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Teachers' Beliefs about STEM Education Based on Realisation of the "Energy as a Value" Project in the Slovenian School System*

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The cross-curricular project *Energy as a Value* described in this study involved almost all subjects in the K-12 curriculum of the so-called technical gymnasium. It became the framework for an effective Science, Technology, Engineering and Mathematics (STEM) education. Although the project offered interdisciplinary connection of all STEM subjects, promoted problem-based learning and pointed out to applications of subjects' contents to engineering profession it was not added up as a successful one. Teachers' satisfaction was questionable at the end of the four-year project time. Teachers were not initiators for a new project. The Engineering Education Beliefs and Expectations Instrument for STEM education is used in order to find the reasons for such an ambitious project not being carried out again. The instrument documents teachers' beliefs and expectations about pre-college engineering instruction, college preparation, and career success in engineering, and compares teachers' views. It is applied to teachers of technical gymnasiums in Slovenia that teach STEM subjects in order to find out if there are differences between beliefs of teachers that carried out the *Energy as a Value* project and teachers from other technical gymnasiums, as well as differences between beliefs of mathematics/science teachers and technology-based/engineering teachers. The results of statistical analyses give answers about obstacles that teachers who carried out the ambitious STEM education in a particular school system might be confronted with.

Keywords: STEM education; teachers' beliefs; K-12 curriculum; interdisciplinary engineering project; project-based learning

1. Introduction

Following the acronym adoption, no single, universal definition of STEM (Science, Technology, Engineering, and Mathematics) exists and it holds different meanings to different people [1, 2]. Sanders [3, p. 21] describes that "STEM education includes approaches that explore teaching and learning among any two or more of STEM subject areas and/or between STEM subjects and one or more other school subjects". National research Council [4] exposes that the bulk of research and data concerning STEM education at the K-12 level relates to mathematics and science education; research in technology and engineering education is less mature because those subjects are not as commonly taught in K-12 education. Furthermore, varieties of conceptual connections among STEM subjects use the fact that science inquiry and engineering design provide opportunities for making STEM learning more concrete and relevant.

In the last two decades, there have been many articles written about STEM education and integration and therefore many reviews about this topic were provided [1, 5–7]). Brown stated in [1] that among eight popular journals for STEM subjects' educators and researchers, the most frequent studies were those that included students at the K-12 level. He found many articles that do not identify themselves as articles about STEM, but are connected to the four disciplines in STEM education (article [8], for example). The majority of the K-12 research is conducted for articles in practitioner journals with description of action research activities, in which teachers try a new method or activity in the classroom, report on the results and share detailed instructions for fellow teachers to complete a similar activity [1]. However, among huge numbers of articles there are not many studies about integration of all STEM subjects into K-12 curriculum and not many concrete analyses about effectiveness of such education ([1, 6]).

Successful integrations of all the STEM subjects in the K-12 curriculum often use projects, that can be realized out of school like in [9] or in school like in [10–13], following the PBL approach. In these realizations, PBL refers to project-based learning where knowledge of mathematics, science and technology is applied to engineering projects; and is carried out over a longer period of time. Authors of the mentioned articles analyse students' attitudes in such approach [10, 11], their motivation [9] and achievements [12, 13]. They report about students' positive experiences in the described STEM education.

Effective change of STEM educational strategies should involve long-term interventions, should last at least one semester, should require understanding of particular school system and should change the beliefs of educators involved [5]. There is a limited

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amount of research that examines the prerequisite skills, beliefs, knowledge bases, and experiences necessary for teachers to implement integrated STEM education [14]. One of the challenges teachers face in implementing is how to integrate the related pedagogies into the traditional high school curriculum [15]. Findings of Petrosino, Gustafson and Shekhar [16] indicate great alignment with the apparatus, standards, and technology strands and disparity within the assessment and activities strands between the prescribed unit and its enactment in the course by the teacher. Clarifications of STEM terms, articulation of how students can interact in non-judgmental ways and providing multiple opportunities for interacting within engineering education are some implications for teachers facilitating STEM education, examined by Hudson, English and Dawes [17]. Bell found out that teachers' personal knowledge and perception of STEM is intrinsically linked to the effectiveness of STEM delivery in their own classroom practice [2].

We describe the STEM long-term intervention which involves all STEM subjects in K-12 curriculum. This intervention follows the PBL approach integrated in a particular school system. The present study focuses on teachers' beliefs about the described pedagogical approach, since their beliefs can influence further STEM interventions.

2. Description of the intervention

Secondary education system varies a lot across countries. Therefore, it is difficult to make international comparisons about the effectiveness of such systems. Despite the variations, students' knowledge about basic disciplines of mathematics and science in the last year of secondary education was compared in the Trends in International Mathematics and Science Study [18]. Slovenia participated in this study among other countries worldwide. The analysis showed that prior to entering university, Slovenian students gain very good knowledge of mathematics and science in comparison with students of other participating countries. Their teachers are well-educated, but they lack mutual cooperation in comparison with the teachers of other participating countries. Moreover, in the time of the study, Slovenia ranked second to last with regard to the number of Slovenian students wanting to study engineering [18, p. 141].

