PANEL-DEBATE ON ENERGY PRODUCTION IN HIGH SCHOOL PHYSICS TEACHING

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Abstract: This paper presents a method to develop students' knowledge about energy resources and energy production through scientific argumentation in a panel-debate. The method was used with 15 different 11th grade classes in a high school from Romania. In the last five years a research was conducted about the change in attitudes of students towards different types of energy resources and how they accept environmental hazards due to energy production. Throughout these years several misconceptions were observed regarding the origin of energy resources, the energy production processes and its effects on the environment. In order to have a sound understanding of these misconceptions a study was conducted with the help of a 21 multiple-choice-item energy recources knowledge assessment. The test was completed by 720 9th to 11th grade high school students from nine different schools from Transylvania, Romania. Data analysis show similar misunderstandings to the ones in US schools and presented in other research papers regarding the understanding of energy resources and energy production by students. Together with the importance to have a well prepared society to decide about energy production constrains, comes the need to add an important chapter to the physics curriculum. We present strong arguments to introduce energy production as a new topic in the physics curriculum. Our results show the energy panel-debate is a very effective method to teach this topic.

1. Introduction

In this paper I want to point out the importance of learning scientific argumentation in school. There are many areas of science-based policy in which the public has to make its impact. Many of these issues, such as air quality, local traffic management, genetic engineering of foods, energy production, climate changes are complex. The science underlying these topics may not be straightforward and often uncertain. In these cases there may be empirical uncertainty due to lack of data, uncertainty about the data processing of large number of values, or theoretical uncertainty as well. Even so members of the public are able to come to reasoned conclusions. Coming to an independent, informed view on a topic such as energy production, however, places a great demand on our society. Thus, it comes out as one of the major goals of physics teaching to help students set up correct argumentation based on evidence gathered from different sources of reliable literature.

The demand for energy production is rising worldwide, as there is an average increase with more than 250% worldwide in the last 50 years [1]. Due to population growth and economical development the U.S. Energy Information Administration's International Energy Outlook 2017 projects that world energy consumption will grow by 28% between 2015 and 2040 [2]. Public pressure against the usage of fossil fuels is increasing in many countries, there is a debate going on towards the development of the energy sector. Thus, a restructruring of this important economical sector is imminent. As the environmental impact of energy production on our planet is significant, it is important that all citizens and especially young adults be equipped with the basic knowledge about energy resources and their impact on the environment so as they will be able to make deciscions and to have an opinion about future energy strategies [3]. As the topic raises a lot of controversial issues it is an excellent opportunity to launch a debate with role-play between students. Role-play is a common pedagogical tool for Social Sciences, in some cases is used for discussing climate change as well [4].

Romanian school curricula almost completely neglect the proper discussions about energy resources. In grades 6 to 8 energy resources and production are not in the core physics curriculum, only a possibility to an extension is mentioned in grade 7 as a short chapter energy and life (see order of Ministry of Education nr. 3393/2017, annex nr. 2). The high school curriculum for physics has no topics related to this subject, only the 12th grade geography curriculum sets a chapter only about renewable and non-renewable resources (see order of Ministry of Education nr. 4805/2000). Right now there is a plan of the Romanian Ministry of Education to develop new high school curricula due to be applied starting the academic year 2021-2022. So it is time to raise argumented proposals for possible new topics. Many states (UK, Australia, Hungary, some states in the USA) recognize energy resources concepts as being important for inclusion into the national curriculum. As an example for this you can see the energy systems project developed for STEM curriculum for K-12 students in the USA [5]. Important studies were made to facilitate a better scientific understanding of energy production topics, and avoid misconceptions [6,7].

2. Aim of the Research

The aim of this research is to point out the importance of teaching high school students about energy resources and energy production through a new method: energy debate. This is a debate about the energy production policies. It has been used in the Apáczai Csere János High School in the last 15 years. It was found to be a practical way to eliminate some misconceptions and to introduce a new chapter in the physics curriculum.

An additional goal was to investigate 9th to 11th grade Romanian high school students' knowledge about energy resources and energy production. This was made with the help of an assessment developed by Alec Bodzin and used in US state of Pensylvania for studying knowledge of eighth-grade students on energy resources [8].

The paper also aims to point out misconceptions of students related to this topic, and to show the effectiveness of discussing energy policies with students in the 11th grade.

3. Learning about energy resources and production through energy debate

The energy debate at first was used with 12th grade students, later it was included in an optional environmental physics and geography course developed for 11th grade students. At this age students get sufficient background information on the topic and their intellectual development is high enough to make analyses of complex processes such as energy production strategies. They are also capable of argumentation along a sound documentation. From the experience of these years it can be said that students could easily get involved in studying this subject and were open to additional effort to get the required information.

