (Afonso, Marques, & Fuinhas, 2017). To choose the use of RE resources, however, one has to know their types, application conditions, advantages and disadvantages (Szabó et al., 2018). The purpose for which RE resources would be used, local field conditions and financial resources all influence the decision on selecting the various types of RE (e.g. to build a wind plant in the backyard of a family house is not possible but now solar panels can be installed and utilized for almost anyone). Thus, the right decision requires knowledge, attitude and approach related to applying RE resources. To enable people to acquire and develop this knowledge, attitude and approach is the joint task of the school and the society. The UNESCO's Global Renewable Energy Education and Training Programme revealed in 2004 that although knowledge related to RE was present at various levels of education, learning and education methods based on active student participation (including related chapters of textbooks and course documents) that could have been suitable to create and develop emotional and behavioral elements related to RE were missing (Benchikh, 2004). Fourteen years have passed since the above conclusion, but the problem is still with us. Alberta Council for Environmental Education (ACEE) published in 2018 its recommendations of methods (a collection of interactive activities, games, student projects) that could contribute to the development of attitude elements related to RE in Canada and the United States completing with this the primarily knowledge-focused classes. Similar methodological efforts have been made in Europe as well emphasizing interactive activities

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and programs in the topic of RE apart from teaching knowledge integrated into various courses (Cavanagh, 2007; Colin, 2008; Papadimitriou, 2004). These methodological efforts have presumed that the knowledge of students related to RE, its understanding and procedural knowledge are rather incomplete. Similar results have been revealed by several other research projects studying the knowledge and attitude of students related to RE. Studying the knowledge of Nigerian secondary school students Bamisile, Abbasoglu, Dagbasi, and Garba (2016) have found that the knowledge of students related to RE utilization has been lower than average (41%) independent of gender, age and education type in spite of abundant RE potentials in the studied region of the country. The problem can be explained by, on the one hand, the deficiencies of curriculum requirements related to RE, and on the other hand, the lack of methods that could contribute to the formation of a positive attitude towards RE via applying activities requiring self-contained student activities (project, cooperative and collaborative activities, various competitions, etc.) from practice point of view considering also the context of everyday life. Hasan (2012) has also emphasized the responsibility of schools in forming energy consciousness and has called attention to utilizing possibilities provided by the internet in education. Misconceptions associated with RE have been frequent among Turkish secondary school students involved in his study; their knowledge level has been low despite the fact that RE utilization potential can be regarded good in Turkey due to its geographical location. Some research projects studied the reasons of low level of knowledge regarding RE. Bünyamin, Hakan, and Osman (2010) have mentioned that in the course of a research in 2009 analyzing primary school curricula in Turkey the term RE has appeared as part of education for sustainability only in natural sciences courses, and only in a small percentage even in those. Only solar and geothermal energy sources have appeared among RE. Analyzing secondary school curricula, knowledge related to the topic has appeared only in geography and physics courses. According to Büniamin et al. (2010), even the entry controls could have been blamed for the low level of energy consciousness. Similar research has been carried out also in Europe (Revákné et al., 2018; Szabó et al., 2018) declaring also that primary and secondary school curricula, textbooks and exercise books have been insufficient regarding knowledge and attitude elements related to RE resources. In the case of the studied courses of nature science (grades 4-6) and geography (grades 7-10), elements providing conceptual knowledge have been found primarily while the degree of absence of attitude elements significantly influencing decision making skills has been significant in the studied documents and reference books. Kónya (2012) studying the curricula of secondary school natural scientific courses has found that geography courses have had greatest potentials for environmental education and education for energy consciousness in Hungary as well. Further research has also revealed the elements of detailed knowledge related to RE including knowing the different types of RE resources. In general, solar, water and wind energy resources have been the most well-known ones among students in primary, secondary and higher education and geothermal energy and biogases, for example, have been less known to them (Büniamin, Hakan, & Osman, 2010; Malmos, Jász, & Markóczi, 2017; Roman, 2015; Shin-Cheng, Jing-Yuan, & Hui-Ching, 2017). According to the word association study of Tóth and Gajdos (2012), the knowledge of Hungarian students related to RE has become more structured with age and has been dependent on the type of school where students with the same age have studied. The most structured knowledge has been found in the case of students studying in grammar schools and vocational secondary schools specialized in environmental protection. The terminology network of students in vocational training has been almost the same as that of 8th grade students in primary school. Their study has covered the effects of textbook content on terminology structure and the role of the media as well. They have found strong correlation with textbook content and weak with media effect respectively. Misconceptions of students related to RE resources suggest that the cognitive side of education regarding energy consciousness has been insufficient in school. The fact that most primary school students are "concrete" thinkers while secondary school and higher education students are in the period of formal thinking is not considered despite the fact that different context and methodology have to be applied in environmental education at different age levels (Shin-Cheng, Jing-Yuan, & Hui-Ching, 2017). Establishing energy consciousness requires a complex way of thinking, the establishment and development of which require education to be a harmonized system in both its content and methods taking social and economic effects outside school into account just as the decisive experience obtained in the everyday life of students.

Research Problem and Focus

This research explored the knowledge of Hungarian primary and secondary school students related to RE and its connection with certain influencing factors. The research was part of the „The role of social learning processes

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regarding renewable energy resources in the Eastern Region of Hungary" project (supported by the NKFIH, K 116595 application in Hungary, 2016-2019). This project aimed to study the process of learning RE by the society, focusing especially on knowledge and attitude of adult (aged over 18 years) and young (aged between 10 and 18 years) residents related to RE. The primary reason for the project was the fact that Hungary in the Partnership Agreement for the 2014-2020 EU cycle agreed to increase the share of RE resources within the total final consumption to 15% by 2020. For this the ratio of residential RE utilization has to be increased as well. The question was whether residents are prepared for this or not? How can education prepare primary and secondary school students for knowledge and decision making related to utilizing RE? This research focused on the role of school education but other effects outside school that influence the knowledge of students related to RE are also discussed. Research questions were the following:

1) What are the specifics of the knowledge related to RE of the investigated grades at primary and secondary levels?
2) Are there any significant differences between the knowledge of the investigated grades related to RE?
3) How can the type of residence, the education level of parents, the source of information related to RE and the methods of learning information related to RE influence the knowledge of the investigated students related to RE?

Research Methodology

General Background

This is the research in which the knowledge of primary and secondary school students related to RE resources was studied based on the results of earlier studies (Bamisile et al, 2016; Büniamin et al, 2010; Leggett, 2003; Malmos et al, 2017; Roman, 2015; Shin-Cheng et al., 2017; Tanriverdi, 2009; Tóth & Gajdos, 2012). Students living and studying in the eastern region of Hungary were involved in the research. Stabilized knowledge related to RE resources was analyzed with two tasks suitable for cross queries and correlation between stabilized knowledge and influencing factors was searched in the course of the research.