In Slovenia, a gymnasium offers schooling after obligatory primary school and prepares students for tertiary education. A gymnasium education takes four years and ends with a final aptitude test called Matura. Matura test is standardized at the state level and serves as an entrance qualification for universities. One of the three existing types of gymnasiums in Slovenia is the so-called technical gymnasium with the focus on STEM subjects which offer a solid base at the level of secondary education for studying in the field of engineering. According to the curriculum for technical gymnasiums, students learn these subjects separately. They can gain science knowledge in obligatory subjects such as Physics, Chemistry and Biology. They learn technology in an obligatory subject Informatics and in learning statistics (as a part of Mathematics) or in non-obligatory subjects: Computer science or Computer systems and network. Students gain engineering knowledge in at least one chosen subject: Electrotechnics or Mechanics supported with lab exercises and examined also in Matura and in non-obligatory subjects of Electronics or Mechanical engineering. Mathematical knowledge is learned in the obligatory subject Mathematics.

The aims of the renovated curriculum of mathematics and science in 2008 and curriculum of technology-based and engineering subjects in 2010 are very ambitious in terms of meeting interdisciplinary challenges and requiring teachers' cooperation in cross-curriculum subjects [19]. The curriculum encourages teachers to make connections between STEM subjects and provide STEM education that is not explicitly defined as stated Bell in [2]. Teachers have the freedom to choose the appropriate time for interdisciplinary connections, to organize a timetable for cross-curricular integration, to design a way of interdisciplinary connections and to carry out effective STEM education. This is a hard task for even very competent and successful teachers.

At the technical gymnasium, Novo mesto School Centre, teachers found an elegant solution of STEM education integration in a cross-curricular project. The project was approved by the National Education Institute. It started in year 2009 and 93 first-year students from three classes participated in it. The project was called *Energy as a Value* and it involved 4 modules, one for each school year:

1. Rational usage of energy;
2. Transformations of energy;
3. Energy and traffic;
4. How to reduce energy consumption.

The project involved almost all subjects in the curriculum and it became the framework for effective STEM education. Students were satisfied with this 4-year project, but teachers' satisfaction was questionable. Some remarks were heard at the end of the four-year project time. Moreover, teachers were not initiators for a new project.

In order to find the reasons for such an ambitious project not being carried out again, we used the

Engineering Education Beliefs and Expectations Instrument (EEBEI) for STEM education [20]. The instrument documents teachers' beliefs and expectations about pre-college engineering instruction, college preparation, and career success in engineering, and enables comparison of teachers' views. We applied this questionnaire to teachers of technical gymnasiums in Slovenia that teach STEM subjects in order to find answers to the following research questions:

- Are there any differences between STEM education beliefs of teachers that carry out the *Energy as a Value* project and teachers from other technical gymnasiums?
- Are there any differences between STEM education beliefs of mathematics/science teachers and technology-based/engineering teachers?

In the article, the *Energy as a Value* project realization in STEM education is described in more detail. Furthermore, the method of questioning STEM teachers is written in detail. Based on the questionnaires' analyses we try to get answers on the posed research questions and make a real picture about the *Energy as a Value* project.

2.1 Cross-curricular project realization in STEM education

Our cross-curricular project realization deals with the problem—and project-based learning approach in STEM subjects' integration in K-12 curriculum, where new knowledge of STEM subjects is triggered by engineering problems as defined in [21]. The brief description of PBL approach in *Energy as a Value* project realization is written in [22]. In the following paragraphs, we concentrate on subjects' integration and problem examples.

The project *Energy as a Value* connected teachers of all STEM subjects to cooperate with each other. For each module teachers of all STEM subjects designed engineering problems connected with various energy transformations, rational usage of energy, recent energy changes in traffic and ways to reduce energy consumption. Each teacher prepared problems from the mentioned engineering fields that trigger learning of particular content or applied new subject content to the field of engineering. Physics was the "leading subject" of this project. In this subject, students got the basic knowledge for solving various engineering problems in other courses.

Mathematics teachers also drew explicit connections with other STEM subjects when teaching statistical contents. We describe the project from the mathematical point of view because we cooperated with a mathematics teacher. In the curriculum for technical gymnasiums there is some extra time allotted to projects (called project week) and mathematics teachers used this time for cross-curricular interaction. For each school year, engineering real-life problems were designed that integrate contents of statistics as a part of Mathematics with at least one curriculum subject across K-12 curriculum of a technical gymnasium and trigger learning of a particular mathematical content [23]:

1. *Rational usage of energy* (interdisciplinary connection of the subjects Mathematics (statistical contents) and Informatics). Electricity is very important to our daily life and we can hardly imagine living without it. We are surrounded by different electrical appliances which make our lives more comfortable or more enjoyable. At the same time, we are increasingly becoming aware of our wasteful use of electrical energy. Find out how much electricity you use in your household every day for half a year. Using the available data, explain monthly fluctuations in energy consumption. Compare what you have found out with your classmates. Could this usage of energy be reduced?
2. *Transformations of energy* (interdisciplinary connection of the subjects Mathematics, Physics and Chemistry). Various energy conversion processes take place in the human body, which is why a certain amount of calories is needed for the body to function properly. Assess, over a longer period of time, what your daily energy requirements are and compare these to the average values for your age and sex. Develop a plan of physical activities to burn off the calories of a pizza.
3. *Energy and traffic* (interdisciplinary connection of the subjects Mathematics, Informatics, Mechanical Engineering). An agency of a famous car magazine hires you to make an advertisement for the best five car-shops having the smallest number of complaints. To get the data for your analysis, choose randomly 50 car-shops and find out, how many costumers (out of a 100) put in a complaint (about a purchased car) during a one-year period. Based on measures of centre and variation of the data, determine the binomial distribution for the random variable for the number of car costumers' complaints (per a 100 sold cars). Compare theoretical and empirical distribution and make comments.
4. *How to reduce energy consumption* (interdisciplinary connection of the subjects Mathematics and Sociology). Fill in the Questionnaire about reasonable use of energy (given to students). Determine the types of variables in it and their ranging scale, so that the questionnaire score will represent a degree of someone's energy consumption. Consider the questionnaire's items critically and give your own additional questions. Discuss and comment the questionnaire's objectivity, sensitivity, validity and reliability. Compare classmates' pre- and post-project questionnaire scores. Can you see any positive changes?

