EXAMPLE OF GOOD PRACTICE FOR SUPPORTING STEAM IN TECHNICAL SUBJECTS LEARNING

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Abstract: The article is focused on an example of the application of STEAM education in technical education in the Czech Republic and Slovakia. The trend and need for STEAM education is worldwide. The given example can also be taken over to other levels of education or technical interest activities. Above all, the possibilities of connecting technical education in the Czech Republic and Slovakia with the STEAM concept are discussed here.

Key words: STEAM education, technology, technical education

1 Introduction

Today's society is slowly but surely preparing for the arrival of Industry 5.0. Which marks the next level of the industrial revolution, which, in addition to the previous observation of Industry 4.0, focuses on sustainability, the climate crisis, but also on the human being as an individual and unique personality (Renda, Schwaag Tataj, 2022). As part of the preparations, there is a need to develop creative thinking, which we can support with STEAM (Science, Technology, Engineering, Art, Mathematics) teaching that is current across continents (Breiner et al., 2012).

STEAM education is not only important for adults in the framework of the above-mentioned industrial revolution, it is even more important for children who acquire basic competences, such as independent thinking, comprehensive approach, integration of knowledge, etc., which they will need for application in life (Horáček, 2020).

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Therefore, it is necessary to create new tasks that are in line with the concept of STEAM education or modify older tasks to meet the basic idea of STEAM, which is to integrate the student's knowledge from multiple fields into one task or project. Projects should be from a real environment, motivate students and leave them room for personal research or experiment (Breiner et al. 2012).

The above has prompted us to modify the older task so that it finds application in STEAM teaching and its presentation as an example of STEAM teaching not only at the university, but also among younger pupils or children in interest departments.

2 Objective

The aim of the article is to present one of the examples of the successful implementation of STEAM teaching in the field of university technical teaching at the faculties of education, when the students had the task of solving a creative task with the basics of STEAM teaching. It shows one of the possibilities for technology students to effectively connect their knowledge acquired in various subjects with a modern approach, which they will be able to apply in their teaching during their future teaching practice.

3 STEAM education

STEAM education is a relatively new concept in education, which refers to the connection of science, technology (technology), engineering, mathematics and art into one teaching subject, which develops in students the knowledge and skills needed for the current and future labor market in a more comprehensive manner. Under art in this concept we understand liberal arts, visual arts, digital media, crafts, aesthetics or performance art (Colucci-Gray, Burnard, et al., 2017). STEAM education is based on STEM education, which does not create interdisciplinary relationships, but directly deals with individual areas in a multidisciplinary framework. The learning style is more inquiry-based and project-based, encouraging real-life problem-solving through deep learning experiences (Breiner et al. 2012). Different teaching methods are also related to STEM education, such as Project-based learning, Inquiry-based science learning, Content and language integrated learning (Tasiopoulou et al. 2022).

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STEM concept was created at the end of 1990 and is currently used not only in the field of education, industry and state management (ministries), but also at the World Economic Forum, UNESCO, OECD and PISA. STEM education was created to expand people's knowledge and skills in science and technology with a strong emphasis on critical and creative thinking. This education should be applied from primary schools to universities (Siekmann, 2016). OECD explains that creative and critical thinking is increasingly important in the labor market, contributing to a better personal and social life. In the field of innovation and with regard to digitization, or the use of artificial intelligence and robotics, competences that are less easily automated are very valuable. And even if we were to remove the economic aspect, we can say with certainty that creativity and critical thinking contribute to the proper functioning of democracy. For the above reasons, education in all subjects and at all levels of education in the Czech Republic and Slovakia should also be oriented towards the development of creative and critical thinking, also in the field of science and technology. As studies and experiments show (Conradty and Bogner, 2020; Hacioglu, Y. & Gulhan, F. 2021; Iskandar et al, 2020; Rahmawati et al. 2021; Sirajudin et al. 2021; Wilson, H. E., et al. 2021; Yaki, 2022), STEAM education is the optimal choice for traditional face-to-face teaching for the development of the aforementioned competencies.

