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Are Activation Teaching Methods Really Effective?

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Abstract

The primary aim of the presented paper is to demonstrate the effectiveness of activation teaching methods in the teaching of technical subjects at secondary vocational schools through pedagogical research using a pedagogical experiment. The effectiveness of the activation teaching methods is demonstrated in the Integrated Rescue System subject taught in the field of Security and Legal Activity. The object of the research are pupils who were 2nd year pupils in the 2019/2020 school year, as well as teachers of the analyzed subject. The pedagogical experiment was carried out in three consecutive years, namely in the school years 2019/2020, 2020/2021 and 2021/2022. The presented paper has the classic structure of a scientific work; it is divided into a theoretical and an analytical part. We processed the theoretical part of the work using secondary analysis. Pedagogical research was used in the analytical part of the work. Both qualitative and quantitative pedagogical research were used. Qualitative pedagogical research was carried out using a semi-structured interview with open questions. Observation was also used. The quantitative part of the pedagogical research was carried out using a standardized questionnaire. Another method of quantitative pedagogical research was the pedagogical experiment, i.e., its implementation led to obtaining outputs of a quantitative nature. When evaluating the results of pedagogical research of a quantitative nature, we used mathematical-statistical methods for our chosen variables, which were not only processed, but also analyzed through the statistical program SPSS Statistics 22.0. We proved through a pedagogical experiment of a longitudinal nature that activation teaching methods are really effective in teaching technical subjects at secondary vocational schools, while within the framework of that pedagogical experiment it was proved that it is possible to apply activation teaching methods very effectively in the so-called flipped classroom model, which we present as suitable for effective activation teaching of secondary school pupils.

Keywords: Secondary Vocational School; Effectiveness of Teaching; Activation Methods of Teaching; ICT in Education.

1. Introduction

Working with activation methods in today's advanced times is certainly an absolute necessity, which is in many ways declared by the long-term practice of teachers of technical subjects in many secondary vocational schools and confirmed by numerous scientific studies, for example Tusupbekova et al. (2019) [1], Yagafarova & Kamennaya (2019) [3], or Stanislavovna & Radjabova (2022) [3]. Activation teaching methods not only complement the educational process appropriately but, above all, attract the attention of pupils and draw them into the lesson. By implementing these teaching methods, it will subsequently be achieved that pupils will begin to perceive the teaching in a different way and stop wanting to acquire new knowledge only in a traditional passive way. Under the assumption of appropriate use and correct timing of the application of activation methods, teaching is more attractive, more pleasant, and more comprehensible [4]. This approach should ensure increased motivation among pupils for the subject matter discussed in technical

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subjects. In practice, however, this represents, among other things, an increased time requirement for the preparation of adequate arguments leading to the aforementioned increased motivation of pupils and, of course, an increased time requirement for the preparation of the teacher for the teaching unit [5]. A secondary, yet unmissable, reason for the implementation of activation methods in the teaching of technical subjects is the fact that, within the framework of education conceived in this way, situations arise when the pupil becomes the teacher's partner. As a result of these situations, pupils' self-confidence can be increased, and a so-called feeling of success can appear, which is very important for every teenager. Such moments can significantly positively affect pupils' further personal growth.

The attractiveness of activation methods is also supported by progress, represented primarily by information technologies that can meet the requirements and demands of the present time. For this reason, information technologies play a very important role in the implementation and application of activation methods in the teaching of technical subjects, as they can very easily stimulate pupils' curiosity and thereby increase their interest and motivation. In the trend of today's world, information technology is the focus of society, and this ensures that in order to meet the needs of the users, there are continuous improvements and various upgrades in this field. This fact is a guarantee that if information technologies are used correctly in teaching, they contribute significantly to the continuous improvement of the quality of education [6, 7].

Even though many positive reviews are published and countless positives for activation methods are identified, for example, Tazhikenova (2012) [8] or Schegoleva et al. (2018) [9], there is still a relatively strong group of teachers who continue to prefer face-to-face teaching in their practice [10, 11]. Activation methods are methods where the pupil's activity is clear and distinct. That is, not only thought activity but also his behavior, and this idea is the starting point for our research. The aim of the presented paper is to demonstrate that the very implementation of activation methods in the teaching of technical subjects will increase the effectiveness of education and the level of knowledge of secondary vocational school pupils.

The subject of our research is activation teaching methods in the work of teachers of technical subjects at secondary vocational schools. Pecina & Svoboda (2015) [12] published their research in the given area of research, and they investigated what teaching methods of creative teaching are used by teachers of technical subjects (outside of practical teaching) at secondary vocational schools and what knowledge they have about selected methods. The research was carried out in the South Moravian region. A total of 250 questionnaires were distributed in the South Moravian region. The research (questionnaires and guided interviews) was conducted in 13 secondary schools [12].

From the obtained data, it follows that the most commonly used of the classic (traditional) teaching methods are interpretation (explanation, description) and writing in a notebook. To a high extent, teachers also use discussion methods (interview, dialogue, discussion), which is a very positive finding. The method of independent work with materials is also often used. The method of working with a computer is used in a variety of ways. The research found that the methods of school laboratory and experimentation, observation of objects and phenomena, and practical demonstrations are little used, which is not a very positive finding for the teaching of technical subjects. Among the methods of activating teaching, teachers include group work, independent work, and the project method with varying intensity. Relatively few include (according to their expression) solving problem tasks. To a minimal extent, teachers use the didactic games; a large part do not use them at all. The research showed that teachers consider the creative activity of pupils as important and necessary, but creative teaching methods are used relatively minimally. However, there is a noticeable effort to apply these methods to teaching [12].

Chiang & Lee (2016) [13] and Zukerstein et al. (2010) [14] published work in the field of developing technical creativity through project-based teaching. Nilsook et al. (2021) [15] conducted research on the project-based learning management process for vocational and technical education. Watson (2018) [16] investigated whether teachers of technical subjects use creative teaching methods. 124 respondents took part in the survey. The research found that teachers try to use creative teaching methods and are aware of them. However, the problem is their low frequency of use. Their use is hampered by the lack of tools and equipment [16].

Grossman (2009) [17] investigated how complex teaching methods are represented in the work of teachers of technical subjects (frontal teaching, partner teaching, group and cooperative teaching, brainstorming, project teaching, computer-supported teaching). 67 respondents took part in the survey. The research results are positive. The teachers richly combine all the above-mentioned comprehensive teaching methods, i.e., both classical methods and methods supporting the activity of pupils and the development of creativity. These methods are used both by novice teachers with up to 2 years of experience and by more experienced colleagues as well.

According to Yuan (2021) [18], among the current research on the effectiveness of education of the "what works" type, the research of Marzano et al. (2000) [19], whose primary goal was to identify the teaching strategies that are most likely to increase the pupils' achievement, can be stated. Research studies from the last three decades of the 20th century, mainly in the United States of America, served as a source. The overview shows the nine categories for which the results of the meta-analysis showed the highest average effect size (the categories are ordered from the highest effect size).

- Identifying of similarities and differences in the curriculum;
- Summarizing and taking notes;
- Encouraging the efforts of pupils and providing the recognition for their work;
- Homework/preparation and practice;
- Non-linguistic representations;
- Cooperative learning/teaching;
- Setting goals and providing feedback;
- Creation and verification of hypotheses;
- Activating of prior knowledge.

As can be seen, the largest effect size was demonstrated by the teaching activities based on the identification of similarities and differences in the curriculum, such as comparisons or classifications, which pupils actively perform during the learning tasks.