3. 1. The energy debate method

Argumentation has a central role to play in science and in learning about science. Nonetheless, we rarely use methods that help develop scientific reasoning [9]. In this subsection the energy debate method is presented. This particular debate method consists of four different parts, for which six lessons are allocated. The first lesson for an introduction (first part), two for preparatory discussion (second part), other two for the effective debate (third part), and the last one for the discussions after the debate (fourth part).

3.1.1. Introduction to the panel-debate. In the introduction the teacher presents the topic of the debate: students have to put themselves in a role-play situation, as participants of a live broadcast TV show with a thematic panel-debate about the future of energy production for their region, in our case Transylvania. It is important to have a strong implication of students in the debate and it is more probable that a student will be able to get more relevant data about the local energy production than about some remote region. During this class students get a short introduction on current energy production issues and they can propose invited guests and experts for this "TV programme". As they put themselves in the role of the moderator of this show students come forward with several possible invited speakers: experts for different energy resources types (solar, nuclear, wind, hydroelectric, fossil fuel, geothermal, biomass other renewable energy), environmental activists, politicians (mayor of our town, prime minister, the minister of finance), geologist or European Union energy policies expert. There are roles which could be shared by several students, like environmental activists, because it is important to leave students to get involved in a field which is of their interest. Students with less motivation for this topic or those with lower communication skills can be left to be just simple observers of the debate. The task for them is to write a critical evaluation about the panel-debate and if possible to present it in the evaluation part of this process.

3.1.2. Preparation, a global view. After the introductory phase some major problems about usable energy production (mainly electricity) are reviewed: 1. the need for energy is increasing as population and the standard of living is rising worldwide, 2. there is a need to decrease the costs of energy production using technological innovations, 3. power plants are depreciating in time, they need future investments and modernisations, 4. the environmental impact of power plants should be reduced. It is important to familiarize students with the units of measurement used in energy production in orther to be able to compare the effectiveness of different power plants. The energy mix (the distribution of the various energy sources) of different countries is presented (see Figure 1.) and discussed with students. We analyse data regarding the extent of carbon dioxide emissions associated with energy production by country. For example in Figure 1 Netherlands and Poland stands out with a large share of fossil fuels, in case of France the large share of nuclear energy is discussed, while Sweden is the top country using renewable resources. The last issue in our discussions is the local energy production which could be followed by detailed updated daily data on the website of the Romanian National Energy Production Agency (www.sistemulenergetic.ro), which is a valuable and reliable source of information. We could discuss the daily energy consumption variations of the society and the sources of the energy production that could follow these. The seasonal changes were followed as well in order to have a better view of the complexity of the national energy production system.