Sample

The research was carried out in primary and secondary schools in the eastern region of Hungary in the spring of 2018. Considering age group specifics and the differences of associated education content and teaching methods, 4th and 7th graders in primary school and 11th graders in secondary school were involved in the research (Revákné et al., 2016). An important aspect was to involve students in the research from every settlement type (village, small town, city). Settlements with similar population were selected from the same types for the research. One further aspect was the results of the National Competency Measurement organized by the Educational Authority between 2015 and 2017. National Competency Measurement measures the comprehension and mathematical competencies of primary (6th and 8th graders) and secondary school (10th graders) students at national level in every academic year. Students were involved in the sample of the research from schools performing below and above the average. Permission from the regional Klebersberg School District Centre was required for carrying out the research in the schools. Permission from the parents of students involved in the research from the selected schools was also of course. The final composition of the sample and the exact number of selected students were obtained taking all the above aspects into account (Table 1).

Public education in Hungary is primarily controlled by the national core curriculum that specifies the fundamental educational goals and content that appear in curricula and textbooks as unified requirements. Although the students involved obtained their knowledge related to RE resources from different textbooks of several publishers, the same minimum requirements appeared in the textbooks of different publishers at a given grade level or in a given course as a result of this unified curriculum. Therefore, on the basis of earlier research results, no significant differences due to textbook differences were considered regarding permanent knowledge (Revákné et al., 2018).

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Table 1. Distribution of students involved in the research according to the type of settlement and school.

Settlement	Number of settlements (*N*=15)	Number of schools (*N*=32)			Number of students (*N*=1322)		
		Primary school (*n*=20)	Secondary school (*n*=12)		4th grade (*n*=466)	7th grade (*n*=529)	11th grade (*n*=328)
			Grammar school (*n*=7)	Vocational grammar school (*n*=5)			
Village	8	8	—	—	92	111	—
Small town	5	7	2	2	192	191	96
County center (major city)	2	5	5	3	182	227	232

Instrument and Procedures

Two tasks were aimed at studying the knowledge of students related to RE resources using the cross-query method. In the first open end task students had to write down three terms or words that come into their mind, first for RE as a stimulus word. Since it can be assumed that the most stabilized words in the knowledge of the students related to RE would be response of the students, the solution of this task yielded information on the stabilized knowledge of the students related to RE (Tóth & Gajdos, 2012). In the second, multiple choice task (closed end task) renewable and non-renewable energy resources were listed and students had to choose the renewable ones. Cross query meant that the student mentioned the given term in the first task while in the second the student had to select it (if it was listed). Based on such cross-query tasks (corresponding of recall and selection in this case), the stability of knowledge can be analyzed (Revákné & Radnóti, 2011).

The first task was the same for all grades: Write down a maximum of three words that come into your mind related to renewable energy resources within 1 minute! The second task was also the same for all grades: Underline renewable energy resources among the following!

There were differences, however, in the listed terms. The same terms (nuclear energy, wind turbine, iron ore, coal fired power plant, solar collector, biogas, biodiesel, crude oil, geothermal energy, lignite, water energy, firewood, natural gas, photovoltaic cell) were used for 7th and 11th graders. A smaller number of terms were given for 4th graders (nuclear energy, wind energy, natural gas, solar energy, crude oil, lignite, biodiesel, water energy, geothermal energy, firewood, biomass, coal). Terms listed in the task were selected from textbooks already learnt by students in the given grade.

When the reliability of the second selection task was analyzed, the task was divided into two parts. The first was the selection of RE resources. Cronbach's alphas values of this were .78, .87 and .89 at grades 4, 7 and 11 respectively. The second part was related to the listed fossil energy resources. Cronbach's alphas values of this second part were .74, .86 and .85 at grades 4, 7 and 11.

Four questions were given to students in relation to influencing factors. In the first question students had to indicate the type of the settlement their school can be found in (village, small town, city).

The second question was related to the level of education of the parents of students. Students had to categorize the education level of the parents into five major categories: primary school, vocational training school, vocational secondary school, grammar school, higher education.

The third question was related to how information in relation to RE resources was obtained (school curriculum, television, radio, family members, press, newspapers, residence directions, forum, leaflet, internet, friends). This latter question was similar to the question used in the research of Hasan (2012) asking for the source of information related to RE with a closed end question. Sources of information listed by Hasan (2012) were completed according to Hungarian conditions. The role of the factors in the question had to be evaluated by the students on the basis of the Likert scale from "not at all (1)" to "completely (5)".

The fourth question regarding the methods of obtaining information (team work, watching films, self-contained work at home- even using the internet, project work, presenter outside school, visiting factories/

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works/power plants, other trip, specific theme week, e.g. sustainability theme week, textbook content, tasks in exercise book) related to RE was asked only in the case of 7th and 11th graders as 4th grades could not have answered reliably such questions. In this fourth question several methods and sources of information could be selected by the students.

The first task was solved firstly by the students. They had 1 minute after the stimulus word was said to write down on a piece of paper the three words or terms that came into their minds related to RE. Following this the pieces of paper with the association were collected. After this the sheets containing second task and the questions related to the influencing factors were given to the students. The survey took 45 minutes for 4th graders and 35 minutes for 7th and 11th graders.

Data Analysis

In order to identify the grade specifics of knowledge related to RE analyses within the grades while to compare the knowledge of the grades analyses among grades were carried out. Following this, connections among performances in solving the two tasks were analyzed to assess the stability of knowledge.

In the assessment of the first task among the two tasks used for the investigation of knowledge related to RE the number of the types of associations mentioned by the students in the different grades was studied first then the relative frequency of the mentioning of those association types was investigated. The ratio of the number of relevant associations regarding RE in relation to the total number of mentioned associations was analyzed at every grade. The ratio of that how many associations out of the possible three were mentioned by the students was also investigated by grades.