For other overviews of effective teaching strategies, reference can be made to the Educational Practice series of the UNESCO International Academy of Education [20, 21]. Among the most up-to-date overviews of the effectiveness of education research is the study by Seidelová & Shavelson (2007) [22], which summarizes the results of the research in the field of effectiveness of education in the last ten years (1996–2006). The authors use the term effectiveness of education in the broad sense of the word, i.e., similar to Scheerens (2004) [23]. They do not refer to the teaching as an instruction but consistently adhere to the combination of teaching and learning. As a basic research method, the authors used a meta-analysis of research studies that investigated the effects of education on learning. The effectiveness of education was examined from three points of view:

1. The first was based on the fact that the effects of education on learning can be different. Some parts of the education can affect the cognitive development of the pupil, while others can affect the development of his motivation to learn, and finally the components of the education can affect the learning processes.
2. The second point of view is that the authors categorized the studies they drew on into two different teaching models. The first model was the traditional process-product model as described above. In addition, they developed their own approach, which is based on current models of teaching and learning, where learning is characterized as a self-regulated and constructive process of creating a supportive learning environment [24, 25]. Based on these assumptions, the authors created a new teaching model, which consists of the so-called teaching components:
 - Area of knowledge/subject/character of the curriculum;
 - Time for learning;
 - The organizational framework of learning;
 - Classroom climate;
 - Setting of goals;
 - Management of learning activities;
 - Evaluation;
 - Regulation, monitoring and decision-making.
3. The third point of view looked at the role research design plays in the determining the effectiveness of education. The authors found that there are two distinct approaches to effectiveness of education research. The first of these is based on large-scale correlational research, in the second approach, researchers focus on the learning of specific educational content. This approach is based on a growing number of quasi-experimental and experimental studies of the effects of the specific teaching approaches on pupils' learning [26].

The concept of effectiveness of education has been successfully developed for several decades and is currently proving to be very vital. In the Czech environment, the effectiveness of education began to be investigated more in the 1980s [27, 28], in the mid-1990s Průcha's overview monograph *Pedagogic evaluation* (1996) [29] was published. Although interesting partial studies have been published since then, a comprehensive theoretical monograph has not been created recently.

An overview of the effectiveness of education research in the last decade abroad shows the fact that the emphasis is shifting from the search for universal recommendations and general conclusions to bigger differentiation and a deeper view of the effectiveness of education [30–32]. It has been repeatedly proven that procedures and strategies are effective in general [33, 34]. Learning situations in the real conditions of school teaching come to the forefront of the researchers' interest. This requires focusing on the specifics of teaching different subjects with different curriculum. Experimental research that focuses on the proximal components of teaching appears to be valuable. A more detailed view of the effectiveness of education cannot be imagined without them [35, 36].

Other research carried out confirming the effectiveness and success of activation teaching methods in the teaching of technical subjects at secondary vocational schools includes research by Longo (2015) [37], Dalton & Gerdes (2021)

[38], or Cabrera-Solano et al. (2023) [39]. However, in the Czech Republic and Slovakia, there is not enough relevant research confirming the effectiveness of activation teaching methods in the teaching of technical subjects at secondary vocational schools.

2. Literature Review

2.1. Effectiveness of Education: Methodological Approaches

The term effectiveness of education can be encountered most often in educational policy materials, legislative documents, and program statements of various political entities [18]. The effectiveness of education is related to the results of the teaching process, i.e., to the level of knowledge, skills, habits, attitudes, and abilities [40]. The concept of effectiveness is not entirely clear [41]. It is associated with various other terms: efficiency, economy, productivity, expediency, and usefulness. In the English language, several other expressions, e.g., efficacy and efficiency, are used in connection with effectiveness. The concept of effectiveness is appearing in connection with statements about the success of pupils, schools, teachers, or educational systems, which should be based on serious evaluation or research processes; otherwise, they remain empty proclamations or speculations. The term effectiveness is used in the pedagogical sphere with different meanings, which can be a source of misunderstanding. *"The meaning of the term effectiveness is not defined precisely and usually overlaps with the term quality"* [29].

The word effectiveness basically has an effect; semantically, it refers on the one hand to some effects, results, or consequences, and on the other hand to their source, origin, or causes. Thus, effectiveness is generally an expression of a certain relationship. Often, the relationship between some result and what caused or influenced this result. Teaching usually involves some (relatively) final results or outputs, such as the pupil's knowledge at the end of the school year, the number of pupils admitted to university [18].

In education, it is possible to assess effectiveness as the degree of achievement of set goals in connection with the economy (the degree of utilization of financial costs for the teaching process) [42]. From this point of view, it should be mentioned that if the school achieves the set goals, we can talk about the effectiveness of the school, but this does not necessarily mean its effectiveness because it may spend a disproportionate amount of money to achieve the goals. On the contrary, a school can be economical, but it may not be effective, i.e., it does not achieve the set goals. However, it is necessary to emphasize that it is very difficult to determine the financial evaluation of the contribution of, e.g., primary school graduates, and therefore effectiveness in the sense of economy is used very limitedly in pedagogy [41, 43]. In pedagogy, the effectiveness of education is perceived as the degree of achievement of its goals, it is *"the relationship between teaching results (e.g., pupil knowledge) and what caused this result"* [44].

However, it is not only about finding out the results and comparing them with the set and desired goals. It is also necessary to determine why good or bad results were achieved and what needs to be improved or made more efficient in the teaching process. Therefore, it is necessary to determine the degree of perfection (quality) of the given teaching process, its teaching methods, organizational forms, material resources, climate in the classroom, assessment of pupils, entry conditions (entry knowledge, skills, habits, attitudes, and abilities of pupils, their state of health, etc.). Next, the characteristics of teachers, teaching goals, choice of subject matter and material, and technical support of teaching [41].

2.2. An Overview of Effectiveness of Education Research

In contemporary pedagogy, effectiveness becomes the subject of much scientific research. An overview of research into the effectiveness of education abroad (USA, Great Britain) and in our country in the past and at present is described by Pandey and Pandey (2021) [44].

In order to determine the effectiveness of education, in addition to the determination and specific definition of the teaching goals, it is necessary to establish tools for determining (measuring) the results of the teaching process. The level of knowledge and intellectual skills can be determined by cognitive didactic tests, and the level of psychomotor skills by psychomotor didactic tests (in practical teaching, these are comprehensive and control tasks). Pupils' abilities can be measured with the ability tests (intelligence tests, creativity tests), and pupils' attitudes can be measured with the questionnaires, attitude scales, observing their behavior, or by other methods [41–47].

The effectiveness of education is the subject of a study by Johnes et al. (2017) [43], whose intention is to provide the reader with techniques that increase the effectiveness of education. They perceive effectiveness as the degree of mastery of learning material, which does not mean only short-term or longer-term memorization of content but also the acquisition of the ability to perform challenging thought operations with this content [11, 43].

The effectiveness of education is influenced by many factors that cannot be easily affected. It also follows from this that research into the effectiveness of education can focus on various factors that influence it. The effectiveness of education usually considers the school as the basic unit; the effectiveness of teaching works at the level of the class or individual teacher. There are five basic types of effectiveness research in education [23]:

- I. Research on equal opportunities (justice) in education;
- II. Economic studies of educational production functions;
- III. Evaluation of compensation programs for disadvantaged pupils;
- IV. Study of exceptionally successful schools;
- V. Study of the effectiveness of teachers, classes and teaching processes.

The concept of the effectiveness of education as a framework for the systematic investigation of the influence of school education on pupils appeared in the second half of the 20th century in the United States of America. In the first phase, empirical research focused on the personality traits of teachers (e.g., whether they are friendly or aloof in relation to pupils). The concept of teacher teaching styles also appears in this period. Research on teachers' teaching styles continues to the present day and focuses on manifestations of teachers' conceptions of teaching as fixed patterns of behavior dependent on values, which teachers prioritize when their professed values come into conflict in specific teaching situations and a decision needs to be made on which to prioritize [47, 48]. However, most of the studies at the time did not confirm that there was a clear relationship between the personality traits of teachers and the results of pupils. Further research therefore focused more on the manifestations of teachers' behavior during teaching, for example, Reynolds (2006) [49], McDonald (2023) [50], or Wahlberg and Paik (2000) [20].