4 Creative tasks

In all subjects, teachers create learning tasks. When creating these tasks, the teacher must take into account that the tasks created by him should be imaginative, to interest pupils or students and draw them into learning and learning in the given subject. The teacher must be able to explain the proposed task to the pupils or students correctly (answer any questions), then the pupils and students can understand the task correctly (Slavík, Wawrosz, 2004).

Slavík et al. (2010) identify as primary common features, other experts also identify with these features, the following learning tasks:

- encourages the student to be active,
- based on the field and directed towards the learning goal,
- establishes the educational situation and conditions its form, organization and course.

One of the subsections of learning tasks can be described as creative tasks, because their basis is built on the creative activity of the pupil or student (Slavík

et al, 2010). The greatest interest in the mentioned sub-chapter of creative tasks was towards the end of the 20th and the beginning of the 21st century. We will give one example for all, Robinson et al. (1999) they consider innovation, value and imagination to be the three basic characteristics of creative tasks in education. They emphasize that the basic features marked by them are indispensable for achieving the creative process.

Innovation can be described as creating something new and at the same time not established or non-standard in a given industry (Maňák, 2001). Value can be defined as a specific property of creative expression verifiable in practice (Dorotíková, 1998). Imagination can be translated as an idea that is considered a component of creative activity and, as such, is a classic common denominator for creation in various fields – it can be used across fields (Nguyen, Shanks, 2009). Pupil or student uses imagination as a medium through which he portrays and conveys his experiences and that is why it is often used in creative tasks (Janík, Slavík, 2009).

According to Amabile (1996) and Lubart (1994) a creative task can also be characterized as a problem that does not have a strictly given single solution, but on the contrary has several possible solutions or only an open end.

5 Technical education

In the Slovak Republic, technical education in primary schools is defined through the School Reform of 2008 (Act No. 245/2008 Coll. on Education and Education), which was innovated and has been operating since the 2015/2016 school year under the name of the Innovative State Education Program, to which are subject to documents such as the updated Framework Curriculum and Educational Standards (Pavelka, 2015). For primary education, technical education is included in the subject Work-based education, which is taught only in the 3rd and 4th year (iŠVP – 1.st. 2015). At the second level of elementary schools (lower secondary education), there is a subject Technology, with a one-hour subsidy in grades 6 to 9. The characteristics of the subject state that the subject is primarily based on practical activity. The educational standard of the subject is divided into two areas: technology and home economics. The field of technology is compulsory, household economics is optional, but its time subsidy cannot exceed one third of the total subsidy (iŠVP – 2. st. 2015). Unfortunately, practical activity in the subject of Technology is complicated due to the low material and technical provision of the workshop and the financial budget of the schools, some schools in Slovakia

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do not even have suitable premises-workshops even today in 2023. Since 2021, Slovakia has been preparing a new reform of the content and form of education (curriculum and textbook reform), which is to be put into practice across the board by September 2026. The biggest change is the organization of education in elementary schools into 3 multi-year cycles, thus abandoning the previous first and second degree. At the same time, teaching should be reoriented from face-to-face teaching and handing over ready-made information to situational teaching, where students can interpret and connect information with reality. The Technology subject will continue to belong to the Human and World of Work educational area, but it will consist of 3 components: Technology, Entrepreneurship and initiative, Career Education, which are found in all three cycles. At the same time, content and performance standards are assigned to the entire cycle, not to individual years, as was the case until now. The hourly allowance remains the same at 1 hour per week (Liptáková a kol., 2022).

In the Czech Republic, technical education at primary school is defined by the so-called *Framework Educational Program for Primary Education* (abbreviated RVP ZV), which was established in 2005 and replaced the so-called *Primary School Educational Program* (Serafín, Havelka, Kropáč, 2017).

In this RVP ZV, technical education is represented by the educational area Man and the world of work. This educational area is mainly focused on work activities and technology, but also on cooking, land work and theoretical knowledge of the labor market. The concept of this educational area is based on practical life situations that students can get into or are getting into. Unfortunately, the time allowance at the 1st grade of elementary school is only 5 teaching hours and at the 2nd grade even only 4 teaching hours. In this time allowance, at the 1st stage, the outputs from the thematic areas *Work with small materials*, *Construction activities*, *Cultivation work* and *Food preparation* must be met. At the 2nd level, only the thematic unit *World of work* is compulsory and each school must choose, based on the conditions, focus and equipment of the school, at least one of the other thematic units such as *Work with technical materials, Design and construction, Cultivation work and husbandry, Household operation and maintenance, Food preparation, Working with laboratory equipment* and *Use of digital technologies* (RVP ZV, 2021).