In order to further study the specifics of knowledge related to RE, 5 association groups were formed in every grade out of the associations mentioned in the first task:

1) Irrelevant words: words that have nothing to do with RE resources (e.g. rain, light, cloud, liquid, decency, internet, made-up, bird, paper, oxygen, walk)
2) Words related to energy utilization: methods, devices and technologies related to the utilization of any energy (e.g. current, machine, convector, socket, floor heating, batteries, refrigerator, washing machine)
3) Words related to fossil energy resources: non-RE resources and devices and technologies meaning their utilization (e.g. coal, crude oil, natural gas, diesel oil, gas-powered car)
4) Words related to RE resources and their utilization: the term renewable energy resource and terms naming power plants and technologies converting it to electric current or heat (e.g. Sun, solar energy, solar collector, photovoltaic cell, wind, wind turbine, wind mill, wind power plants, water, water power plant, water energy, geothermal energy)
5) Positives related to the application of RE: words expressing the advantages of applying RE or the positive effects of applying RE on nature, society and the environment (e.g. economical, conservationist, environmental-friendly, sustainable society, effective, modern, environmentally sound, energy saving, thrift, reuse, smart house, not running out, consciousness, necessary, cooking).

The total number of mentioning of the associations appearing in the given association groups was also investigated at every grade. Based on the results the relative frequency of mentions was calculated for each grade and each association group (total number of real mentions / total number of possible mentions related to all association types).

For studying the significance of differences in the above-mentioned investigations Kruskal-Wallis *H* test was applied (χ^2 value within it) for comparing the performance of the three grade levels and *Z* test was used for comparing two grade levels. Friedman test was applied to assess relative frequencies of mentioning of associations within a grade.

To find out which were the most typical associations at the different grades the word association method was used. This method is suitable for analyzing the knowledge structure of students related to the given term (Cardellini, 2008; Garskof, Houston, & Ehrlich, 1963; Nakiboglu, 2008). For this, stimulus words related to the term are given and the students give different associations (terms) to these stimulus words. The relative frequency of the associated terms can be calculated for each stimulus word, based on the values of which the strength of the connection between the stimulus word and the mentioned association can be different (see Table 2). Based on this, association maps can be drawn (Kluknavszky & Tóth, 2009). Association maps show only those associations

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the relative frequency of which reached 5 %. In this way the character and quality of the knowledge of students related to RE were assessed.

Table 2. Strength and indication of relative frequencies in the net of terms (Kluknavszky & Tóth, 2009).

Relative frequency of associations	Strength of connection	Indication
Below 5	Very poor	Not indicated
5.0-12.0	Poor	
12.1-20.0	Moderate	
Above 20	Strong	

In the second task related to the selection of RE resources the relative frequency (number of correctly selected terms / total number of terms) related to the selection of RE resources and fossil energy resources was investigated separately and this relative frequency was regarded an interval variable. Solution rates at the three grade levels showed normal distribution therefore ANOVA one- way variance analysis was applied to study differences among and within grades. In the case of the selection task, two-sample t-test was used for comparing the solution rates of two grade levels. In the second task the frequency of the selection of the given RE resources was also studied. 1 point was given if the particular RE resource was marked and 0 point was given if not. As a result, to assess relative frequency of the selection related to RE resources Cochran's Q test was applied within grades (because of dichotomous scale), while to analyze the differences among the grades the Kruskal-Wallis H test was used.

In order to verify the volume of differences, effect sizes were calculated as well (*d* values for Kruskal-Wallis *H* test, *Z* test and two-sample t-test, η^2 for Anova, and *q* values for correlations respectively) (Cohen, 1988; Lenhard, & Lenhard, 2016). According to Cohen (1988), the following intervals for *d*: 0 to .1: no effect; .2 to .4. small effect; .5 to .7: intermediate effect; .8 to ≥1: large effect; for η^2: .000 to .003: no effect; .010 to .039. small effect; .060 to .110: intermediate effect; .140 to .200: large effect; for *q*: < .1: no effect; .1 to .3: small effect; .3 to .5: intermediate effect; >.5: large effect.)

In order to show how stabilized is the knowledge of the students regarding terms related to RE, correlation analyses were made to investigate performance in the case of the first, association and second, selection tasks using Spearman's rho value.

Regarding the questions related to the influencing factors the impact of the settlement type (where the school was found) was investigated on the performance in tasks related to knowledge within grades. Significant differences regarding the performance of students from villages, small towns and county centers (major cities) were sought. The significance of differences was analyzed using Friedman test (in the case of grades 4 and 7) and *Z* test (for grade 11) in the case of the first, association task while the averages of the second, selection task were compared using the ANOVA one way variance analysis (grades 4 and 7) and the two-sample t-test (grade 11). Different assessments for 11th graders can be explained by the fact that there were no secondary schools and thus no 11th graders in the studied villages therefore in the case of 11th graders only the results of small towns and county centers could be compared.

Considering the influencing factors, the impact of the educational level of parents on performance in the first and second tasks related to RE knowledge was investigated next. The impact of the education level of the father and that of the mother were investigated separately in the case of all grades. The average of the number of correct associations in the first task and the average of the solution rate related to RE resources were calculated in relation to grades and to the educational level of parents. ANOVA was applied to investigate the differences according to the educational level.

In the question related to the influencing factors the role of knowledge sources related to RE resources was assessed by the students using a 5-point Likert scale. For detecting differences among the roles of the given sources of knowledge Kruskal Wallis H test was applied for comparing the three grades and Friedman test for evaluating within a grade.

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In the fourth question related to the influencing factors students assessed some methods within and outside school influencing the learning of terms related to RE on the basis of a dichotomous scale (1 point was given if the student marked the given method and 0 point was given if not). So, differences among the roles of the given methods within a grade were studied using the Cochran's Q test while differences between grades 7 and 11 were analyzed using the Z test. Spearman's rho value was used again for studying correlations between performances achieved in the first, association task related to RE knowledge and methods helping to learn. The same measure was applied to study correlations between performance in the second task related to RE selection and methods helping to learn as factors influencing knowledge.

In order to further research the impact of influencing factors on knowledge related to RE, multivariate analysis of variance was performed. The joint impact of the sources of knowledge on performance in the two tasks related to RE knowledge and the joint role of methods influencing learning were investigated separately.

Research Results

Students' Knowledge Related to Renewable Energy

First the word association task was assessed. The number of associations in every grade, and their relative frequency were considered and finally, the percentage of association types mentioned in the studied grade that were correct, relevant terms in relation to RE was also regarded (see Table 3).

Table 3. The number of associations given to RE resources, their frequency and relevance by grades.

	4th graders (N= 466)	7th graders (N = 529)	11th graders (N= 328)
Number of associations	116	112	69
Relative frequency of associations	0.25	0.21	0.21
Relevant associations /total	62 %	72 %	88%

The number of associations showed different values by grades, however, these were not comparable due to the different number of students in the grades. Therefore, the relative frequency of associations was considered, which showed no significant difference among the grades. When the ratio of correct, relevant associations in relation to the total number of associations given by the students (relevant associations/all associations) was analyzed the Kruskal-Wallis *H* test yielded significant differences among the three grades (χ^2=92.75; *df=2; p*<.001). The effect size related to the difference among the grades was intermediate (*d*=.527). The highest number of correct associations was given by 11th grade students followed by 7th graders and 4th graders. Although the performance of 4th and 7th graders was close to each other, Z-tests revealed better performance in the case of 7th graders (*Z* = 5.12; *p*>.001; *d* =.214) regarding the ratio of relevant associations. The effect size indicated small impact to difference between two grades (*d* =.214).