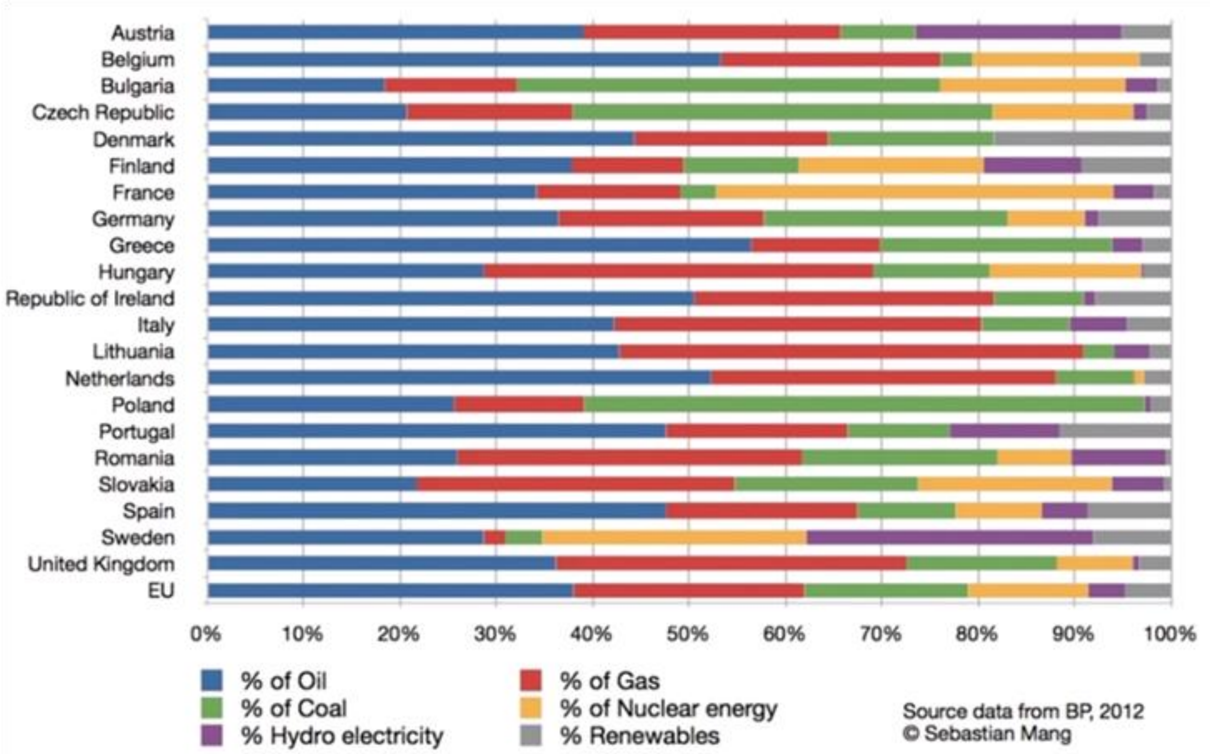

Figure 1. *Energy mix of countries from the European Union in 2011 [10].*

In this preparatory phase each participant in the energy debate gets individual guidance for his role with some relevant printed or online resources regarding his field of interest. Students have to make research for additional resources and an outline of their presentation for the debate. Students are expected to gather information about costs of building and operating a power plant, study the need of human resources of each type of power plant and the environmental impact of each.

3.1.3. The energy panel-debate. The activity is organized in a double lesson time (2 x 50 minutes), usually without a break, as students are so highly motivated that, they do not even claim for a break. The arrangement of the classroom is important in order to have an impression of a round-table discussion, as seen in Figure 2. The observers are located outside the circle, as they take notes, and they can have questions or comments during the panel-debate. Students prepare nametags with their role stated on them. Usually they make it spontaneously without this being an expectation towards them. A general mode of progress of the energy debate is described in the followings, which depends very much on the attitude of the class involved in this process and also depends highly on the personality of the moderator.

Figure 2. *Energy debate under progress in 2018. (photos made by the author of this article)*

A possible course of the debate is as follows. The main role is that of the moderator of the debate, also a student, who starts with a short keynote speech to present the framework of this debate and some general information regarding the need for a new energy strategy of this region. The moderator on first hand gives the word to the energy experts in different resources. After the presentations delivered by each expert, there is an opportunity for reflections by environmental activists, with a possibility of reply by the expert. Students in the role of politicians may pose questions as well in order to gather information. The EU energy policies expert comes after to present main power plant types, which are financially supported by the European Union. This is followed by the presentation of the geologist about possible energy resources in the region, which could be used in the future. At last politicians present their policies to adopt for the energy production sector. After their statements, energy experts and environmental activists may come forward with additional proposal or criticism of the presented views. At the end the moderator says some final words and sums up the main conclusions of the debate.

It has to be mentioned that in most cases 11th grade students have a strong culture of debating, they take their roles very seriously, can pose critical questions and give structured answers regarding the topic. Experts deal with a lot of new information and in many cases their opinion is relevant.

3.1.4. Discussion after the debate. The last activity after the energy debate is the evaluation itself, where students with the role of observers point out the main the essential elements of the debate. Usually they tend to be very critical as well, but it highlights the fact that through this activity they gathered a lot of new information.

In many cases students report about a fundamental change in attitude towards specific energy resources. In general they outline misconceptions regarding renewable energy resources, like the term “green energy” is misleading them to think these do not have any environmental impact, and that they could be used on large scale. Another strong concern regards the nuclear power plants, but for many students it was revealed by grounded argumentation of their classmates that these, under control, could be an acceptable alternative. It is an important part of this activity that the teacher needs to rely strongly on pupils, and must not interpose with any remarks during the debate. Only through the evaluation phase the teacher gives feedback to each participant and the eventual unsound pieces of information are corrected.

3. 2. Evaluation of the energy debate method

The debate method has multiple positive effects on students' intellectual development: building self-confidence, increasing verbal skills, it leads to open-mindedness, critical and logical thinking [11]. In the last five years (2014-2018) a study was made, at the end of the energy panel-debate activities, on the change of student’s attitude about energy production due to this method. In each year one class of our school participated in this activity. After each debate a survey was made about students’ opinion on the following question: what is the energy mix that you would accept for our region in the future (for year 2040). So they had to give the percentage of the 5 main energy production types from the total energy production of the country. Students knew the actual production from the above mentioned website of the national energy production agency. It has to be mentioned, that only four activities followed the precise methodology of our energy debate method, while in 2015 the activity was organised without the second part, the “preparation, a global view”. In this case students did not get any guidance, they had to gather information on their one, and they were not provided suggestions of biographical resources either.