The RVP ZV has already been revised several times during its existence (most recently in 2021 – a small revision) and it is currently awaiting a major revision, which will transform the educational field Man and the world of work into the educational field Man and technology.

Technical education at primary school was noted in the Czech Republic at the beginning of the second millennium, when, as part of the so-called information literacy, school workshops were canceled en masse in many schools and transformed into computer science classrooms, with the understanding that, thanks to information literacy, work activities would no longer be needed, or the workshops were allowed, but in not entirely dignified conditions (Serafín, Havelka, Kropáč, 2017). Today we can already see that work activities are still needed, which is why even within the framework of projects from the MŠMT (Ministry of Education, Youth and Sports) workshops are currently being built, renovated and modernized again (Dostál, 2018).

6 Methods

The method of action research was used, which took place as part of the teaching throughout the semester. Action research belongs to so-called qualitative research. According to Nezvalová (2008), the basic factor of this type of research is that each teacher improves his teaching and thus the school or institute. Three building blocks can be distinguished in action research, namely *action, reflection* and *revision*. These pillars can be divided into five parts, these parts keep repeating, always after completing the entire row. They are *planning, action, observation, reflection* and *new planning* (Nezvalová, 2008).

In the *planning part*, we prepared a general assignment that met the requirements of both STEAM teaching and creative teaching, and which also contained clear evaluation conditions. After assigning the task, the students were *observed* at work choosing a suitable procedure, measuring and preparing and actually constructing the final product. Always at the end of each exercise, a discussion took place with the students about their behavior in the given exercise in semi-structured interviews. As part of the *reflection*, some of the mentioned possibilities causing a wrong conception or misunderstanding of part of the task were corrected.

Within this type of research, the role of the educator is essential. This type of research helps spread awareness within education and society itself, and increases the responsibility and self-concept of educators. All this is aimed at achieving better student results and their understanding during teaching, which is definitely a significant benefit (Noffke, Zeichner, 1987).

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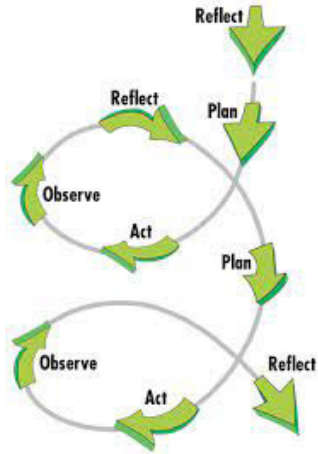

Picture 1: Action research

Another chosen method is the monologic method, where explanation and description were mainly used, especially at the beginning during the presentation of the project assignment.

The last dialogic method was mainly used as a teaching interview, which was practiced throughout the semester (research). During the work, students led discussions in groups about assignments or proposed solutions and answered additional questions about their projects (Horáček, 2017).

The researcher in action research has, in contrast to traditional research. Equal status with research participants (Bargal, 2008). In our case, the researcher took on the role of a mentor or guide who assigns the task and can explain it further or answer questions, advise when creating sketches of constructions (with the help of discussion, he diverts students from fatal failure, but at the same time leaves students the opportunity to create), and also offers a wide range of materials that they may or may not use. Of course, they will familiarize students with the evaluation criteria at the beginning.

7 Designed STEAM task

The proposed task integrates students' knowledge from the fields of technology, physics and mathematics, therefore we can call it STEAM. From technology, it takes over knowledge of materials and their properties, technical drawing and

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structures, physics is represented by the action of forces in the structure with the functionality of the bridge. From the point of view of mathematics, we can apply basic calculations and geometric drawing as part of mathematics. Within the framework of the abbreviation Art, it is also possible to connect with art education, especially the design of the final product.