First project year the central focus of subjects' integration was rational usage of energy. At various subjects of the first K-12 curriculum (Mathematics, Physics, Biology, Chemistry, Informatics) teachers acquainted students with renewable energy and rational usage of energy in households. In Mathematics, students measured electricity consumption in their households. The monitoring continued for several months during which time they recorded data daily. They collected data, organized them and used basic statistical analysis to write reports for mathematics course. They learned how to use software programs introduced in Informatics for data analyses. Students developed capacities for critical judgement about the efficient use of electricity in the home. That kind of knowledge is applicable in various real-life engineering problems and offers a useful base for life-long learning. In Physics, students learned about rational usage of energy through various activities.

Second year of the project's realization students' learning was centred on forms of energy (mechanical, chemical, electric, sound, nuclear etc.) and energy transformation. It was supported by many experiments. Mathematics teacher designed an engineering problem that connected knowledge from physics, chemistry and mathematics. The transformation of energy problem offered some algebra calculations as well as development and evaluation of inferences and predictions that are based on data and exploration variability of real-life data.

Third project year many experiments and other activities supported science learning. Three factors that influence fuel exploitation (efficiency) varied through experiments. Various activities were offered to show changing of viscosity of motor oil at different temperatures. Students simulated the effect of insufficiently inflated tires on the speed of the car and fuel efficiency. Moreover, they studied the influence of air resistance on fuel efficiency. Based on these activities, some cars with the best fuel exploitation could be exposed. In Mathematics, cars' efficiency was measured with the smallest number of costumers' complaints. The problem triggered learning of basic concepts of probability distribution and construction of sample distributions. Students used empirical data to simulate and compare them with theoretical probability distribution. With the help of their teacher students became aware of the fact that engineers need to modulate real data to get information they can use for further work and to solve many engineering problems. In the subject Mechanical engineering students had to construct an aerodynamic vehicle.

The fourth year of project realization students learned how important it is to reduce energy consumption and they did some activities of reducing. The focus of learning in science subjects were methods of recycling, elimination of waste, chemical and physical properties of composed materials and advantages of these materials in comparison with decomposed materials etc. In Mathematics, students learned about different variables, basic principles of questionnaire design, and relation between a sample and a population. They selected and used appropriate statistical methods to analyse univariate and bivariate data. They learned to identify trends in bivariate data. Engineers need to know how to compare various data and how to predict something based on data they measured or they gained with other types of methodology. Comparison of students' views of energy consumption before and after a 4-year long project could give students and teachers recognition of changing the view about energy as a value.

In the described 4-year long project students had the opportunity to be actively involved in real-life problems incorporated in the module. Having the opportunity to deal with engineering problems from different perspectives, they could improve understanding of particular content.

3. Method

In Slovenia, there are eleven technical gymnasiums with one, two or three pupils' parallel classes. They spread across eight Slovenian regions (out of twelve). First, we contacted the headmasters of these schools to get permission for teachers' inquiry and advice on what kind of the questionnaire they prefer: a paper and pencil design or an online survey. Headmasters preferred paper and pencil design. Second, we delivered material for inquiry (EEBEI questionnaires with envelopes for anonymity as well as letters for whom they were intended) by post or personally and arranged the details of inquiry. Third, we received delivery of fulfilled questionnaires from 10 (out of 11) technical gymnasiums between April 15th 2015 and July 11th 2015. There were from 4 to 13 fulfilled questionnaires in each delivery that represented a stratified sample for this survey.

3.1 EEBEI questionnaire

EEBEI is a questionnaire that measures teachers' beliefs and attitudes indirectly by examining the degree to which teachers agree or disagree with more than 40 given statements. The EEBEI was first introduced at the conference of American society for Engineering Education. It originally included 52 statements forming scales from A to G, but it was reduced to 41 statements to get better measured characteristics [24]. The improved EEBEI was tested on American teachers [20]. As reported in [20] and [24], scales from A to G measure teachers' beliefs about using student's academic performance to inform instruction (A), about using student's interests and cultural background to inform classroom activities (B), about connecting in- and out-school learning (C), about academic prerequisites for careers in engineering (D), about social background for careers in engineering (E), about integrating STEM subjects (F) and about having support for engineering studies in school (G).

We translated the EEBEI and made some minor changes. First, in the scale F we added the fourth statement to the original version: "I collaborate with other teachers at my school to develop interdisciplinary lessons that focus on engineering" that was removed from the original version to get better reliability. However, the difference in reliability was very small [24] and this item suits to our study. Second, we omitted the item in the scale E: "All other things being equal, Asian students are more likely to pursue engineering than other students.", while Asian students are very rear in Slovenian secondary school education. Third, statements in the scale D about academic prerequisites for engineering were adapted to the academic achievements in Slovenian school system. Statements in scales A, B, F and G offer the following answers: 1—almost always, 2—often, 3—sometimes, 4—rarely, 5—never. Statements in scales C, D, E and F offer the answers from 1—strongly disagree to 7—strongly agree similar to the original version [20]. We also added three 7-point Likert scales to the EEBEI including items about interdisciplinary connections in the classroom, about subjects' connection with engineering profession and about wishes to improve such connections. Therefore, the translated version of EEBEI (used in this study) has altogether 53 items: 41 items in the scales from A to G as in [24] and 12 items measuring teachers' beliefs in the additional scales I, P and W:

A. Influences on Instruction: Students' Academic Abilities (5-point Likert scale A, 5 items);
B. Influences on Instruction: Students' background and Interests (5-point Likert scale B, 7 items);
C. Beliefs and Knowledge about Students' Out-of-school activities (7-point Likert scale C, 5 items);
D. Careers in Engineering: Academic Achievement (7-point Likert scale D, 6 items);
E. Careers in Engineering: Social background (7-point Likert scale E, 7 items);
F. Teaching for Engineering: Academic Courses (5-point Likert scale F, 4 items);
G. Environmental and structural Support (5-point Likert scale G, 7 items);
I. Interdisciplinary Subjects Connection (7-point Likert scale I, 5 items);
P. Connection between Subjects and Engineering Profession (7-point Likert scale P, 4 items);
W. Wishes for Connection's Improvement (7-point Likert scale W, 3 items).

Beside demographic questions about gender, years of teaching, degree of teacher education and the areas of instruction as in [20] and [24], the questionnaire includes 4 additional open questions not included in any scale: "Do you know what the abbreviation STEM means?", "If your answer is yes, explain what it means to you.", "Which activity for interdisciplinary connection in the school would you expose?" and "Which activity of subjects' connection with the Engineering Profession would you expose?". These questions can give us an impression of STEM activities that have been realized in technical gymnasiums. The paper and pencil design version of the EEBEI was printed on one paper A4 format.

3.2 Sample

The population for this survey are teachers of STEM subjects in all technical gymnasiums in Slovenia. In the school year 2014/15 there were 6 technical gymnasiums with one class of first-year students (altogether 162 students), 4 technical gymnasiums with two classes of first-year students (altogether 215 students) and 1 technical gymnasium with 3 classes of first-year students with altogether 94 students [25]. Since the number of classes in technical gymnasiums as well as other types of secondary educational programs varies across school years, there is not a fixed number of teachers that teach STEM subjects. The minimum number is 4 teachers for STEM subjects per class: one teacher for Mathematics and Physics, one for Biology and Chemistry, one for Informatics and Computer science or Computer systems and network, and one for Electrotechnics and Mechanics. The maximum number is 8 STEM teachers per class: separate teacher for each STEM subject. Therefore, in the school year 2014/15 we could expect a minimum of 68 ($= 17 \times 4$) STEM teachers and a maximum of 136 ($= 17 \times 8$) STEM teachers for all classes in technical gymnasiums throughout Slovenia. Moreover, the maximum number of teachers is less likely to be achieved in reality, since a teacher of a particular subject usually teaches more than one class due to economic constraints.

The sample in this study consists of altogether $n = 80$ teachers from 10 technical gymnasiums in the country that fulfilled EEBEI in the school year 2014/15. That is 59% of the possible maximum number of STEM teachers of technical gymnasiums in Slovenia. There are 50 female teachers and 28 male teachers in the sample and 2 teachers that did not reveal their gender. Teachers have on average 19.7 years of teaching ($SD = 9.1$ years). They have a suitable degree of education. Only 6% of teachers finished a professional study program as their highest degree, 73% finished a university study program as their highest degree and 21% attained a Master or Doctoral degree. In the sample, there are 17 mathematics teachers, 9 technology-based teachers, 32 science teachers and 22 engineering teachers. Considering questionnaire guidelines, in the case of a teacher teaching subjects from various mentioned fields, he/she has chosen one field to which his/her answers refer.

4. Results

Due to the minor changes of the original EEBEI questionnaire and its translation to Slovenian language, we calculate reliability of each scale in translated version and compare it with the value of the original version. The Cronbach's alpha for scales from A to G are similar to these from the original version [20] (written in brackets):

> A—0.62 (0.70); B—0.79 (0.83); C—0.86 (0.78); D—0.86 (0.83); E—0.80 (0.80); F—0.87 (0.92); G—0.86 (0.78). Cronbach's alpha for the additional scales I, P and W is 0.84, 0.85, and 0.72, respectively. Only the reliability for the scale A is low, but is still acceptable.

To get an answer to the first research question, we compare beliefs of two groups of teachers from the sample: teachers who teach at a particular technical gymnasium and realized the project *Energy as a Value* (they form the group PBL) and teachers who teach at the rest of technical gymnasiums (they form the group REST). There are 12 teachers in the PBL group and 68 teachers in the REST. To get the answer to the second research question, we compared answers from 49 science/mathematics teachers who form the SM group and 31 technology-based/engineering teachers who form the TE group. There are 58.3% mathematics/science teachers and 41.7% technology-based/engineering teachers in the PBL. In the REST, the percentages are 61.8% and 38.2%, respectively. We analysed the data with SPSS for Windows version 22.

4.1 Differences in beliefs regarding STEM education between PBL and REST teachers

Teachers' values from 1 to 5 (or to 7) representing the answers to items in all scales are included in the statistical analysis. An average score, calculated on the bases of teacher's values of all items in each scale is taken into statistical comparison between both groups PBL and REST. Boxplots in Fig. 1 represent teachers' scores of 5-point Likert scales that all have a midpoint 3. Both scales assess teacher's ratings of the frequency with which these conditions occurred [24]. Mean ratings above 3 indicate that, overall, teachers believe that these conditions are more uncommon than common. Boxplots in Fig.2 represent teachers' scores of 7-point Likert scales in both comparable groups with a midpoint 4.