Gradually, teachers' behavior began to be correlated with pupils' performance. This approach was later called "process-product," and under this designation, it became a certain framework designation for research on the effectiveness of education in general (basically, it is a kind of basic model that is rather developed in subsequent periods than being fundamentally denied). The process is most often understood as the teaching of the teacher, and the product as the pupil's results [18, 51].

Quantitative approaches clearly predominate in research into the effectiveness of education. Only now are they accompanied by qualitative methods. In the 1980s, so many research studies were conducted that it allowed meta-analyses to be conducted that synthesized previous research findings in the field of the effectiveness of education [52]. The outputs of these meta-analyses are categories of variables measured using the so-called effect size. Measuring the effect size allows us to express the strength of a difference or relationship in such a way that we can compare it with the results of other studies. This allows us to decide, for example, whether a new teaching strategy has a bigger effect on pupil results than another method [53]. Among the best known is the meta-analysis by Fraser et al. (1987) [54] and Wahlberg and Paik (2000) [20]. Walberg and Paik (2000) [20] mention such variables as encouraging pupils (reinforcement) or working in small groups among the most effective teaching methods. Fraser et al. (1987) [54] came to the conclusion that variables such as teaching quality are most correlated with pupil performance, such as the amount of instruction or feedback.

In the early 1990s, a comprehensive meta-analysis was carried out, which summarized the current findings in the field of research on the effectiveness of education with regard to the influence of educational, psychological, and social factors on learning [55]. Although it includes studies that look at both contextual and school factors, most of them (36%) deal with "curriculum and instructional design and implementation", "pupil characteristics" (24%), and "instructional practices" (18%). One of the outputs of this meta-analysis is the classification of factors (rank-ordering) according to the relative importance of "distal" (distant) and "proximal" (close) with respect to their influence on pupil performance. The following list shows the factors ordered from the closest factors to the most distant factors [55]:

- Pupils' study prerequisites;
- Teaching practice (practices);
- The educational context of home and community;
- Form of curriculum and teaching;
- School culture, school climate, school demographic conditions;
- State and territory government and organisations.

If we leave aside the pupil's study prerequisites, then in the teaching practice factor, the most strongly correlated with the pupil performance are the variables of class management (e.g., the teacher's overview of what is happening in the classroom), classroom climate, assessment in the classroom, the amount of teaching (e.g., the amount of time spent by the pupils at work), and teacher-pupil interaction (e.g., pupils respond positively to questions from other pupils and from the teacher). In their interpretations of effective teaching practice, authors such as Yuan (2021) [18] or Grrosskopf et al. (2014) [56] distinguish two types of interaction during teaching:

1. **Professional (Academic) Interaction** between teacher and pupil. It should guide pupils to become aware of subject-specific knowledge structures, for example through appropriately posed questions.
2. **Social Interaction** between teacher and pupil. It should discourage pupils from disruptive behavior and create a "learning-supportive atmosphere" in the classroom; in addition, the use of the praise and the corrective feedback is mentioned.

This meta-analysis seems to support teaching approaches such as mastery learning based on a behavioral approach while also respecting cognitivist or constructivist approaches, emphasizing metacognition and teacher-pupil interaction [18]. Research into the effectiveness of education in the 1990s essentially confirms the main characteristics of effective teaching that were formulated in the previous period [23]. It identifies as new trends:

- Return to the examination of teachers' personality characteristics;
- Bigger teaching attention to higher order skills, self-regulated learning and "constructivist" approaches;
- Understanding of teaching as the facilitation of pupil learning through creating the learning activities and encouraging pupils [23].

In the USA, the question of the effectiveness of the work of teachers was given attention in the debate about the standards of teaching competence [57]. Empirical findings include that among the most important features of teacher effectiveness belong the subject knowledge and verbal (communication) skills [58]. Twelve relatively stable characteristics of effective teachers have been identified in Great Britain, which are organized into four groups (clusters) shown in the following table (Table 1) [47].

Table 1. Characteristics of effective teachers

Quality area	Criterion	
Professionalism	Commitment	A commitment to do the best for each pupil and to enable all pupils to be successful.
	Faith in others	To believe that all pupils are capable of being successful and coping with the adversity.
	Fairness and reliability	To be constant and fair, to keep one's word.
	Respect	To believe that every pupil matters and deserves a respect.
Thinking, Reasoning	Analytical thinking	Ability to think logically, to solve problems and to recognize the cause and the effect.
	Conceptual thinking	The ability to see the essential features and connections even in the case of a large number of unrelated details.
Expectation	Perseverance	Tenacious energy for the setting and the pursuing bold goals for pupils and the school as a whole.
	Searching for information	The ability to discover the essence of things: the intellectual curiosity.
	Initiative	The drive, the enthusiasm for action now in the context of coming events.
Leadership	Flexibility	The ability and the willingness to adapt the needs to the situation and to change the tactics.
	Accountability	The drive and the ability to explain clearly the expectations and parameters and to hold others accountable for their performance.
	Enthusiasm for learning	Interests and abilities to support the pupils in learning and to help them become the confident and the independent learners.

In a sense, current research on the effectiveness of education is returning to an aspect that has been around since the 1960s. This is the attention paid to the active involvement of the pupil and his learning strategies as essential "mediators" between teaching practices and pupils' results. These studies conclude that pupils' learning outcomes depend primarily on their learning strategies and motivation to learn. On this basis, the teaching factors are defined that appear to be important in regulating the pupils' learning so that it leads to the expected outcomes. They are divided into three main dimensions: relevance, time, and structure [23]. The dimension of relevance refers to the choice of subject matter in relation to the educational goals and in connection with the curriculum. It also includes ensuring that the implemented curriculum corresponds to the intended curriculum, linking the curriculum between the grades and the classes, and ensuring that teaching content matches the content of the didactic tests and other assessment tools. This last aspect is usually described as a "learning opportunity" [23].

The time dimension refers to both allocated time and "net teaching time", which can be defined as official teaching time minus time "lost" by other activities. Finally, the time "spent working on learning tasks", which is an expression of the time when students are actively involved in learning activities [23].

The structure dimension is a certain teaching "technology" (in the procedural sense, i.e., not in the sense of the application of the information technology). Structured teaching in such forms as 'coping learning' has shown positive results in studies of the effectiveness of education, especially for disadvantaged pupils in the first stage of the primary schools, but also at higher stages in the teaching of higher cognitive level skills. Based on these findings inspired by constructivism, this dimension should be seen as a continuum running from the providing of a firm structure and the "scaffolding" of the learning process to providing the pupils with autonomy. Effective education can then be understood as the correct level appropriate to the pupils' learning requirements, learning tasks, and educational goals. The structure dimension also includes frequent monitoring of pupils' progress and providing feedback and encouragement based on assessment results. In this sense, it is not only about providing cognitive support but also about supporting the pupils' engagement. Adapting the level of difficulty to the specific needs of pupils can also be a specific aspect of the teaching structure [23].

3. Material and Methods

The methodology process workflow flowchart is shown in Figure 1.