The assignment of the STEAM task is on a general level, the students are tasked with coming up with a solution for how a toy car weighing 2 kg can cross a gap 70 cm long. As part of the assignment of the STEAM task, all rules for the creation of similar tasks were respected and at the same time it respects the definition of STEAM education as it stands. Students are always divided into groups of a maximum of 3 students, with the groups having the same general assignment and the same selection of aids and materials. Each group can choose which path or method to complete the assigned task, at the same time, students are encouraged to use the brainstorming method within their group. The total time to solve the task is 2× 45 minutes. The task is designed in accordance with the so-called problem-based learning method, which is used in STEAM education, where students solve a specific problém more or less independently in groups.

In particular, students have at their disposal commonly available consumables and aids, it is up to them which material or aids they use. Apart from the general specification, there is only one condition – insulating tape can only be used for joints, not as a building material.

Students have the following tools and materials at their disposal: paper, newsprint, skewers, Hercules glue, scotch tape, straws, string, rubber bands, PET bottle, scissors, ruler.

Picture 2: Tools and materials

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Among the evaluation criteria of the given task, first of all, the fulfillment of the assignment (length and load-bearing capacity of the resulting bridge), the creative approach of the individual groups to the task, the design of the individual solutions, similarity to the original drawing and economy (the amount of material used) were also evaluated in a semi-structured interview.

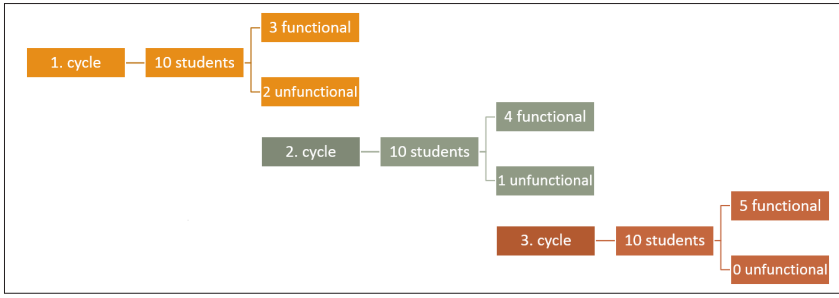
8 Results

During three consecutive semesters (SS 2022, WS 2022 and SS 2023) the proposed STEAM task was piloted in teaching at the Faculty of Education in the Czech Republic. At the same time, piloting took place within the last semester (SS 2023) at the Faculty of Education in Slovakia.

For the implementation of the proposed task, at the Faculty of Education in the Czech Republic, exercises in the subject Construction Activities (optional subject) were chosen. The research sample was a heterogeneous group of 3rd and 4th year full-time students. In Slovakia, it was specifically for the subject Technical hobby, and here too it was a heterogeneous group of students in the 2nd year of full-time study. As part of the selection of students, a deliberate selection was chosen, in terms of their predispositions and experience with construction, which are very important for the proposed task. In addition, the similarity of the content of individual subjects in the Czech Republic and Slovakia also played a role.

The conditions in all groups were identical. In each semester, the groups had the same assignment, choice of material and discussion with the teacher.

As part of the action research, not only the individual assignment options were verified, but also the amount and types of material. The original selection of



Picture 3: Scheme of cycles

assignments and material was determined on the basis of professional literature and an already functional older task that was transformed for the purposes of a modern concept within the framework of STEAM education. Action research, as such, took place in three cycles, which can be seen in Picture 3, where the task was piloted and subsequently modified. Each cycle ran for one semester, or part of a semester.

The results are divided according to individual semesters and faculties where the proposed task was piloted. A larger space is devoted here to the Faculty of Education in the Czech Republic, where piloting took place over a longer period of time, with a group of 10 students per semester. This course is very popular because it is more practical, however the course capacity was 10 students.

In the first hour of the seminar, the students were introduced to the assignment, possible materials and tools they can use and divided into pairs. There was also space for individual discussion in pairs, how the process will proceed, how the construction will look, which material will be used and in what way. Students had the opportunity to ask questions at this stage if something was not clear to them. Part of the introductory lesson was the possibility of a drawing or sketch on paper with calculations and the beginning of construction. In the second hour of the seminar, the construction of the task according to the drawings continued, and in some groups there were regular modifications of the construction or replacement of the used components. At the end of the seminar, there was a final demonstration of fulfillment or non-fulfillment of the assignment, in the form of a direct weight and length test, whether the bridge met the general parameters of the assignment or not.