For each scale, we used Mann-Whitney U-test to measure differences between teacher's scores in both comparable groups (as well as the more frequently used t-test for comparison with other results). We sum up main characteristics for both tests for each scale in the Table 1 to find statistically significant

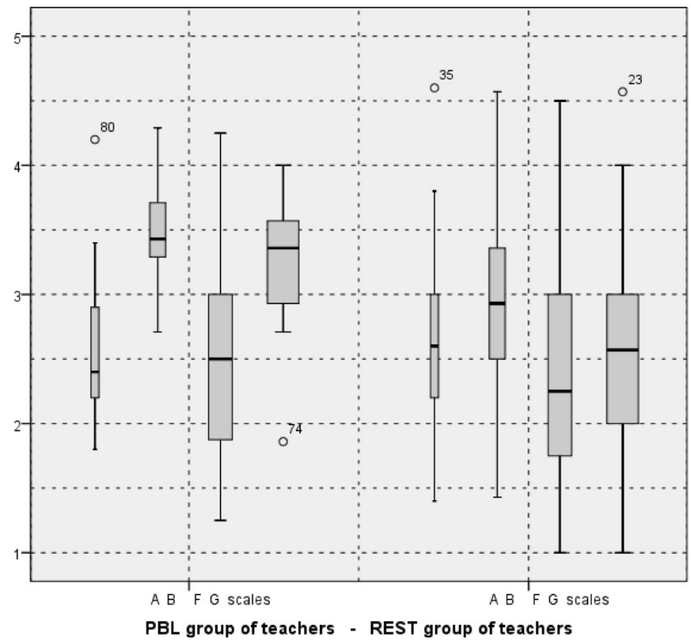

Fig. 1. Boxplots showing Differences in Teachers' scores in Scales A, B, F and G between the PBL and REST teachers.

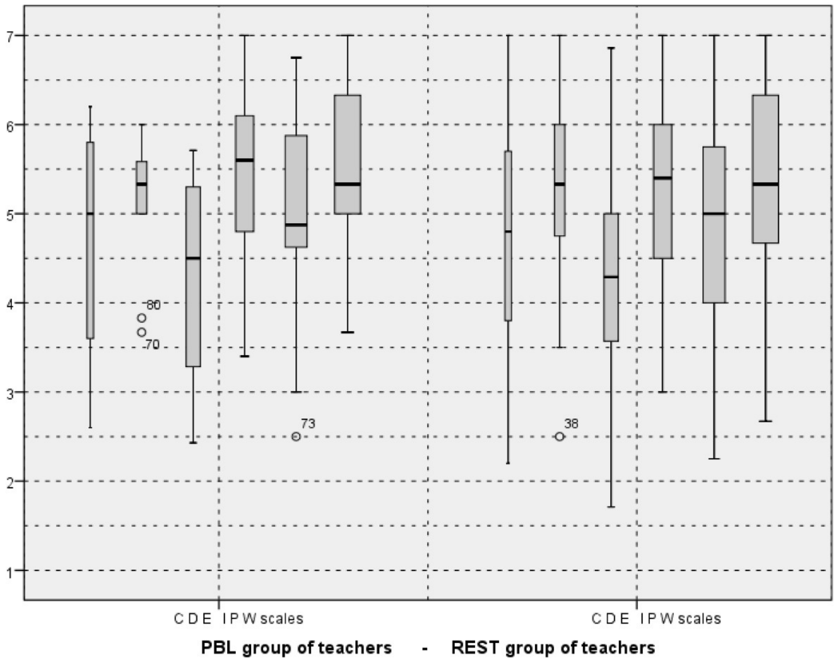

Fig. 2. Boxplots showing Differences in Teachers' scores in Scales C, D, E, I, P and W between the PBL and REST teachers.

differences in beliefs of teachers in the PBL and REST. Both tests show that the differences in average scores between comparable groups are statistically significant only for two scales: B and G.

The average scores of the scale B (Influences on Instruction: Students' background and Interests) in the group PBL and REST are $M_{PBL} = 3.477$ ($SD_{PBL} = 0.406$) and $M_{REST} = 2.963$ ($SD_{REST} = 0.633$), respectively. Mann-Whitney U-test (as well as the more common t-test) shows that the difference in averages is statistically significant at the level $p < 0.01$. Regarding these results, we can conclude that PBL teachers used student's interests and cultural background to inform classroom activities less often than REST teachers. In the scale G (Environmental and structural Support), the average $M_{PBL} = 3.226$ ($SD_{PBL} = 0.576$) in the group PBL is also higher than the average $M_{REST} = 2.530$ ($SD_{REST} = 0.785$). While the difference is statistically significant at the level $p < 0.01$ we can conclude that PBL teachers believe that their school provided resources for students interested in engineering (career day, practical information etc.) and worked with parents less often than REST teachers. We are going to interpret this unexpected result in the conclusion section.