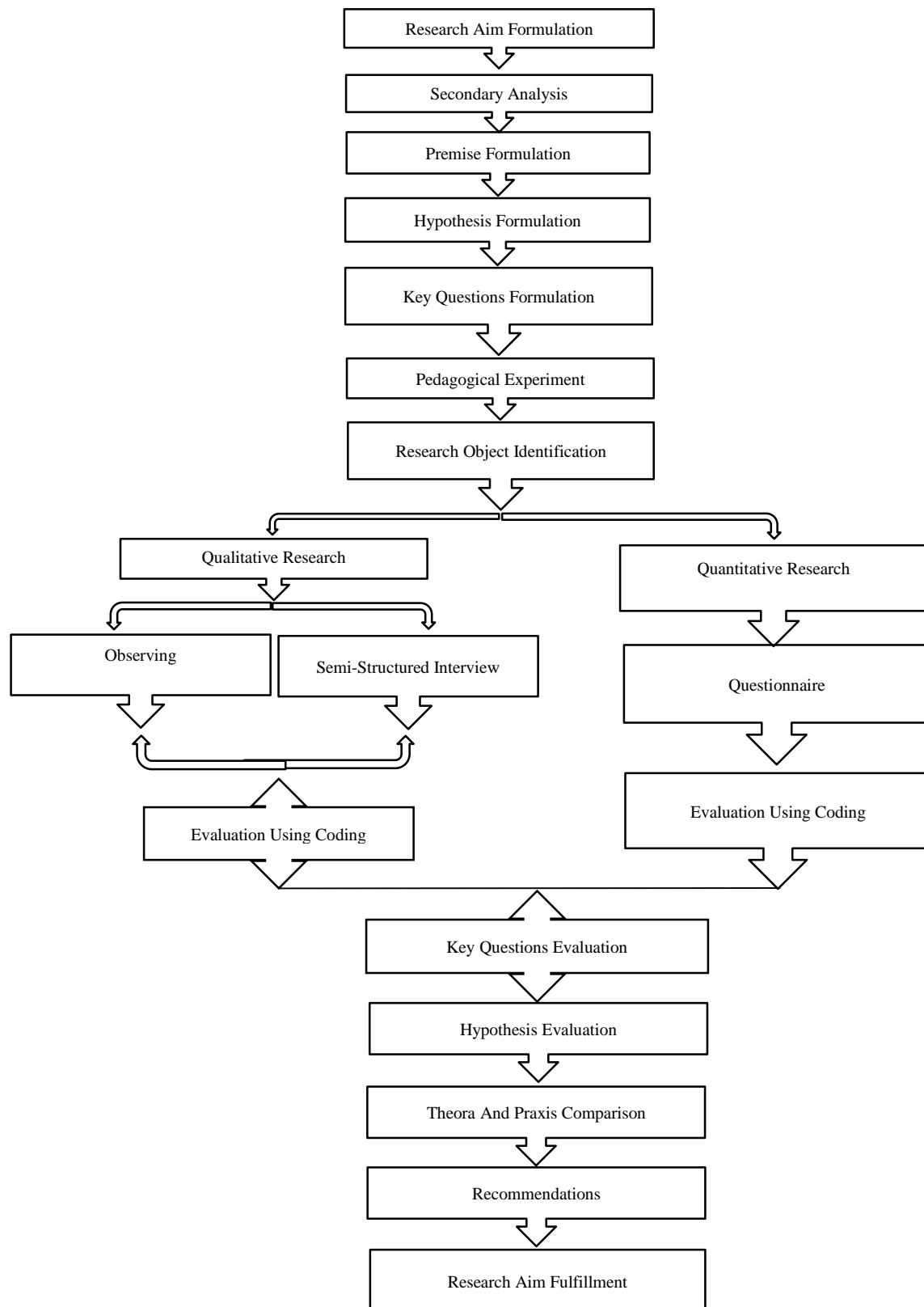


Figure 1. Methodology process workflow flowchart

3.1. Research Aims and Hypotheses

The primary aim of the presented paper is to demonstrate the effectiveness of activation teaching methods in the teaching of technical subjects at secondary vocational schools in the context of the implementation of a longitudinal

study through the pedagogical research using a pedagogical experiment. The effectiveness of the activation teaching methods is demonstrated in the subject Integrated Rescue System taught in the field of Security and Legal Activities (code 68-42-M/01), which is implemented at XY Secondary School. The subject Integrated Rescue System is taught in the 2nd year (2 hours per week), in the 3rd year (1 hour per week) and in the 4th year (2 hours per week) of the above-mentioned field. In each grade, three classes are opened, the subject is taught by two teachers, while only one teacher of the analyzed subject will participate in the pedagogical research carried out by us. This is a matriculation field. The object of the research are pupils who were 2nd year pupils in the 2019/2020 school year, as well as teachers of the analyzed subject. The pedagogical experiment is implemented in three consecutive years, namely in the school year 2019/2020, 2020/2021 and 2021/2022.

In the context elaborated in the theoretical part of the paper, we understand the effectiveness of activation teaching methods as a positive difference in the knowledge of pupils caused by the implementation of activation teaching methods compared to the knowledge of pupils who continue to be taught using the standard frontal teaching and interpretation methods without targeted activation. By this positive difference, we perceive a higher average assessment of pupils at the end of the monitored period compared to the average assessment of pupils at the beginning of the monitored period.

As part of our research, we are therefore based on the premise P: The implementation of the activation teaching methods and their targeted application has a long-term positive effect on pupils' knowledge of technical subjects at secondary vocational schools, which is objectively reflected in their results and assessment. We state the following hypotheses:

Hypothesis H1: The average assessment of pupils in the analysed subject at the end of the 1st half year of the 2019/2020 school year, whose teaching was carried out using the activation teaching methods, will be higher than the average assessment of pupils whose teaching was carried out in a frontal way without activation.

Hypothesis H2: The average assessment of pupils in the analysed subject at the end of the 2021/2022 school year, whose teaching was carried out using the activation teaching methods, will be higher than the average assessment of pupils whose teaching was carried out in a frontal way without activation.

Hypothesis H3: The average assessment of pupils in the analysed subject at the end of the 1st half year of the 2019/2020 school year, whose teaching was implemented using the activation teaching methods, will be lower than their average assessment at the end of the 1st half year of the 2021/2022 school year.

Hypothesis H4: The application of the activation teaching methods even during the online teaching in the period of lockdown and quarantine due to the COVID-19 pandemic has a positive effect on the attractiveness of the teaching implemented in this way.

We will also try to find answers to these key questions:

KO1: Which of the activation teaching methods is most suitable for both teachers and pupils?

KO2: How do pupils subjectively evaluate the application of the activation teaching methods in their education?

KO3: When applying the activation teaching methods, are pupils more drawn into the lesson, are they more motivated, do they find the lesson more interesting?

KO4: Does the application of activation teaching methods have a positive effect on the classroom climate?

KO5: Do pupils learn the subject matter faster and easier when activation teaching methods are applied?

KO6: Is it possible to apply the activation teaching methods without reservation also within the framework of the online teaching?

However, the aim of the research is not, and cannot be, to provide a detailed or exhaustive analysis regarding the implementation and application of the activation teaching methods, as such a goal would far exceed the required scope of the presented contribution. Our effort is to formulate the conclusions of the presented research in such a way that they are not only academic considerations, but above all the practical analyses and outputs capable of an independent life.

3.2. Specification of the Research Implementation Procedure

To process the pedagogical research within the analytical part of the paper as a starting point for comparison with the outputs of available research, both Czech and foreign, towards the formulation of real and feasible proposals and recommendations for the implementation and application of activation teaching methods in the teaching of technical subjects at secondary vocational schools, a pedagogical experiment, a semi-structured interview and a questionnaire survey were used. The pedagogical experiment took place over the course of three monitored years. They are the school years 2019/2020, 2020/2021 and 2021/2022. The pedagogical experiment took place regardless of whether the teaching was carried out face-to-face or online. The experimental group was class 2.A (3.A and 4.A in the following monitored

years), when, after an agreement with the teacher, activation was implemented in the teaching of the analysed subject, activation teaching methods were used in every lesson, regardless of the form of teaching. The following activation teaching methods were used:

- Role;
- Playing;
- Brainstorming;
- Work in groups;
- Mind maps;
- Simulation;
- Practical demonstration;
- Guided discussion;
- Case study;
- Excursion.