In the first, association task the students had to mention a maximum of three associations. The ratio of mentioned associations per maximum number of associations was 81% in the case of 4th graders, 73% for 7th graders and 88% for 11th graders. The difference among the grades is significant and the impact is small based on the effect size (χ^2=43,31; *df*=2; *p*<.001; ; *d*= .292).

In order to describe the frequency of the mentioning of association types, association groups were created. The relative frequency of mentions related to all of the associations in every association group was determined (see Table 4).

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Table 4. Relative frequency of mentioning of associations related to the given fields by grade.

Association fields	4th graders	7th graders	11th graders	χ^2	*df*	*p*	Effect size (d)	
Irrelevant	.006	.004	.007	17.44	2	<.001	.141	no effect
Energy utilization	.011	.005	.006	23.94	2	<.001	.126	no effect
Fossil energy resources	.014	.009	.008	2.69	2	.260	.090	no effect
Renewable energy resources and utilization	.072	.064	.078	18.19	2	<.001	.190	no effect
Positives of renewable energy	.013	.017	.018	4.88	2	.087	.121	no effect
χ^2	466.29	595.23	606.19					
df	4	4	4					
p	< .001	< .001	< .001					

Significant difference among the grades was found in the case of irrelevant words and those related to RE resources, their utilization and energy utilization. The performance of 7th grade students was poorest in these fields. Within the grades, however, the relative frequency of mentioning the words and associations related to RE resources, their utilization and positives was clearly the highest. Table 4 also indicates that the knowledge of 4th and 7th grade students related to RE is not firm yet and less settled compared to that of 11th graders. Effect sizes indicated no assessable impact regarding the differences among the grades in the case of either association groups (see Table 4).

For the detailed analysis of the association task, the association maps related to RE in the case of the studied grades were created (see Figures 1, 2, and 3). The frequency of mentioning each association was determined in the case of each grade. Only words mentioned with a frequency higher than 5% were plotted on the association maps (see Table 1).

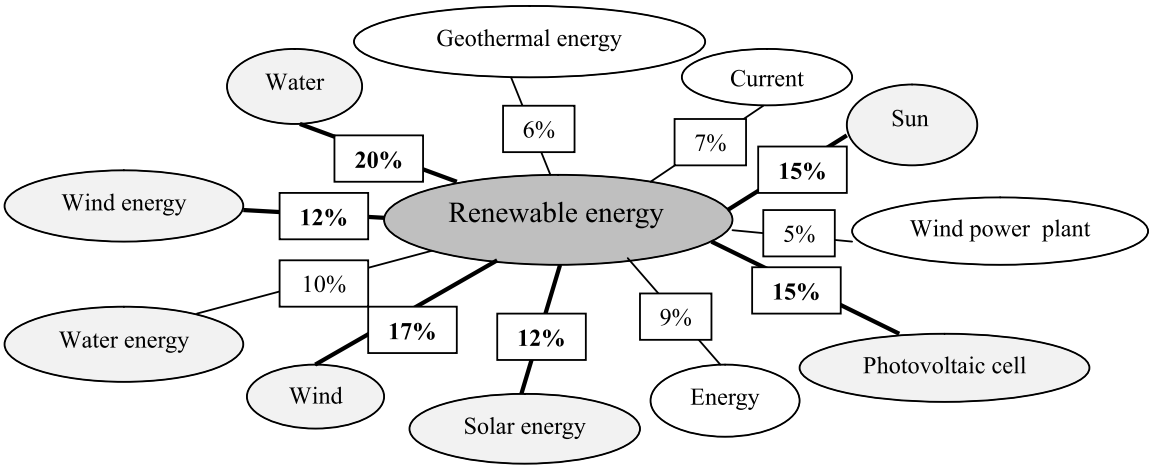

Figure 1. Association map of renewable energy in the case of 4th graders.

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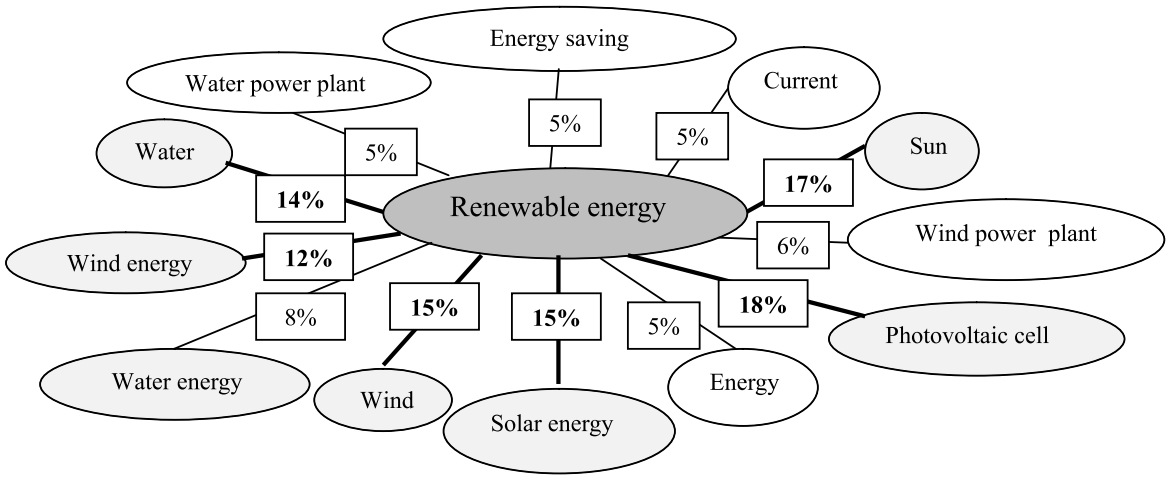

Figure 2. Association map of renewable energy in the case of 7th graders.