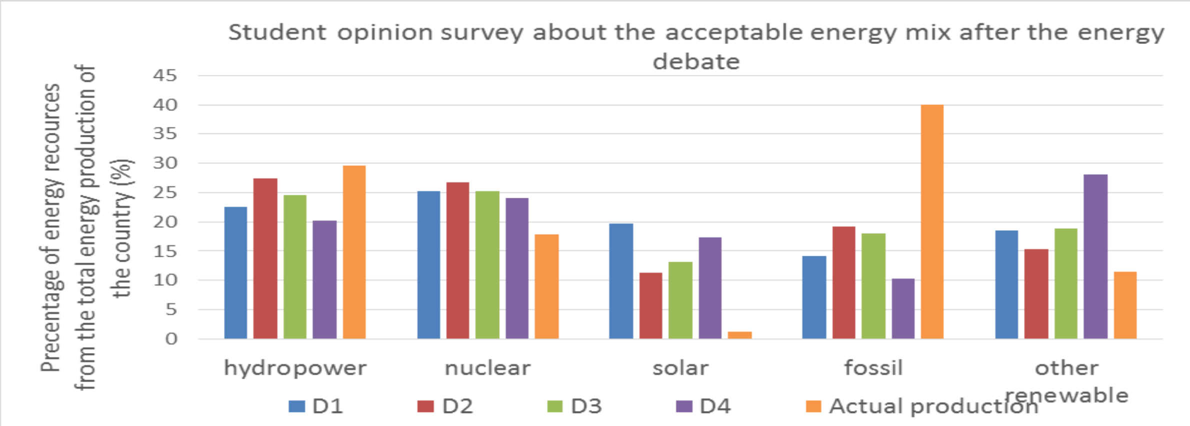

Figure 3. *Survey of student opinion after the energy debate about the acceptable energy mix compared with the actual energy production in Romania (www.sintemulenergetic.ro, 2016)*

Debate 1 (D1) took place in 2014 with 28 students, debate 2 (D2) in 2016 with 24 students, debate 3 (D3) in 2017 with 26 students, and debate 4 (D4) in 2018 with 24 students. Figure 3. shows average values for the question above for those classes which followed the activity in accordance with the presented methodology. We can observe very similar attitudes of students. Differences show just the effectiveness of presentations from different students playing the energy experts role: in 2014 one student was very persuasive about using solar panels, in 2017 a student got very strong arguments for other renewable resources, especially for geothermal ones, which could be a very important resource in Transylvania, whereas in 2018 a student was convincing about the negative impact on the environment of hydropower stations.

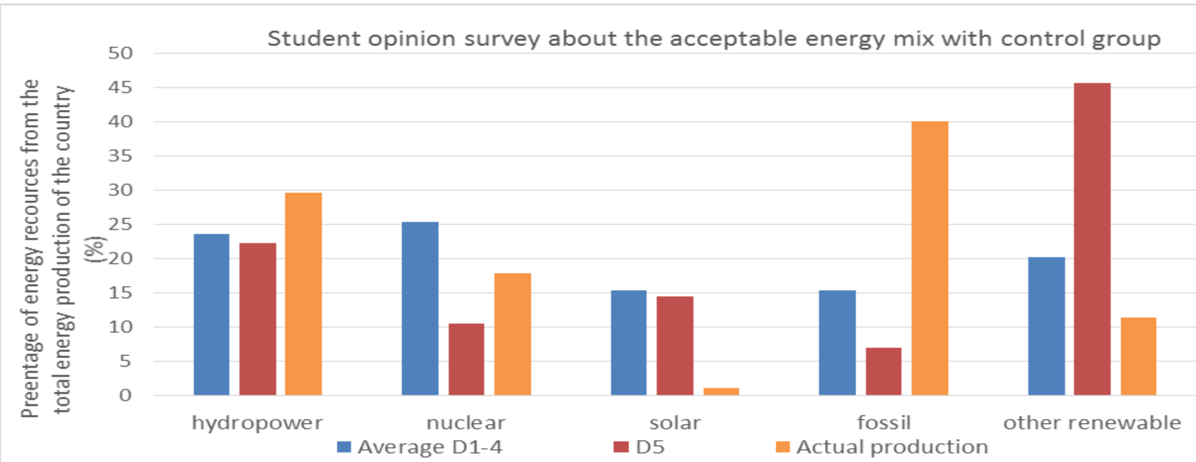

Figure 4. *Comparison of a control group (D5) with the average of the above presented four groups (D1-4), participants of the energy debates, and the actual production in 2016.*