The control group was class 2.B (3.B and 4.B in the following monitored years). In the teaching of the control group, the activation teaching methods were not used, the frontal teaching was carried out using the explanatory method. Both the experimental and control groups are taught by the same teacher. Class 2.C is taught by another teacher. For the pedagogical experiment, we purposefully chose classes with the same teacher, due to the assumption of the objectivity in the assessment of pupils' knowledge and due to the same approach to teaching in both classes. The pupils were not informed about their inclusion in the experiment, the teacher's task was only to inform the pupils in the experimental group that they were currently implementing the activation of teaching. As a part of a personal meeting in June 2019, the implementation of the pedagogical experiment was discussed, the methods of activation that will be used as a part of the experimental teaching were identified. These methods were subsequently applied to teaching during the three monitored years.

In agreement with the teacher, the researcher carried out at least 1x per month the hospitalization in both the experimental and control groups, using the observation to check the use of activation teaching methods in the experimental group (frequency of their application, type of activation method, didactic tools for the application of the given activation method, study materials, the ability to apply the activation teaching methods in online teaching, the difference in the application of activation methods in face-to-face and online teaching), as well as the motivation of pupils to learn (pupils' interest in the subject matter and the teacher's explanation) and pupils' concentration during the lesson (class climate, disruption by pupils) both in the experimental, and control groups. These visits were also carried out during the period of lockdown and quarantine, i.e., during the time of online teaching. A total of 29 hospitalizations were carried out in both the experimental and control groups during the monitored period.

A semi-structured interview was conducted with the teacher of the analysed subject. He is a man, age 46. Originally trained as a paramedic, graduate of higher vocational school in the field of Certified Paramedic. For 8 years he worked as a paramedic in the Medical Ambulance Service of the capital city of Prague, then after a serious work accident leading to reduced mobility, he worked for 7 years at the dispatch centre of the Medical Ambulance Service in the capital city of Prague, has been teaching first aid, rescue and emergency medical services for 11 years. He is a graduate of DTI University in the study program Teacher Training in Vocational Subjects and Practical Training.

The introductory meeting took place in June 2019. Thanks to the personal flexibility, proactivity and propensity for innovation, which are more than typical of the analysed teacher, we agreed on the implementation of a pedagogical experiment. Activating teaching methods were identified, which were subsequently implemented in the teaching of the analysed subject in the 2nd year of the analysed secondary vocational school, for the following three years, i.e. in both the experimental group and the control group, the monitored period was the time from the beginning of the 2nd year until graduation.

The semi-structured interview took place in April 2022, i.e., at the beginning of the matriculation exams for both the experimental group and the control group. The semi-structured interview took place in the building of the analysed school on 24 April 2022 and lasted 90 minutes. The entire conversation was recorded on a dictaphone in a mobile phone.

The teacher's responses were then analysed using coding. We coded into these areas:

1. Demographic data.
2. Previous use of activation teaching methods.
3. Current application of selected activation teaching methods:
 - Difficulty of preparation for teaching.
 - Application of activation methods in online teaching.
 - Pupils' reaction to teaching using activation teaching methods.

- Educational results when applying activation teaching methods.
- Classroom climate in the experimental group.

4. Recommendations.

A questionnaire survey was conducted among the pupils of the experimental group. Both analyzed groups were monitored for a period of three years, the questionnaire survey was carried out at the end of the 4th year of study before starting the matriculation exams. The questionnaire survey was carried out in the period March - April 2022, and was evaluated as a part of the research in the months of June - August 2022.

The aim of the questionnaire survey among the pupils of the experimental group was to find out whether the teacher used the activation teaching methods in analysed subject, if so, what methods were used and how the pupils themselves subjectively evaluated the use of these methods in teaching. To fulfil the aim of this research, we decided to examine both the teacher's point of view and the pupils' point of view, because only a certain harmony between the pupil and the teacher can form a whole, which in the end constitutes the very perfection of the whole process. The questionnaire contains 33 open and closed type questions. We designed the questions in such a way that they correlated with the coding areas of the results of the interview with the teacher of the analysed subject. A time limit of 20 minutes is required for pupils to complete the questionnaires.

This study answers the key questions in the above-cited way. Individual key questions are answered using the results of the observation (hospitalization), an interview with the teacher and a questionnaire survey among the pupils of the experimental group. For both the experimental and control groups, we further examined the pupils' achieved knowledge, which was projected into the school assessment, i.e. grading. We examined and subsequently compared and statistically evaluated the final assessment of the subject in the midterm and at the end of the school year. This assessment was submitted to us by the teacher of the subject under investigation.

Due to the fact that the experimental and control groups were taught by the same teacher, we could work with the premise that the assessment of the achieved knowledge in both analysed groups are objective and comparable. To evaluate the research results projected into the evaluation of hypotheses, we used the mathematical-statistical methods for our chosen variables, which are not only processed, but also analyzed through the statistical program SPSS Statistics 22.0. We primarily used the arithmetic mean, the pivot tables and the Pearson's chi-square (χ^2) test. Various Czech and foreign information sources were used for the final comparison.

3.3. Characteristics of Respondents of Pedagogical Research

For the needs of the pedagogical research carried out by us, it was necessary to select a sample of respondents who were willing to cooperate and certain comparisons of the identified outputs over time were possible. The effectiveness of activation teaching methods is demonstrated in the subject Integral Rescue System taught in the field of Security and Legal Activities (code 68-42-M/01) implemented at the XY Secondary School. The number of pupils in the experimental and control groups did not change during the monitored period. The experimental group consisted of 18 pupils, of which 12 were girls, the control group consisted of 17 pupils, of which 10 were girls.

4. Results and Discussion

4.1. Outputs of a Semi-Structured Interview

Below we present a transcript of the semi-structured interview with the use of summarization according to our chosen codes.

Code 1: Demographic data

The respondent of the semi-structured interview, who served to provide an insight into the issue of the application of activation teaching methods not only during the face-to-face but also during the online teaching, was a male teacher aged 46, who has both professional education and experience, as well as pedagogical education. His teaching experience is 11 years. With regard to his expertise, the length of both professional and pedagogical experience, we can therefore state that he is a well-founded teacher with sufficient pedagogical experience for the application of the pedagogical experiment we have chosen. We can therefore consider his conclusions as relevant solved issues; they can serve to generalize information towards the formulation of proposals and recommendations in the context of the implementation and application of activation teaching methods in the teaching of technical subjects at secondary vocational schools.

Code 2: Previous use of activation teaching methods

The respondent stated that even in his previous practice, before the implementation of the pedagogical experiment, he had used the activation teaching methods. Specifically, he stated that he had often used simulations, role plays, field trips, hands-on demonstrations, guided discussions, worksheets, case studies. However, he admitted that he did not use

these professional names of particular activation teaching methods, and mostly did not even know them. After the introductory meeting before the pedagogical experiment and the theoretical study of these activation teaching methods, he allowed their earlier application in the teaching of the analysed subject.

Code 3: Current application of selected activation teaching methods

Code 3a: Difficulty of preparation for teaching

The respondent does not state that the preparation of the teaching of the analysed subject using the activation teaching methods would be fundamentally more demanding. It was more time-consuming to prepare the materials for the application of activation teaching methods, it was more mentally demanding to prepare the teaching for the control group, where frontal teaching was used with the use of the interpretation with a minimum of application of activation teaching methods.