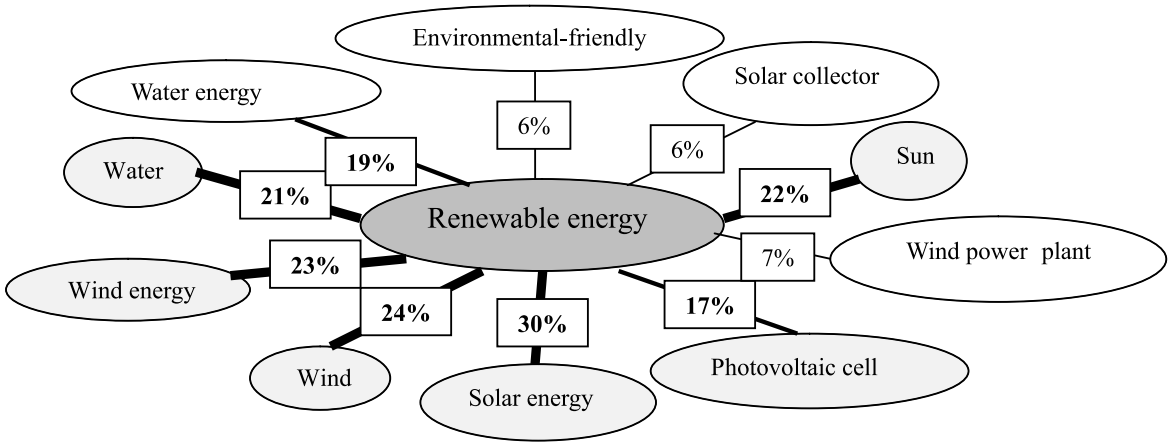

Figure 3. Association map of renewable energy in the case of 11th graders.

Association maps are similar to each other independent of grade level. The terms sun, solar panel, solar energy, solar collector, wind, wind energy, water and water energy appeared most frequently with moderate or in the case of 11th graders strong correlation with the term RE. Associations showing weak connection included wind power plant, water power plant, energy, geothermal energy and electricity as a term related to application. In the case of 4th graders, only associations related to the term and application of RE appear while in the case of 7th and 11th graders the terms of energy saving and environmentally friendly suggesting positive relations also appear with weak correlation.

Following the analysis of the association task the success of students selecting RE resources in the second task was considered. The rate of solution of the task in relation to selecting renewable energy and fossil energy resources was studied separately. Considering the rate of number of RE resources selected correctly from the list, the results of 4th graders were poorest (52%) followed by that of 7th (57%) and finally that of 11th graders (69%). The difference among the results was significant according to the ANOVA analysis ($F(2)=66.80$; $p<.001$). Effect size of differences is intermediate ($\eta^2=.118$).

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Relative frequency of selection in relation to each of the RE resources was analyzed as well. Regarding selected with highest relative frequency in grades followed by wind energy, wind turbine, water energy and geothermal energy, solar energy, solar collector and photovoltaic cell. Least known and thus least frequently selected RE resources were biomass, biodiesel and biogas. Table 5 also reveals that 11th graders performed best compared to the other grades which is similar to the total rate of solution of the task. Effect sizes related to the differences among the grades indicated weak or not detectable impact in the case of every RE resource except for wind turbine (large effect).

Table 5. Relative frequency of the selection related to RE resources in the studied grades.

Renewable energy resources	Relative frequency of the selection related to RE resources			χ^2	*df*	Z (5% alpha level)	p	Effect size *(d)*	
	4th grade	7th grade	11th grade						
Wind energy	0.84								
Solar energy	0.91								
Biomass	0.14								
Biodiesel	0.17	0.33	0.37	45.61	2		<.001	.278	small effect
Water energy	0.84	0.75	0.94	51.93	2		<.001	.237	small effect
Geothermal energy	0.67	0.65	0.84	39.86	2		<.001	.270	small effect
Firewood	0.11	0.30	0.27	54.94	2		<.001	.270	small effect
Wind turbine		0.64	0.89			12.5	<.001	.844	large effect
Solar collector		0.73	0.91			5.66	<.001	.394	small effect
Biogas		0.32	0.41			3.11	<.005	.214	small effect
Photovoltaic cell		0.85	0.92			2,87	<.005	.197	no effect
Cochran's Q	1229.09	826.45	929.40						
p	<.001	<.001	<.001						

The relative frequency of the selection of fossil energy resources was also analysed, showing values of .11, .16 and .06 ($F(2)=27.06$; $p<.001$; $\eta^2=.040$) at 4th, 7th, and 11th grade levels respectively.

The second task was aimed to be a cross query to see how the knowledge of students related to RE resources is stable compared to the results of the word association task. The connection although significant was weak in all three grades (*Spearman's rho*: 4th graders: .196; $p<.001$; *Spearman's rho*: 7th graders: .231; $p<.001$; *Spearman's rho*: 11th graders: .116; p<0,05). Based on the effect size of the correlations, there was no difference between grades 4 and 7 ($q = .030$) regarding the relative frequency of relevant associations and the solution rate of the selection task. The same was true for comparing grades 4 and 11 ($q = .082$). The effect was small in grades 7 and 11 ($q = .119$), meaning that correlation was smaller in grade 11 compared to grade 7 between the number of relevant associations and the solution rate of the selection task.

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The first question related to the role of influencing factors investigated the effect of the settlement type where the school can be found (see Table 6).

Table 6. The average of the number of correct associations in first task and the rate of solution of the selection task in different grades by settlement type.

Grade	Average of the number of correct associations - first, association task			Rate of solution of the selection task -second, selection task		
	Village	Small town	County center (major city)	Village	Small town	County center (major city)
4th grade	2.04	1.63	1.71	0.48	0.53	0.53
7th grade	1.83	1.68	1.72	0.49	0.57	0.61
11th grade	-	2.22	2.39	-	0.64	0.71

In grade 4 students attending school in villages mentioned significantly more correct associations related to RE (χ^2=11.67; *df*=2; *p*<.005). Effect size regarding the differences of the effect of settlements indicated small effect (*d*=.320). In the case of 7th graders, no significant differences could be found in the number of correct associations according to the settlement type (χ^2=0.73; *df*=2; *p*=.692) and the effect size also indicated no detectable effect (*d*=.163). In the case of 11th graders, the difference between the performance of students in small towns and major cities was not significant considering the number of correct associations (*Z*=1.39; *p* =.164). Regarding the second, selection task, the difference among the performance of students in schools in the different settlements was significant in the case of all three grades (4th graders: *F*(2)= 3.30; *p*<.05; η^2=.014; 7th graders: *F*(2)=8.77; *p*<.001; η^2=.032; 11th graders: *t*=2.98; *p*<005; *d*=.363). In all three grades students of schools in major cities performed best while students of schools in villages performed worst (see Table 6). Settlement type had greatest effect on performance in the selection type in the case of 11th graders as students in major city schools performed better and the effect size indicated large effect.