The energy debate activity from 2015 (D5) was used to serve as a control group and to see how students can process information and data about energy resources and energy production without any preparation and guidance. The same discussion and evaluation was made with this class as well, posing the same question about the future of the energy mix in our region. As we can see from Figure 4., after the energy debate the attitude of students showed the same misconceptions as other students reported in their final remarks on their knowledge before the energy debate was taken. This control group thinks that in a relative short period of time other renewable resources could have a 45%, and sunpower a 15% share from the total energy mix, which could largely substitute the nuclear (10%) and fossil fuels (7%), which they strongly reject. Their views are based just on some superficial informations.

4. Assessment of general knowledge about energy resources and energy production

As presented in the last section, through the experience of the last years with energy debate it was observed that students lack a lot of knowledge regarding energy resources and energy transformation processes in the production of electrical energy, even more a lot of misconceptions could be seen surrounding this important topic. In order to have a better understanding of these problems a survey was conducted with a large sample of youngsters from high schools in Romania.

4. 1. Participants of the survey

In this research 720 students taught by thirteen teachers from ten high schools from Romania were involved, from eight different cities of the Transylvania region. Of all the students 264 (36.7%) were from 9th grade, 258 (35.8%) from 10th grade and 198 (27.5%) from 11th grade, see Figure 5a. The majority of students, 573 (79.6%) were studying in theoretical high school classes, only 20.4% in technological classes, mainly comprising the economic profile. Out of those studying at theoretical highschool classes 462, so about 64% from the total number of students, were enrolled at a science academic program: mathematics and computer programming or natural sciences, and 111 students were following a humanities program: social studies or languages (Figure 5b.). All the students got only some fragmentary information about energy resources and energy production during their school studies. This was through a wider perspective of natural resources in 4th and 8th grade geography classes or evenually by the study of foreign languages (mainly English and German or French). Thus, most of their knowledge comes from media programmes, online resources and readings.

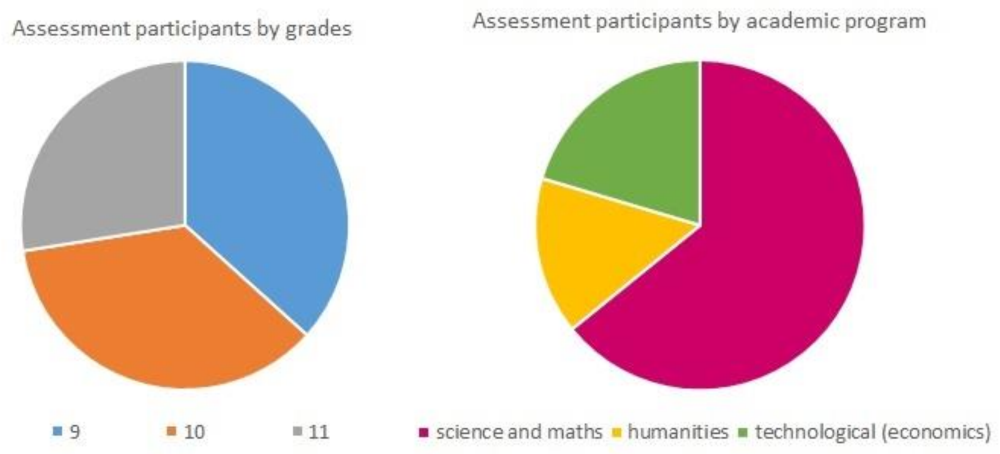

Figure 5. *Statistic data of the participants in the energy resources assessment (5a. left - distribution by grades, 5b. right - distribution by academic program)*

4. 2. Assessment method

The Energy Resources Knowledge Assessment was used from the study of Bodzin, who made a 39 multiple-choice-item test on three main energy content areas: I. energy resources acquisition; II. Energy generation, storage, and transport; and III. Energy consumption and conservation. A modified version of the test was applied in order to take maximum 15 minutes to fill in, so only 21 items were chosen from Bodzin's assessment [8]. There were 9 items regarding the first content area, 7 items concerning the second one and 5 items measure knowledge about the third area. Assessment items are contained in Table 2., 3., and 4. respectively.