Due to the relatively recent graduation from higher education in the field of pedagogy, the concept of pedagogic experiment and activation teaching methods was not unknown to the respondent, there was no need to study the individual methods chosen for the pedagogic experiment in principle and in detail or to consult with someone.

The respondent does not find a fundamental difference in the preparation for the face-to-face teaching and online teaching of the analysed subject, either with the use of activation teaching methods or without their application in the teaching.

Code 3b: Application of activation methods in online teaching

The respondent does not indicate a fundamental difference in the application of activation teaching methods in face-to-face or online teaching. The difference was only in the length of preparation of teaching materials for the experimental group.

He states that it was essential to realize and to identify which of the activation teaching methods is the most appropriate to apply in online teaching and to stick to it throughout the implementation of online teaching.

The respondent states a subjective feeling that, especially during the online teaching, the pupils were more alert and attentive thanks to the application of the activation teaching methods in comparison with the control group, in which the frontal teaching was carried out with the use of the interpretation.

Code 3c: Pupils' reaction to teaching using activation teaching methods

According to the respondent, it is not possible to subjectively evaluate how pupils reacted to the application of activation teaching methods. He only states that he had a subjective feeling that the pupils in the experimental group that used activation teaching methods were more attentive, especially during the online teaching, probably due to the expectation of a moment of surprise when they will be called upon to solve a problem (question, task, assignment).

Code 3d: Educational results when applying activation teaching methods

The experimental group, where pre-selected activation teaching methods were applied, always had a better evaluation of tests and papers on average than the control group. Further on in presented paper we will confirm this using the statistical methods. Nevertheless, we can still state that the application of activation teaching methods, regardless of whether the teaching is carried out face-to-face or online, had a positive effect on the pupils' knowledge, which was manifested in the form of a mathematically higher assessment of written control papers, tests and the final assessment on the certificate.

Code 3e: Classroom climate in the experimental group.

The respondent did not subjectively identify a difference in the classroom climate of the experimental group and the control group.

Code 4: Recommendations:

The nature of the analysed subject tends to the application of such activation methods as practical demonstrations, simulations, role-playing, which, however, is possible only in the case of the face-to-face teaching. The face-to-face and the online classes allow for the application of tests, case studies, worksheets, videos and brainstorming.

The respondent recommends to realize the teaching of technical subjects in such a way that the teacher prepares the theoretical basis for the teaching, most often in the form of a PowerPoint presentation, recommends to the pupils, if necessary, online videos on the given issue, and subsequently uses problem-based methods during the teaching, specifically the solution of case studies, tests and worksheets, when pupils work not only with the information they have studied at home in the theoretical background, but they can also search for information directly in the classroom on the Internet. These recommendations are also confirmed by Sari (2020) [59], Tomasik et al. (2021) [60], Kousloglou (2023) [61] or Dignath, (2021) [62] and Glotova & Kolchugina (2021) [63].

4.2. Results of a Questionnaire Survey among Pupils of The Experimental Group

Pupils of the experimental group, class 4.A, took part in the questionnaire survey. There was a total of 18 pupils, of which 12 were girls and 6 were boys. In the control group, class 4.B, there was a total of 17 pupils, of which 10 were girls and 7 were boys. The number of pupils in the class and the gender structure did not change during the implementation of the pedagogical experiment. Both girls and boys in the interviewed experimental group described their relationship to school as positive. All boys prefer an active approach in teaching, the same preference was confirmed by 10 girls, i.e., 83% of girls. 2 girls prefer to passively receive an explanation of the material being discussed (Figure 2).

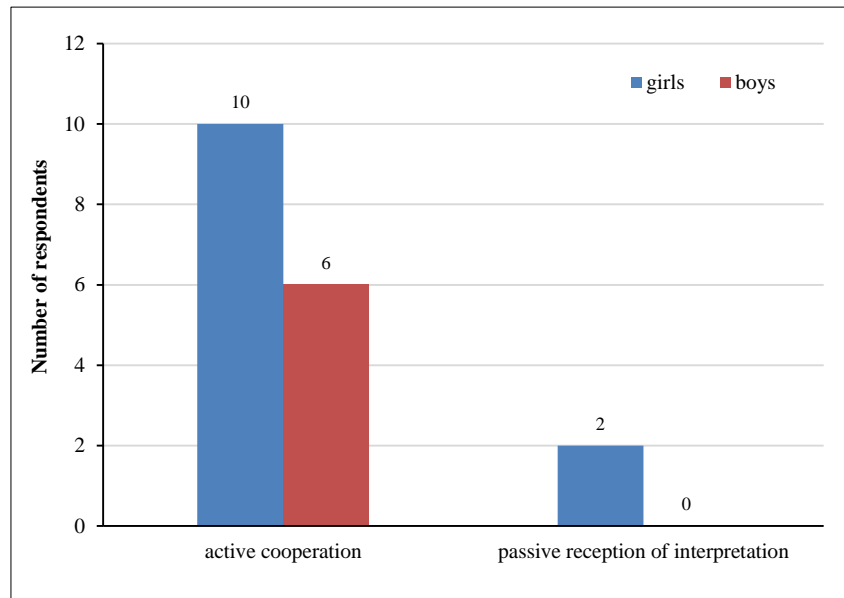


Figure 2. Preference for active collaboration in teaching

Almost all girls noticed a change in teaching management in the analyzed subject in comparison with other subjects, but only 50% of boys identified this change (Figure 3).

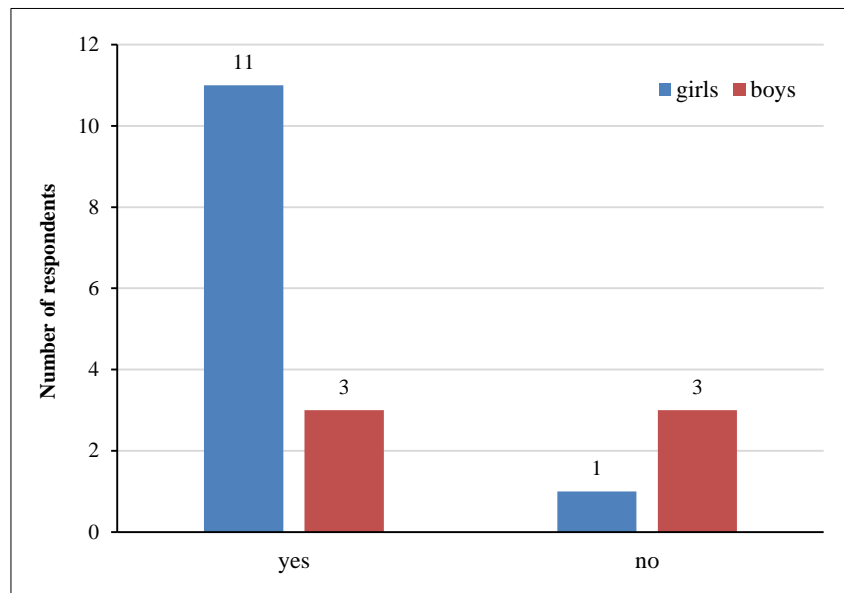


Figure 3. Identification of a change in teaching management in comparison with other subjects

Most of the girls (83%) were aware that activation teaching methods were implemented in the lessons. For boys, the situation is the opposite, most of them (83%) did not notice the application of these methods in the teaching of the analysed subject. Only girls responded to the question about the fun and popularity of teaching realised with the use of activation teaching methods, when 66.6% of the girls said that they liked the teaching and found it more fun, cheerful and not boring (Figure 4).