4.2 Differences in beliefs regarding STEM education between SM and TE teachers

Up to this point, we have compared beliefs of teachers that realized the *Energy as a Value* project and teachers from similar schools that did not realize this project. It seems that there are not many differences in beliefs between both groups of teachers. Therefore, we should look for the causes for the project not being successful elsewhere. Nathan and others [20] were detecting differences between teachers with different professional training and program foci. Teachers of STEM subjects in our country do not have any professional development training such as Project Lead the Way as in the USA, for instance, that is described in [14]. However, teaching subjects such as Mathematics, Physics, Chemistry or Biology at a technical gymnasium

Table 1. Differences of Beliefs in Scales

Scales	A (1–5)	B (1–5)	C (1–7)	D (1–7)	E (1–7)	F (1–5)	G (1–5)	I (1–7)	P (1–7)	W (1–7)
PBL mean	2.600	3.477	4.650	5.153	4.323	2.521	3.227	5.442	4.938	5.499
REST mean	2.607	2.963	4.766	5.270	4.290	2.391	2.530	5.237	4.998	5.343
PBL SD	0.693	0.406	1.310	0.723	1.155	0.914	0.576	1.053	1.225	0.926
REST SD	0.577	0.633	1.196	1.010	1.040	0.828	0.785	1.013	1.174	1.040
U-test Sig.	0.669	0.005**	0.989	0.705	0.803	0.640	0.002**	0.487	0.969	0.699
t-test Sig.	0.969	0.008**	0.761	0.701	0.920	0.623	0.004**	0.523	0.871	0.629

* Statistically significant at the level $p < 0.05$. ** Statistically significant at the level $p < 0.01$.

differs from teaching subjects such as Informatics, Computer systems and network, Electrotechnics, Mechanical engineering or Electronics. The first group of subjects that are taught by mathematics/ science teachers are those of basic disciplines while in the other group of mentioned subjects teachers integrate knowledge of basic disciplines and apply it to the field of technology or engineering. Moreover, subjects of basic disciplines are also common in the curricula of other types of gymnasiums while the other mentioned subjects are specific for technical gymnasiums. Therefore, we might expect that these differences also reflect in different teachers' beliefs.

We divide teachers of technical gymnasiums in two groups regarding both mentioned groups of subjects they teach. In the sample, there are 49 (61.3%) science/mathematics teachers who form SM group and 31 (38.7%) teachers of technology-based/engineering subjects who form the TE group. The highest degree of teachers' education is similar in both groups ($\chi^2(df)$ = 0.257 (4), p = 0.879). Moreover, PBL teachers are divided in these groups in similar rates: 58.3% and 41.7%, so the dependence of the statistical results upon previous analysis is not expected.

Similarly, to the previous section, we sum up main characteristics for each scale of teachers' beliefs and analyse differences between SM and TE groups in the Fig. 3 and Fig. 4. U-test (as well as t-test) shows that differences in average scores between comparable groups are statistically significant for the scales F, G, I, P and W. In detail, results for the scale F in the Table 2 show that TE teachers are more likely than SM teachers to claim that science and mathematics content taught in their classes was integrated in engineering content (M_{SM} = 2.716 (SD_{SM} = 0.795), M_{TE} = 1.927 (SD_{TE} = 0.662), p = 0.000). Further, SM teachers are less likely than TE teachers to identify sources of support for engineering in their schools; the difference in the scale G named Environmental and structural Support is statistically significant at the level $p < 0.05$. In both scales, higher score means less positive beliefs (this is true for all 5-point Likert scales). Both comparable groups also differ significantly at all additional scales: Interdisciplinary Subjects Connection (I), Connection between Subjects and Engineering Profession (P) and Wishes for Connection's Improvement (W). Averages for SM teachers are lower than averages for TE teachers. The results suggest that beliefs about interdisciplinary connection between STEM subjects and integration of engineering practice into STEM subjects are stronger for TE teachers than SM teachers. Moreover, TE teachers do not have such explicit wishes for improvement of mentioned connections and integrations compared to SM teachers (see the Appendix).

Differences in beliefs between SM and TE teachers measured in the scales A, B, C, D and E are not statistically significant. These results are similar as in [20]. The only difference is in the result for the scale D about prerequisites for careers in engineering (Careers in Engineering: Academic Achievement). We have to mention again, that we made some minor changes in scale D because the educa-

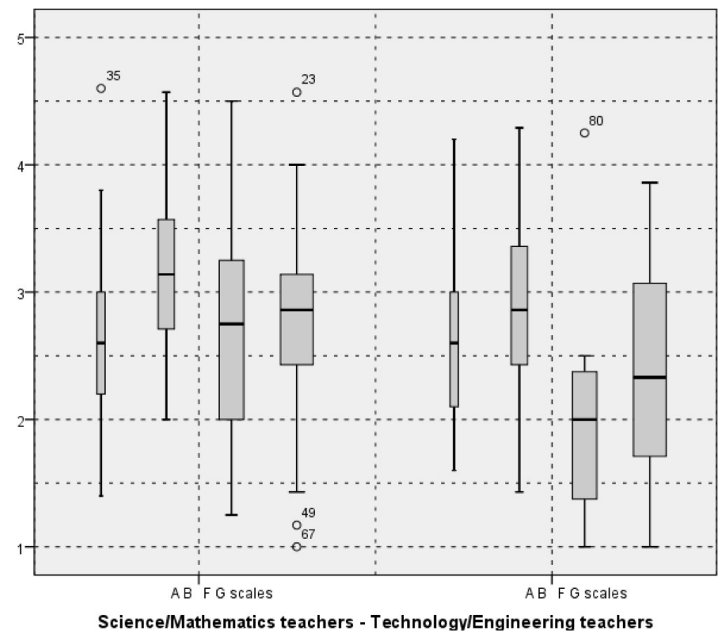

Fig. 3. Boxplots showing Differences in Teachers' scores in Scales A, B, F and G between the SM and TE teachers.