For an easier data handling and processing an online application (www.quizizz.com) was used, which allows several students from different locations to fill in the same quiz (maximum 5000) on any kind of device with a browser (PC, laptop, tablets, smartphones). Questions appear on each student's screen, so they can answer questions at their own pace, and review their answers at the end. The application gives detailed reports at class-level or student-level, which could be downloaded in an excel worksheet. The application helped us to send easily the assessment test to all the participant schools, and to get back the results instantly, as soon as the test was completed. In this way data could be analyzed. The assessment was filled out as a homework project (as anyone with the code of the project could complete it within the given period of time) in the last week of the 2018-2019 academic year.

4. 3. Findings

Table 1. displays the summary statistics of the students' knowledge about energy resources and production. For each correct answer students got one point, while for wrong ones zero point, thus the maximum score was 21. Mean scores for the entire assessment group reveal similar misconceptions and a low level of understanding as in case of the existing literature [8,11,12,13], regardless the country of origin of students surveyed in these studies (US state of Pennsylvania, Turkey or Thailand and New Zealand, Germany). Most of the students do not realise the negatve impact on the environment of so called green recources, as hydroelectric dams, solar plants, wind turbines or geothermal power plants. Many students think that in a very short term more than half of the energy production of a country could be covered by renewable energy resources.

The mean value shows that students could answer correctly in average only to the half of the items and standard deviation is relatively high. We can observe a difference in the mean value according to the student's academic program in which they are enrolled. Students with stronger background in natural sciences have suceeded much better. Better scores of students from social studies or languages compared to students from technological classes could be explained by their higher entering scores at high school admission in nineth-grade and by the science subject in their core curricula in eleventh grade, subject that students from technological classes do not have.

Table 1. *Energy recources and energy production assessment results based on the academic programs (n=720)*

Students academic program	N	Mean scores	Standard deviation
all academic programs	720	10.54	3.9
mathematics and computer programming or natural sciences	462	11.53	3.7
social studies or languages	111	9.32	3.1
technological (economics, turism, etc.)	147	7.61	3.2

Item analyses were conducted by including item difficulty level and item discrimination of each item. Item difficulties ranged from 0.24 to 0.71. Two items had item difficulty levels (P value) less than 0.3, nine items had a P value between 0.3 and 0.5, which were high difficulty level items. Nine items were of medium difficulty with a P value ranging between 0.5 and 0.7. Only one item was of low difficulty level, with a P value above 0.7. Item discrimination ranged from 0.31 to 0.6. It should be mentioned that items with a low P value (very difficult items) have low item discrimination [15].

In the tables below a detailed examination is made for each item separately, data is being presented separately acording to the three energy content areas surveyed. The whole group of students is considered. Of course, as we would take the separate groups according to their academic background we would see the same differences as presented in Table 1., where students from the natural science academic program had slightly better results. Most of the misconceptions could be seen in the case of each group, only the level of misunderstandings is different. Table 2. regards the first energy content area, energy acquisition: renewable and non-renewable energy resources. From these results it is shown that students from Romania have approximately the same knowledge about energy resources as students from Pennsylvania. Their slightly better performance could be due to their older age group, as they are 1 to 3 years older, so they have much more experience. It is striking at first sight that the only item from the whole assessment where the performance of American students was significantly higher was the first one, where Romanian students had just a 58% success-rate, while more than 80% of American students knew the correct answer. Almost 36% of Romanian students think that water is the original source of energy for almost all living things on earth, which shows a misunderstanding between energy source and nutrition (item 1). A very high rate (71% and 65%, items 2 and 5) of students can distinguish between renewable and non-renewable biofuels. About the definition of renewable energy resources (item 4) many students have some misconceptions. Students think that renewables do not produce air pollution (14%) or they are very efficient to use for producing energy (12%), or can be converted directly into heat and electricity (15%). Romanian students have a much better, but not too good knowledge (42% compared with 13%) about the origin of petroleum and natural gas (item 3), than the American students, even many of them (21%) think that they come form dead dinosaur remains. Similarly, they could not name the fossil fuel which is formed from swamp plants that lived millions of years ago (item 6), as very high rate (33%) of students think that it is petroleum, instead of coal (32%). Item 8 shows that many students do not have any knowledge about the energy producing mechanism in a nuclear power plant, as in many cases (34%) they regarded nuclear energy nonrenewable because it produces waste that is very radioactive.