Knowing the average of correct associations in the association task it was considered compared to the education level of parents and also the average of the rate of solution of the selection task in different grades (see Table 7 and 8). Based on the Friedman test, significant differences regarding association frequencies were not found within grades (see Table 7). In the solution of the task related to selecting RE resources significant differences were found in solutions according to the educational level of the father in 4th grade *(F*(4)=2.19; *p*<.05; η^2=.033), that of the father *(F*(4)=9.41; *p*<.001; η^2=.099) and the mother (*F*(4)=7.71; *p*<.001; η^2=.096) in the 7th grade while that again of the father (*F*(4)=3.98; *p*<.001; η^2=.081) and the mother (*F*(4)=2.51; *p*<.05; η^2=.046) in the 11th grade. The average performance in the selection task was highest in the case of students with parents with a diploma in every grade (see Table 8).

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Table 7. Average of the number of correct associations related to RE in the association task in the case of different grades by the educational level of parents.

Task		Educational level of parents	4th graders	7th graders	11th graders
Average of the number of correct association (association task)	Father	Primary school	1.43	1.44	2.33
		Vocational training school	1.79	1.59	2.36
		Vocational secondary school	1.39	1.69	2.41
		Grammar school	1.46	1.77	2.63
		Higher education	1.55	1.74	2.17
	Mother	Primary school	1.37	1.48	2.14
		Vocational training school	1.67	1.69	2.14
		Vocational secondary school	1.64	1.48	2.38
		Grammar school	1.47	1.74	2.14
		Higher education	1.52	1.70	2.30

Table 8. Average of the rate of solution of the selection task related to RE in the case of different grades by the educational level of parents.

Task		Educational level of parents	4th graders	7th graders	11th graders
Average of the rate of solution (selection task)	Father	Primary school	0.52	0.44	0.44
		Vocational training school	0.57	0.57	0.69
		Vocational secondary school	0.51	0.62	0.68
		Grammar school	0.52	0.60	0.73
		Higher education	0.58	0.69	0.74
	Mother	Primary school	0.50	0.45	0.63
		Vocational training school	0.54	0.57	0.63
		Vocational secondary school	0.57	0.57	0.68
		Grammar school	0.52	0.64	0.70
		Higher education	0.56	0.67	0.74

The source of information related to RE was also asked from the students. Based on student opinion, school curricula and the internet provide most of the information regarding RE resources while least profit is obtained from printed press and residential inquiries (see Table 9). In the case of 4th graders, the role of the family in obtaining information was more significant than in the case of the other two grades. Effect size related to differences among the grades was largest in the case of the internet and friends indicating, however, small effect.

Table 9. The role of sources of knowledge related to RE (based on the values of Likert scale) obtaining knowledge according to the opinion of students at different grade levels.

	4th graders	7th graders	11th graders	χ^2	df	p	Effect size (d)	
Curriculum	3.30	3.35	3.22	3.81	2	.149	.111	no effect
Television, radio	2.69	3.06	2.97	31.27	2	<.001	.255	small effect
Family	3.00	2.86	2.76	10.25	2	>.05	.126	no effect

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	4th graders	7th graders	11th graders	χ^2	*df*	*p*	Effect size (d)	
Press	2.52	2.46	2.32	2.83	2	.242	.093	no effect
Residential inquiries	2.56	2.60	2.09	30.65	2	<.001	.285	small effect
Internet	3.03	3.41	3.51	53.37	2	<.001	.375	small effect
Friends	2,80	2,33	2.08	65.41	2	<.001	.423	small effect
χ^2	193.71	473.79	547.94					
df	6	6	6					
p	<.001	<.001	<.001					

Multi-variable linear regression was applied to analyze the connection of the role of knowledge sources according to the students, the number of correct associations given to renewable energy resources and the performance in the case of the selection task (see Table 10).

Table 10. Variables explaining the performance in the association and selection tasks related to RE considering information sources based on the values of multi-variable linear regression.

Grades	Task type	Independent variable	*R*	R^2	*B*	*F/p*	*t/p*
4th	Association	Printed press	.165	.165	.132	6.455 /<.005	3.251/<.005
		Internet			.098		2.021/<.05
	Selection	Television, radio	.145	.021	.02	5.001/<.05	2.826/<.005
		Internet			.014		2.056/<.05
7th	Association	Television, radio	.097	.009	.106	3.961/<.05	1.990/<.05
	Selection	Friends	.239	.057	.026	8.452/<.001	2.917/<.005
		Residence information			.023		2.740/<.05
		School curriculum			.025		2.001/<.05
11th	Association	School curriculum	.138	.019	.135	5.533/<.05	2.352/<.05
	Selection	Internet	.152	.023	.024	6.802/<.05	2.608/<.05

Variables explaining the association and selection tasks were studied separately in all grades. Stepwise option achieved the optimal model in two steps in both task types in 4th grade. In the case of 7th grade, the optimal model was achieved in one step in the association task and in three steps in the selection task. Finally, the optimal model was achieved in one step each in the two tasks in the case of 11th grade. Table 10 shows only these optimal models.

Two steps of the optimal model, i.e. obtaining knowledge from the printed press and the internet explain the standard deviation of the number of associations per student mostly in the case of 4th grade. Both variables have significant effects on the number of associations per capita and their predictive value. Optimal model in the case of 7th graders indicated only television and radio as significant explaining variables regarding the number

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of associations. Similarly, in the case of 11th graders only school curriculum determined significantly the number of associations per capita The explaining strength of the above factors was significant in all cases, however, their predictive value (*B values*) was small (see Table 10).

Variables explaining the rate of solution of the selection task include television, radio and the internet in the case of 4th graders while in the case of 7th graders, friends, residential enquiries and school curriculum were decisive in what information students obtained in relation to RE. In the case of 11th graders, internet was important in obtaining knowledge regarding RE. Although the explaining strength of these factors was significant, their predictive value was not high (see Table 10).

Finally, the methods, activities and learning handbooks within schools were studied that could have had effect on knowledge related to RE.

Table 11. Relative frequency of the marking of factors within school indicating their role in learning RE based on replies of 7th and 11th grade students.

Factors within school	7th graders	11th graders
Teamwork	0.47	0.42
Watching films	0.46	0.39
Self-contained task at home	0.25	0.24
Project work	0.33	0.39
Presenter outside school	0.10	0.20
Visit to a factory	0.29	0.35
Trip	0.23	0.14
Separate theme week	0.17	0.13
Textbook content	0.60	0.70
Task in exercise book	0.42	0.20

Table 11 shows that 7th *(Cochrans'Q* = 560.86; *p*<.001**)** and 11th grade (*Cochrans'Q* = 424.55**;** *p*<.001**)** students selected the textbook with the highest frequency as the aid in which knowledge related to RE resources were met most often. Seventh graders considered exercise books also important while 11th graders marked exercise books with small frequency because only a few textbooks were supplied with exercise books in this grade. Table 11 also reveals that students felt that when they had learnt the topic of RE it had been most often in teamwork or in the framework of watching a film or project work. Least information was obtained in theme weeks during trips or in presentations outside the school.