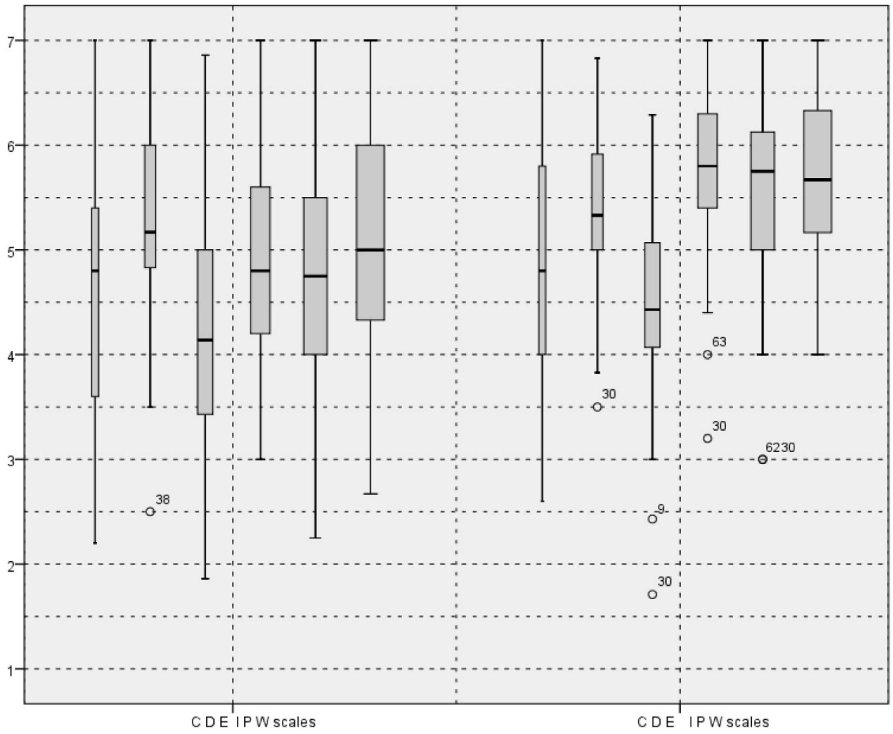

Fig. 4. Boxplots showing Differences in Teachers' scores in Scales C, D, E, I, P and W between the SM and TE teachers.

Table 2. Differences of Beliefs in Scales

Scales	A (1–5)	B (1–5)	C (1–7)	D (1–7)	E (1–7)	F (1–5)	G (1–5)	I (1–7)	P (1–7)	W (1–7)
SM mean	2.624	3.132	4.620	5.180	4.225	2.716	2.788	4.976	4.646	5.123
TE mean	2.579	2.895	4.952	5.366	4.406	1.927	2.393	5.729	5.530	5.752
SM SD	0.580	0.548	1.161	1.042	1.103	0.795	0.730	1.011	1.127	1.033
TE SD	0.616	0.726	1.266	0.846	0.977	0.662	0.843	0.849	1.050	0.882
U-test Sig.	0.687	0.160	0.279	0.455	0.350	0.000**	0.046*	0.001**	0.001**	0.008**
t-test Sig.	0.745	0.101	0.234	0.407	0.457	0.000**	0.029*	0.001**	0.001**	0.006**

* Statistically significant at the level $p < 0.05$. ** Statistically significant at the level $p < 0.01$.

tion system in K-12 curriculum in Slovenia is not the same as in the US and comparison of the results in [20] for this scale is not appropriate.

Answers to the last four questions (that are not the part of original version) show that only 10 out of 80 teachers answered they know the meaning of the acronym STEM (one of them is from the group PBL, nine from the REST); four teachers forgot to mention engineering into mathematics-science-technology connection in their further explanation. While STEM refers to English initials, it is not a surprise that many Slovenian teachers are not acquainted with this acronym. (This acronym is not used in items of the scales in the EEBEI.) Moreover, 39 teachers exposed interdisciplinary activities in their courses and 32 teachers exposed at least one connection between STEM subjects and engineering profession. These data indicate that teachers of STEM subjects in technical gymnasiums are not convinced about STEM education theoretically, but they provided interdisciplinary activities as well as connection between STEM subjects and engineering in their classes.

5. Discussion

New instructional practices and teachers' decision-making strategies are influenced by teachers' beliefs and expectations and about teachers' own instructional practices [24]. Comparison between beliefs of teachers that carried out *Energy as a Value* project and other teachers of technical gymnasiums in the country, points out, that there are not many differences in teachers' beliefs about STEM education. Among 10 scales of teachers' beliefs both groups differ significantly only in scales B and G. Teachers that carried out the *Energy as a Value* project did not use students' interests and cultural backgrounds to inform classroom activities (B) as often as the other teachers did. They might put their attention to coordination between colleague teachers, to timetable of learning particular contents instead to students' interests and cultural backgrounds. Teachers of that particular technical gymnasium also report that they did not have such a good environmental and structural support for engineering (G) than teachers from other gymnasiums. This unexpected result could be interpreted as follows. Teachers were confronted with many difficulties at the time of project's realization that were mentioned in [23]; they had incomplete education about new directions in teaching; the curriculum has undetermined time for interdisciplinary connections and lacks guidelines for teachers about possible ways of connections with engineering professions. Therefore, such obstacles may cause negative beliefs about their school environmental and structural support. Except for these two differences, beliefs between STEM teachers of K-12 curriculum who realized the *Energy as a Value* project and teachers who did not, do not differ much.