Table 2. *Item analyses of the energy acquisition: renewable and non-renewable energy resources content area (n=720)*

Item question	Correct answer	N	P – item difficulty level	Item discrimi-nation	Bodzin – item difficulty
1. What is the original source of energy for almost all living things on earth?	Sun	720	0.58	0.45	0.81
2. Which of the following is not a renewable biofuel?	Petroleum	720	0.71	0.49	0.51
3. Petroleum and natural gas come from	Plankton and sea life that are millions of years old	720	0.42	0.46	0.13
4. The term ‘renewable energy resources’ means resources that...	Can be replenished by nature faster than they are consumed	720	0.52	0.57	0.57
5. Which energy resource is non-renewable?	Natural gas	720	0.65	0.56	0.36
6. Which fossil fuel is formed from swamp plants that lived millions of years ago?	Coal	720	0.32	0.31	0.17
7. Areas with geothermal resources include…	Geysers, fumaroles, hot springs, and volcanoes	720	0.69	0.44	0.48
8. Nuclear energy is considered NON-RENEWABLE because…	The uranium fuel sources are found in rocks that can be mined out	720	0.33	0.51	0.21
9. In the year 2250, most of the world’s energy will likely come from…	A mix of renewable energy sources	720	0.61	0.52	0.58

In Table 3. we examine the results obtained for the second energy content area: energy generation, storage and transport. Data processing revealed that the majority of students do not understand how different energy resources are converted from their source form to electricity. Students do not have a sound understanding of the environmental impact or the advantages of different energy resources to generate electricity. There could be a long debate about item 10: the energy production method with the least environmental impact, as recent researches show that geothermal power plants could cause earthquakes [16]. The population treats with serious reservation the environmental impact of nuclear power plants due to lack of informations about the security of modern power plants. This is shown in our results as well, where nuclear power plants are placed regarding their environmental impact at the same level as coal fired power plants (only 8% indicating these as having the least impact). A very high proportion of students is not aware of possible environmental impact of wind turbines (32%) or of hydropower stations (28%), whereas only 24% indicated geothermal power plants. Students have also misconseptions about the definition of energy efficiency of power plants (item 11), as they indicate in many cases as correct answers the following: every 35 unit of energy that go into the power plant 100 units of electricity is produced (19%), or that from every 100 unit of energy that go into the power plant, 35 units are lost (23%). The 12th item measured how well-informed students are, as in the case of our country as a fairly similar amount of energy is produced by coal, petroleum or in hydropower stations. This is reflected in the answers of the students as well, where 17,5% of students think that natural gas, 20% that water, 23% that petroleum is the most significant source of electrical energy in our country.

Results show a very poor understanding of the advantages of different energy resources, as both in the case of geothermal resources (item 14) and for the best location to build a factory (item 16) wrong answers had a similarly high choice. Energy transformation processes in a hydroelectric power plant (item 15) are not clear for students, as only 28% knew the correct answer.

Table 3. *Item analyses of the energy generation, storage and transport content area (n=720)*

Item question	Correct answer	N	P – item difficulty level	Item discrimi-nation	Bodzin – item difficulty
10. Which type of electricity generation has the least environmental impact?	A geothermal power plant in a hot earth area	720	0.24	0.37	0.14
11. What does it mean if an electric power plant is 35% efficient?	For every 100 units of energy that go into the plant, 35 units are converted into electrical energy.	720	0.40	0.41	0.36
12. Most electrical energy in Romania is produced from…	Coal	720	0.32	0.48	0.22
13. Photovoltaic cells convert ………. directly into electricity	Light energy	720	0.68	0.56	0.43
14. Which is an advantage that geothermal power plants have over fossil fuel burning power plants?	Goethermal power plants do not have to transport fuel.	719	0.30	0.38	0.22
15. In a hydroelectric dam facility, water pressure in the reservoir forces water to turn a turbine that generates electricity.	This is an example of gravitational potential energy being converted to kinetic energy	719	0.28	0.40	0.20
16. The best place to build a new factory is at a location near an electric power plant because…	Less energy is lost during electrical transmission	717	0.40	0.60	0.34

In Table 4. the results about the third energy content area is presented: energy consumption and conservation. This field is the best understood by students from Romania, at each item a notable difference is observed between their knowledge and the one of the students from Pennsylvania. Still they have some misconceptions, especially about energy consumption, as for example many of them think that we use the most electrical energy (item 17) for entertainment (20%) and for lighting the house (18%), probably because these are the appliancies the most used by youngsters at home. As for the devices which consume the least energy (item 18) students identified correctly entertainment (36%), but many indicated cooking and storing food (25%) and lighting the house (21%), which could be in some cases a correct answer as the majority of households have changed their lighting system in the last few years for the energy efficient LED light bulbs. It is not surprising that our students know much better the units of measurement of different physical quantities (item 21), as very much emphasis is put on it in our physics curricula.