The average of number of factors marked by students was also investigated in the case of both grades. There is no significant difference between the rate values in the case of 7th (3.31) and 11th (3.14) grade students (*Z*=1.24; *p*=.215; *d* = .080). In both grades, the students marked three factors on average in the course of which or with the help of which they learnt about RE. The most typical three factors included textbook, teamwork and project work.

Studying the correlation between the relative frequency of correct association and the rate of solution of selection tasks and the number of factors within school selected by one student, only weak connection was found. The value of Spearman's rho was .147 and it was significant (at the .01 level) regarding the number of associations per student in the case of 7th graders. While in the case of 11th graders, this value was .131 and also significant at the .01 level (regarding the differences between the correlations of the two grades, *q* value was .018 that is no effect). Spearman's rho value in relation to correlation between the solution of the selection task and the number of factors within school was .166 in 7th grade and was significant at the .01 level. In the case of 11th graders Spearman's rho was only .040 and was not significant. According to the effect size (*q* =.128) the effect of the grade level was small.

Considering the predictive role of factors within school in the knowledge of students related to RE, information was obtained again using the Stepwise option of multi-variable linear regression (see Table 12).

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Table 12. Variables explaining performance in the case of the association and selection tasks related to RE based on multivariate linear regression considering factors within school.

Grade	Task type	Independent variable	*R*	R^2	*B*	*F/p*	*t/p*
7th	Association	Theme week	.137	.118	.252	4.827/<.05	2.089/<.05
		Textbook			.238		2.297/<.05
	Selection	Textbook	.294	.086	.108	24.761/<.001	5.109/<.001
		Theme week			.131		4.777/<.001
11th	Association	Project	.124	.015	.287	5.084/<.05	2.255/<.05
	Selection	Textbook	.204	.042	.071	7.025/<.001	3.175/<.005
		Theme week			.067		2.155/<.05

Considering the results achieved in the association task, the explaining variables included the theme week and textbook in grade 7 while the project was the explaining variable in grade 11. Their predicting value was significant but not large (see Table 12). Regarding the results achieved in the selection task, explaining variables included textbook and theme week in both grades. Their predictive value (*B values*) was significant but small.

Discussion

The first two questions of the research were related to the knowledge of primary and secondary school students related to RE and whether or not there are differences in the knowledge of the investigated grades. In order to answer the questions two tasks solved by the students were analyzed. In the first, association task students were asked to write down the three associations (three words) that came into their minds related to RE. This question was aimed to investigate the stabilized terms related to RE.

Similarly to the results of Tóth and Gajdos (2012), the number of associations did not increase with grade while the ratio of correct associations relevant to RE resources did. Increasing of number of relevant associations was inconsistent because the smallest number of mentioned associations occurred in the case of 7th graders followed by 4th and 11th graders. The poorest result of 7th graders can be explained, on the one hand, by age group specifics (4th graders are still more creative and communicative while students give more careful and straightforward replies at later ages) and on the other hand, by the fact that primary school education pays not enough attention to the education of knowledge related to RE. The results of 11th graders showed the effects of geography teaching in Hungary which put great emphasis on the topic in grades 9 and 10 in secondary school.

Irrelevant words are worth mentioning as although many words classified here are associated with the application and use of RE resources in a wider sense. Such words showed an especially interesting image in the case of 4th grade students who formulated their thoughts frequently using childish language: e.g. security, good health, good life, fast rush, future, switching on the computer, animals yield, makes robots move, heats, gives hot water, it is on the roof, operates the refrigerator and the washing machine, more electric toys. These thoughts and expressions revealed the sphere of interest of students in relation to the topic and also the real, authentic problems appearing in their own life.

Association maps, drawn on the basis of the word association method (Cardellini, 2008; Nakiboglu, 2008), showed that the knowledge of students related to RE is very similar in all grades. The same associations occur in evaluable ratio (frequency > 5%) in all three grades (see Figures 1, 2 and 3). Associations presented in the association map (frequency > 5%) are also similar regarding both their type and mentioning frequency.

These results are similar to finding of research of Bamisile et al. (2016) and Büniamin et al. (2010) related to students' knowledge about RE but the word association method applied in our research provided more informa-

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tion about learners' knowledge concerning RE. The observable difference is that 4th graders mentioned only terms that could be presented in the association maps related to RE and its utilization while 7th and 11th graders mentioned also examples of the positives of RE. Another typical difference is that the strength of connection between the associations and RE was greatest in grade 11 compared to the other two grades. This reflects that students in secondary school learned and heard more about RE both in school and outside school. Application methods of RE resources and their social, economic and environmental significance together with their positive and negative sides were taught for them in geography. Despite this, however, no significant change in the knowledge system of the studied 11th graders was found compared to 4th and 7th graders. This calls attention to the joint responsibility of education and the society. The problem is caused primarily by insufficiencies in the content of curriculum requirements and textbooks related to RE (the content is dominated by presenting definitions and attitude forming content is little) on the education side (Revákné et al., 2018) while on the society side, the lack of exemplary behavior in relation to RE utilization.

In the second task students were asked to select and mark RE resources out of the listed energy resources. This task was applied as the cross query of the first, association task.

The rate of solution of the second task related to RE resources increased from 4th graders to 11th graders but remained only 69% in grade 11. These results show as well that students have insufficient knowledge about RE because education in and outside school does not pay enough attention to problem of RE. Based on the relative frequency of the selection and marking of the given RE resources in all three grades, the most frequently marked RE resources were wind energy, wind turbine, water energy, geothermal energy, photovoltaic cells, solar collectors, solar energy. This result is not surprising as students meet these terms in everyday life outside school as well and they experience the application of these terms most frequently. While using biogas, biomass and biodiesel, that were the least frequently marked terms, can be hardly heard in everyday life. In this way, the above result clearly reflects the joint effects of school and society on the knowledge of students related to RE resources. The fact that 4th grader students frequently mistake fossil energy resources for renewable ones is not surprising. The fact, however, that 7th grader students do this in higher ratio ($p<.001$) is surprising. Again, the problems of teaching RE resources in primary school can be seen. Even 11th grader students mistake the two types of energy resources but in much smaller ratio ($p<.001$) in comparison with the performance of both 7th and 4th graders that can be explained mostly by the effects of secondary school (particularly geography education) and also by age group specifics primarily the fact that 16-17 years old students pay attention to events in the society.