Comparison between mathematics/science teachers' beliefs and technology-based/engineering teachers' beliefs gives another conclusion. Based on the results of presented statistical analyses we can conclude that both groups of teachers differ in beliefs about integrating STEM subjects (F); about having support for engineering studies in school (G); about interdisciplinary connections in the classroom (I), about subjects' connection with engineering profession (P) and about wishes to improve such connections (W). In detail, technology-based/engineering teachers made relation between science and mathematics contents to engineering activities explicit to students more often than science/mathematics teachers did (F). Teachers' opinions show better environmental and structural support for engineering studies for technology-based/engineering teachers than science/mathematics teachers (G). The level of agreement with items about interdisciplinary connections in the classroom (I) and about subject's connections with the engineering profession (P) is also higher for this group of teachers (P). Consistently, wishes for connections' improvements are stronger for science/mathematics teachers than others (W).

5.1 Limitations of the study

There are certain limitations to this study. First, the sample of PBL teachers who carried out the *Energy as a Value* project is small. This happened, because the number of all STEM teachers that carried it out is also small. Therefore, we cannot generalize the identified differences of PBL teachers to the whole population. Second, we did not calculate the test's characteristics in a pivot study. However, the reliability for all scales of the translated EEBEI is satisfactory. Third, our analyses only point to one reason for such an ambitious STEM project not being repeated. Using in-depth interview, for instance, could give additional information about the project's realization, its obstacles and possible improvements.

5.2 Future work

Energy as a Value project realization took 4 school years in K-12 curriculum and included all particularities of the school system. Teachers of particular STEM realization had to organize cooperation with particular teachers, had to provide additional time for realization of subjects' interactions and had to design interesting engineering problems for students alone. The teachers' freedom to choose the appropriate time for STEM integration, find a suitable coordination of contents from various subjects to successfully solve engineering problems, as well as to organize a timetable for cross-curricular integration and activities were not advantages. All these activities demanded a lot of teachers' additional knowledge and time. Moreover, teachers' cooperation was seen as very low in our country in comparison with other countries [18] and teachers' beliefs about STEM integration was seen as very high regarding this study. It seems that teachers were not prepared for such a big educational change.

For new STEM programs to be realised, teachers need to have not only well developed repertoires of content knowledge about STEM disciplines, but also knowledge about the nature and discourse of STEM disciplines, knowledge about STEM disciplines in culture and society, and positive dispositions towards the STEM disciplines as stated in [26]. As stated in [5], within this new pedagogy, reflective teachers are not the only ones that have to change—they need to be supported by the new curriculum that enables such a change; by new environmental features that encourage new teaching practices; and by stakeholders who collectively develop environmental features. "Partnering with a local university or a nearby school, attending professional development, taking advantage of training offered by curriculum companies, having common teacher planning time, and encouraging open communication can help teachers to feel that they have the support they need to be successful" [14]. Therefore, recruitment into cooperative teachers in STEM education is very important [26]. Since teachers may have different licensures and backgrounds, it is important for schools to provide support and time for collaboration [14]. Moreover, teachers should get quality support not only at school level but also at the national level. Based on this study, mathematics/science teachers may need concrete examples of subjects' integrations and their usefulness and more time for such realization. Technology-based/engineering teachers may need repertoire of covered students' basic STEM disciplines they can use in their own activities. In this way, we could omit differences of beliefs between both groups of teachers that could lead to better cooperation.

6. Conclusions

Differences of beliefs between science/mathematics teachers and technology-based/engineering teachers could be one possible cause for the Energy as a Value project not being successful enough to be repeated again. These differences might cause various obstacles that teachers who carry out effective STEM education in a particular school system might be confronted with. We might assume that the nature of basic disciplines' subjects and subjects in which knowledge of basic disciplines is applied in K-12 curriculum has an influence on differences about teachers' beliefs. Importance to subjects' integration and connection with practice is on a higher level for teachers that teach subjects in which knowledge of basic disciplines is applied than teachers of basic disciplines. These differences can cause different levels of preparedness for such cooperation between both groups of teachers and different level of competences for such cooperation.

School system in our country leans on teachers' enthusiasm for teaching that drives them to do a perfect job. The system needs organized recruitment into effective STEM integration. Moreover, teachers need a confirmation that their work is important in order to put even more energy into their difficult job. This article should encourage teachers and educators who try to integrate STEM subjects to carry on their good ideas although they do not get a positive feedback the first time around.

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APPENDIX

Items in the additional scales in the translated EEBEI questionnaire:

Interdisciplinary Subjects Connection (I), 5 items:

1. I think that learning of the mentioned subjects at my school needs to be interdisciplinary connected.
2. I think that curriculum at my school offers interdisciplinary connection of the mentioned subjects.
3. I think that organization of my school offers interdisciplinary connection of the mentioned subjects.
4. I think I have been engaged in interdisciplinary connection of the mentioned subjects.
5. I carried out a project, a workshop or other school activity for interdisciplinary connection.

Connection between Subjects and Engineering Practice (P), 4 items:

1. I think that organization of my school offers integration of subject's contents and engineering practice.
2. I think I have been engaged in integration of subject's contents with engineering practice.
3. I carried out a project, a workshop or other school activity for integration of subject's contents with engineering practice.
4. I am satisfied with integration of subject's contents with engineering practice.

Wishes for Connections Improvement (W), 3 items:

1. Interdisciplinary connection takes a lot of preparation time for a teacher.
2. I would like more support from others when it comes to activities that promote interdisciplinary connection.
3. I would like more cooperation between my school and engineering institutions, industry etc.

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