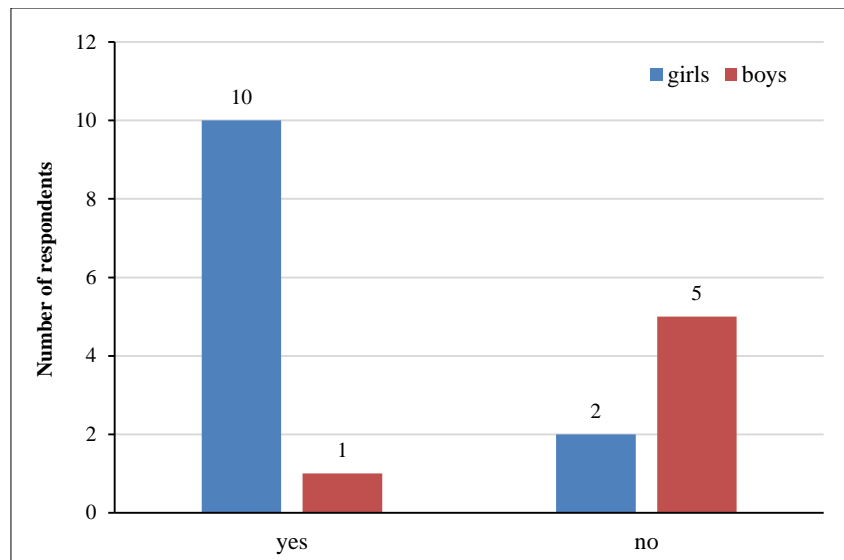


Figure 4. Identification of the activation teaching methods application in the analyzed subject

Furthermore, on Figure 5, we present the subjective frequency of occurrence of individual activation teaching methods chosen by us, which were primarily chosen for the implementation of the pedagogical experiment, from the point of view of girls and boys in the experimental group.

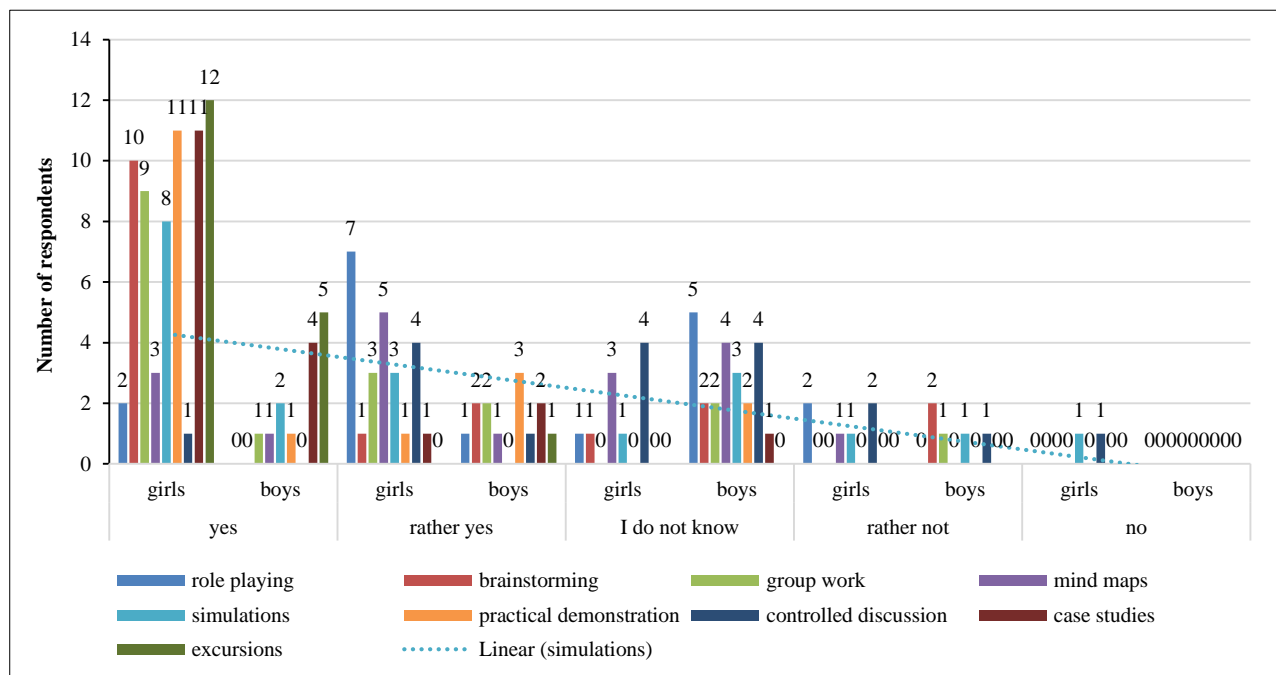


Figure 5. Pupils meeting with selected activation teaching methods

It can be seen from the graph that both girls and boys are aware that excursions, case studies and practical demonstrations were used in their teaching. There is also an evident difference in the perception of the implementation of teaching between boys and girls, when boys very often chose the answer I DON'T KNOW, basically it was their most frequent answer. The question is whether the reason is that they did not want to think fundamentally about their answer when filling out the questionnaire, or whether they really do not perceive how the teaching is realised in analysed subject. Our personal opinion is that the influence of both is visible on this result, which we judge also from the result of the answers to the next question, when 100% of the boys said that teaching using activation methods has only positives, while they did not mention any positives.

92% of girls have a positive perception of teaching with the use of activation teaching methods, with the most common positives being: the class goes by quickly, the teaching is action-oriented, we study a lot of things during the lesson. Only one negative was mentioned and that is that the class is noisy and sometimes the teaching is confused (Figure 6).

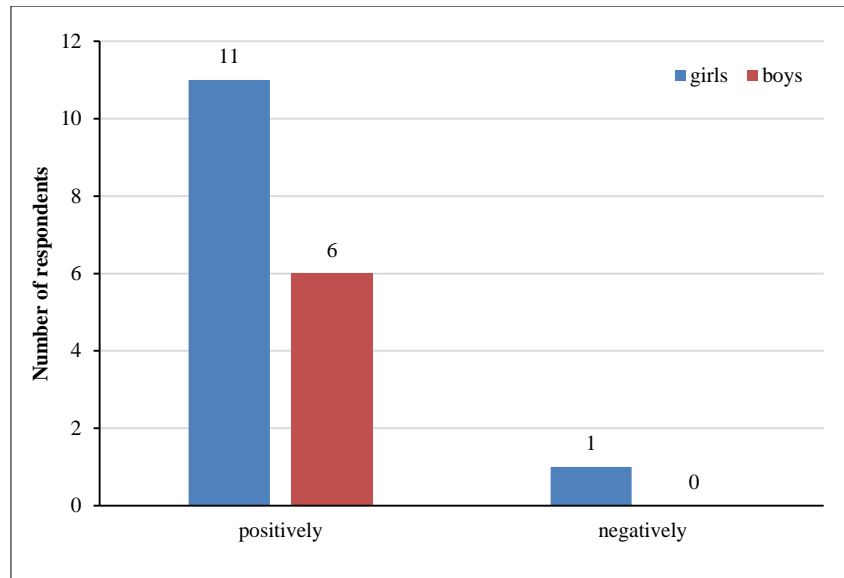


Figure 6. How is the teaching of the analysed subject with the use of activation methods perceived by pupils

83% of pupils stated that they were interested in teaching using activation methods, of which all girls confirmed this (Figure 7).