Table 4. *Item analyses of the energy consumption and conservation content area (n=717)*

Item question	Correct answer	N	P – item difficulty level	Item discrimi-nation	Bodzin – item difficulty
17. Which uses the MOST ENERGY in the average European home in one year?	Heating and cooling rooms	717	0.46	0.47	0.25
18. Which uses the LEAST ENERGY in the average European home in one year?	Entertainment (TV, computer, video games)	716	0.36	0.38	0.10
19. Which use consumes the most petroleum in Romania?	Transportation	716	0.56	0.47	0.30
20. Which energy source is likely to run out first?	Petroleum	714	0.67	0.49	0.30
21. The amount of electrical energy we use is measured in units called…	Kilowatt-hours (kWh)	713	0.66	0.56	0.18

The same energy resources knowledge assessment was completed by one class (24 students) who took over the energy debate activity one year before. This class was following a mathematics-computer programming academic program. A significant difference is observed compared to the similar subset of 462 students, who did not have the energy debate program (control group).

Table 5. *Efficiency analyses of the energy debate method through the energy resources knowledge assessment*

Item nr.	Control group		Energy debate group		Item nr.	Control group		Energy debate group	
	N_1	P_1 – item difficulty level	N_2	P_2 – item difficulty level		N_1	P_1 – item difficulty level	N_2	P_2 – item difficulty level
1.	462	0.65	24	0.83	**12.**	462	0.36	24	0.54
2.	462	0.77	24	0.95	**13.**	462	0.76	24	0.91
3.	462	0.47	24	0.67	**14.**	462	0.32	24	0.62
4.	462	0.60	24	0.91	**15.**	462	0.30	24	0.57
5.	462	0.73	24	0.91	**16.**	460	0.46	24	0.67
6.	462	0.34	24	0.54	**17.**	460	0.51	24	0.71
7.	462	0.75	24	0.91	**18.**	460	0.39	24	0.54
8.	462	0.38	24	0.62	**19.**	459	0.61	24	0.83
9.	462	0.67	24	0.91	**20.**	458	0.72	24	0.95
10.	462	0.27	24	0.46	**21.**	457	0.71	24	0.87
11.	462	0.47	24	0.79					

Results presented in Table 5. show that this group understands better the differencies between renewable and non-renewable resources. They also understand fairly better the mechanisms of electrical energy production. The energy debate group had a mean value for the 21 item assessment of

16.14, while the control group only 11.53, a difference of 40% in favour of the first group. In case of the energy debate group ten items were of low difficulty level, with an item difficulty level above 0.7 and the rest of the items were of medium difficulty with a P value ranging between 0.5 and 0.7. This shows the knowledge aquiered through the energy debate remained in the long run, which demonstrates the effectiveness of the method.

5. Conclusions

This study investigated the impact on student's attitudes of the energy panel-debate, as a new method. The paper gives a detailed description of the method used by the author in the last 15 years. The research made with the last five groups of students show the importance of the discussion and preparation phase of this activity, as this is helping students to a better understanding of energy production systems and to resolve pre-established misconceptions. Results in Table 5. show that due to the energy debate method students acquire a deep understanding of renewable and non-renewable energy resources, and also the majority of the misconseptions were cleared.

While many countries dedicate an important role in the physics curriculum for teaching energy resources and different processes of energy production, in Romania this topic is totally neglected. The envolvement and the high rate of interest of students towards the problems discussed related to the energy debate is a convincing argument to suggest the introduction of this new chapter in the physics curriculum in high schools, especially in the upper grades, 11^{th} or 12^{th}. A possible method of discussion for this topic could be the energy debate method.

A comprehensive energy resources knowledge assessment measured the knowledge of 9^{th} to 11^{th} grade students (ages 15-17). In this assessment 720 pupils took part. It was found that this sample group had low to medium understanding of the energy production processes. We found similarities with assessments made in other countries. Compared with the low level of understanding found by Bodzin for eighth-grade students from Pennsylvania, a better understanding was observed in case of our sample group. This could be explained by their older age group, having acquired more information about the topic in off-school situations, as they did not meet this topic at any school subject.

In subsection 4.3. many misconseptions related to energy resources and energy production processes were presented, based on the Energy Knowledge Assesment, made with a significant control group (462 students). As the same test was completed with students taking part at the energy debate, a relevant shift in comprehention of energy resources and production knowledge was revealed. This is shown by an increase of their knowledge by 40% about this topic. This shows the effectiveness of the energy debate method, and the importance of discussing energy policies with students in the 11^{th} grade.

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