The Faculty of Pedagogy in Slovakia was chosen as the control group, where a total of 10 students were involved in one semester, namely in the subject Technical hobby with the same subsidy of 2 x 45 minutes. In both faculties, both in the Czech Republic and in Slovakia, teaching was conducted by teachers (authors of the article) who have many years of experience in technical teaching not only at the Faculty of Education.

Summer semester 2022

In this semester, for the first time, the idea of adapting the classic bridge structure to a creative STEAM task arose, when the assignment was completely revised, which included, in addition to the minimum criteria for the load-bearing capacity and length of the structure, a list of materials and tools that can be used

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during the construction. Unfortunately, in this phase there was a greater number of questions from the students, which were caused, as it was found in the later semi-structured interview, mainly by a bad interpretation of the assignment, i.e. a poorly formulated assignment. Three groups out of five failed to fulfill the goals and requirements of the assignment, which was mainly manifested by the non-functionality of the resulting construction. At the end of the semi-structured interview, it was further established that the students, in addition to incomplete understanding of the assignment, also underestimated some properties of the construction or material they used. There were also opinions that the materials that were available were not selected appropriately.

Winter semester 2022

In the winter semester, first of all, assignments were adjusted based on the results from the summer semester. The construction material was supplemented with a PET bottle and rubber bands. Thanks to the findings from the summer semester, the modification of the assignment and the addition of additional material options, the construction in groups went significantly more smoothly and without a large number of questions. At the same time, during the resulting testing, most groups (four out of five) fulfilled the assignment and created a functional construction. During the semi-structured interview, it was found that the groups that failed to complete the assignment had the biggest problem with time, as they planned a rather complex construction and did not have time to complete it so that it was functional.

Summer semester 2023

Based on the information obtained from the previous two semesters, there was a slight modification of the assignment, in the form of specifying the time for the construction itself and emphasizing the functionality of the construction towards the end of the seminar. The assignments and discussions in the groups took place in peace, and only one question arose from them, and that was about the possibility of using a PET bottle, which was answered by the teacher (use according to one's own creativity). The construction went without any problems and all five groups managed to create a functional structure by the end of the seminar. Each structure was built differently and materials were used differently, but all structures met the specifications. In the final semi-structured interview, it was found that the students did not have significant problems with the assignment

and the material seemed sufficient to them, although in some cases it took some time before they were able to appropriately use the properties of specific materials and combine them.

At the same time as this piloting, construction took place in Slovakia this semester, where the same assignment and material were used. The students did not have serious problems with the assignment, sometimes a question was asked about the possibilities of construction or the use of material (the answer is always general – try to invent, create, etc.). At the end of the seminar, there was an evaluation and a final load test, and it can be stated that all bridges met the specifications. In the final semi-structured interview, most students stated that they enjoyed the work, but some would prefer to work with wood.

When comparing the results of Czech and Slovak students in the last semester, we get differences mainly in terms of construction design and economy. In terms of structural design, students from the Czech Republic did better, creating functional structures with technical elements (beams, lintels, cables, etc.), in contrast, students from Slovakia mostly stuck to simple functional structures. On the other hand, students from Slovakia excelled in economy, who were able to build functional bridges using a smaller amount of materials.

We can say that these two differences are dependent on each other, since the more technical design in most cases required a larger amount of materials.

9 Conclusion

On the basis of semi-structured interviews and functionality results, it can be stated that the task is fully in line with technical education, at the same time it is creative and fits into the STEAM concept.

The proposed task can be perceived as a creative (none of the bridges were identical to another bridge) STEAM task, which is suitable for use not only in elementary schools, which are interested in a modern way of teaching and connecting knowledge from individual subjects. It describes a suitable assignment that is in line with the stated STEAM concept and at the same time supports students' creativity, own activity and, to a certain extent, technical literacy.

The advantage of this task is that the material is less demanding, which is readily available everywhere, and thanks to the materials used, the resulting solution can be easily disassembled or recycled, and most of the materials used can also be used for other activities. Furthermore, the time allowance needed to complete

the task, which does not exceed the duration of two teaching hours, and last but not least the assignment itself, which can be used for older children in primary school, but also for university students.

10 Resources

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