The correlation between the relative frequency of relevant associations and the solution of the selection task related to RE was found to be weak despite the fact that intermediate or strong correlation was assumed. This poor correlation can be explained by, on the one hand, missing associations, not mentioned by students, that are included in the list of the second task with poor frequency even there as well (e.g. biomass, firewood, biogas, biodiesel). On the other hand, sometimes a given student mentioned a correct association but forgot to underly in the second task. It may be also that students could name three correct associations related to RE resources that were not listed among the terms to be underlined in the selection task. The fact that the correlation, taking the above into account, was weak in the case of all grades suggests that the knowledge of Hungarian students in relation to RE resources is not sure independent of age. The lack of applying knowledge in practice and connecting knowledge to everyday life can be presumed to be in the background of the above together with the fact that alternatives of RE resources are not known enough even by the adult population in Hungary (Szabó et al., 2018).

Among factors that effect on performance in the association and selection tasks was the settlement type where the school of the students can be found. The investigated students in the studied major cities had greater (and probably more reliable) knowledge regarding RE resources. In the background there could be several factors like better organizational, pedagogical, methodological and infrastructural conditions of schools and education, information and education possibilities outside school like various forums, educational programs, projects, better financial conditions for urban people providing opportunities to the self-application of RE resources. Studying the accurate effects of the above factors could be the topic of another research project.

Investigating the influencing role of the educational level of parents, differences were found only in the case of performance in the second, selection task. Best performance in selecting terms related to RE resources was achieved by students of parents with higher education diploma in all three grades.

When the effect of the sources of knowledge related to RE resources on performance in the first, association and the second, selection tasks was studied, regression analysis clearly showed that school curriculum media, in-

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ternet, and residential informing were the most important sources and influencing factors of knowledge related to RE in all grades. In harmony with earlier research (Hasan, 2012; Szabó et al., 2018) this means that school interwines with social processes are jointly responsible for forming the energy consciousness of future generations. It is worth noting that the role of family members was not included among explaining variables in either cases indicating that the performance of the students solving the tasks was less influenced by information obtained from the family. This can be explained by that the adult members of the family also have little information regarding RE resources and their utilization as their application is not widespread enough and these application possibilities are not known enough in Hungary. As a result, RE resources and their application are rare topics of family chats.

The effects of methods within the school on performance in the second selection task were also investigated in grades 7 and 11. The most frequently marked methods with the help of which students learn about RE were textbook, teamwork and project work. Considering the number of marked factors among the listed ones, the same three methods were marked most frequently in the case of both grades. Regarding the effect of methods applied in school on performance in the tasks, only weak correlation was found between the number of methods selected by one student and the relative frequency of correct associations and the rate of solution of the selection task. There was no evaluable difference between the two grades in the above aspect. The performance of students learning knowledge related to RE with the help of more methods was not better in either tasks and in the case of either grades. This indicates that not the number of methods, aid and activity types in the course of which students learn RE is primarily important but presumably the efficiency of these factors regarding content, didactics, motivation, and cognitive and emotional aspects.

According to the regression analysis, textbooks, theme week and project were the most effective methods in school regarding performance in the tasks, i.e. students obtained the deepest knowledge regarding RE using these methods. In the course of a theme week students learn about a theme in school over one week generally using the project method. This involves intensive, self-contained student work in which the given topic is approached from a wide range of aspects using the associated terminology actively while solving problems. The same term, in this way, appears often in practice resulting in the terms becoming permanent and in more secure knowledge. This makes the role of theme weeks and project works reasonable in deepening knowledge, i.e. in the present case, making performance better in solving the two tasks. Similarly, textbook content is also the core in forming terminological and procedural knowledge entailing great responsibility on textbook writers.

Conclusions

The research investigated the knowledge of primary and secondary school students related to RE and its connection with knowledge influencing factors. Regarding knowledge related to RE students with age (7th and 11th graders) apart from knowing RE resources and their application were able to give examples for the environmental significance of RE and also for the benefits of its utilization. This is the result of increasing intellectual development level, on the one hand, and of expanding knowledge learnt in school or obtained from the social environment, on the other hand. Due to their age, 4th graders had more associations related to RE that were mostly irrelevant associations. Associations in their case and also in grades 7 and 11 suggested that experience from everyday life is decisive in forming the knowledge of students related to RE. Results of the two tasks used for the analysis of knowledge also proved that knowledge related to RE learnt in school and at the same time experienced in everyday life became more stable. Considering the influencing factors, the role of the settlement type where the school was located was decisive. Students of city schools had better knowledge related to RE that can be explained partly by differences in the schools of (more developed education infrastructure in cities, higher level of education) and partly by differences in the lifestyle (higher standard of living) in different settlement types. Another factor influencing the knowledge of students related to RE was the educational level of parents. Children of parents with higher educational level are more informed and have better knowledge related to RE. In the series of influencing factors, the role of media, residential information, internet, school curricula, textbooks, projects and theme weeks requiring the cooperation of students and active learning was also important to obtain knowledge related to RE.

An important conclusion of the research is that education in school must not ignore the age specifics of students in the process of obtaining knowledge related to RE. This was proved most of all by the results in relation to 4th graders shedding light on the fact that in this age not the knowledge obtained in school related to RE stabilizes primarily but knowledge experienced at home in their own environment becomes more stabilized. As

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a consequence, students at this age should not be made tired with abstract scientific terms but active education has to be provided for them in accordance with their mental development level and fields of interest based on the familiar examples of the environment surrounding them. One starting point could be the application of the terms listed by the students in this research as ideas originated from the thoughts of the students in the education of RE resources. With this the principle of constructive pedagogy stating that one should build on the students' pre-knowledge in the process of teaching and then incorporate new knowledge elements into the already existing thinking schemes. The above also helps the identification and elimination of misconceptions related to RE resources.

The research also proved that the knowledge of students related to RE increased with age, however, overall it was poor in the case of every grade. This means that despite effects in and outside school this type of knowledge of the students is not implicit. Curricula and textbooks could have a significant role in solving the above problem if they do not focus on terminology level knowledge but take some attitude and approach forming elements among the requirements. The incorporation of as many tasks of observation, experiment, data analysis, cooperative and project work in textbooks and workbooks as possible. A fundamental change of attitude is necessary in education to form the knowledge of students related to RE to make it a firm base for real decisions related to the application of RE.

Based on the results of the research, further trainings are planned focusing on teaching and learning methodology for primary and secondary school teachers. Moreover, the results of the research will be incorporated in the curriculum of teaching methodology of natural sciences teachers' training as well.

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