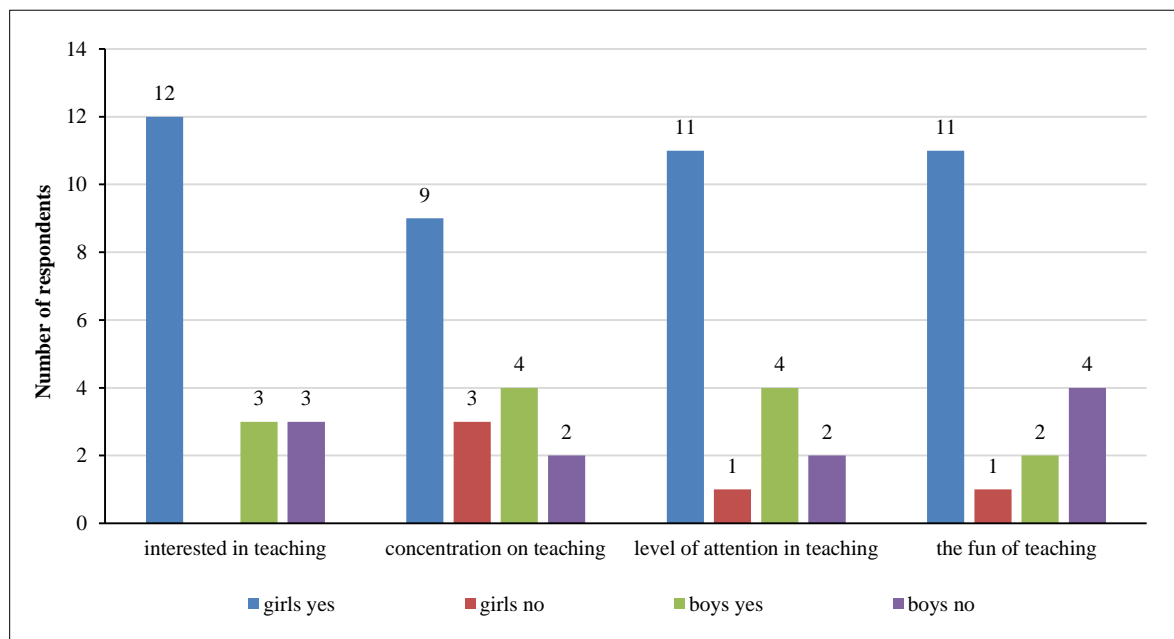


Figure 7. Assessment of interest, attention and concentration in teaching using activation methods by pupils

In the same way, the majority of girls and boys state that thanks to the activation, they concentrated more on their lessons and were more attentive, also due to the greater fun of the lessons realized in this way.

The majority of girls (66.7%) state that thanks to the application of activation teaching methods, they took away more knowledge and information from the lessons of analysed subject than from other subjects, but the boys do not share the same idea, when only half of them confirmed this. 75% of the girls say that due to the implementation of activation methods in the lesson and the absorption of a lot of information in the lesson, their home preparation for the lesson or tests and assessments is shorter than in the case of other subjects. Again, only half of the boys confirmed this statement.

Generally, pupils report a positive acceptance of activation teaching methods of the analysed subject (83% of girls and 83% of boys). 92% of girls and 83% of boys identified the application of activation teaching methods even during online teaching. They report that they used video-based teaching, case studies and a large number of tests and worksheets. The pupils rate the online teaching as more fun (83% of girls and boys), they watched videos and, thanks to the impossibility of writing papers or being called to the blackboard, online teaching did not stress them (Figure 8).

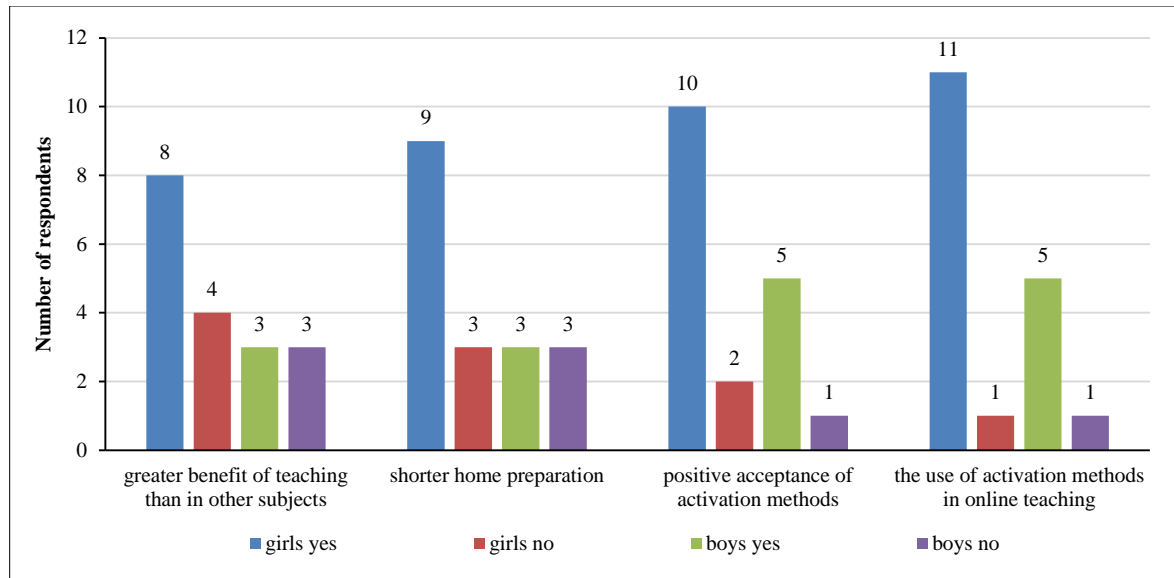


Figure 8. Evaluation of the positive aspects of the activation teaching methods implementation

When using the activation teaching methods, there were no major problems either on the side of the pupils or on the teacher's side, as can be seen from Figure 9. Above all, the girls found the use of activation teaching methods to be generally problem-free.

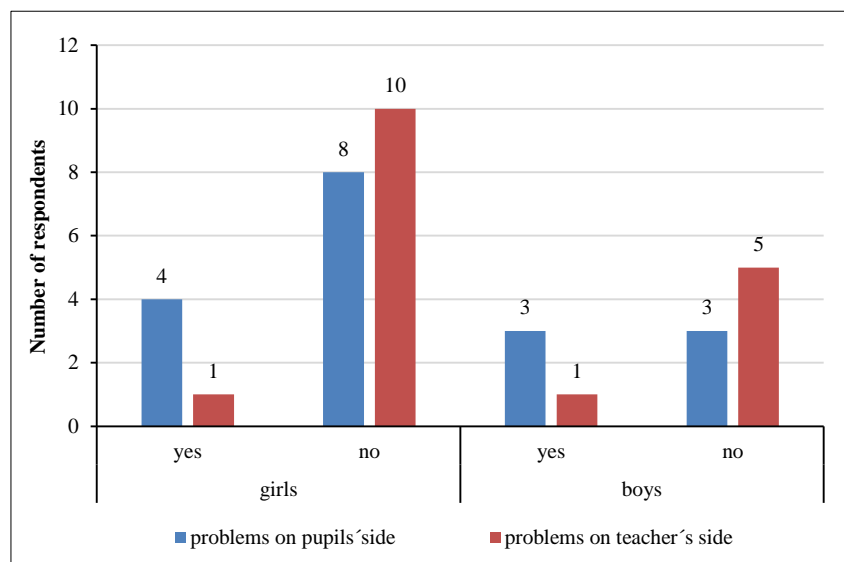


Figure 9. Problems on the side of pupils or teacher when applying activation teaching methods

Among the more common problems faced by pupils, the respondents included:

- Unwillingness to work in a group (frequency 9);
- Unwillingness to present the prepared outputs or solutions to assigned problems and case studies (frequency 8);
- A dead phone that was supposed to be used to search for answers to questions in a test, case study or worksheet (frequency 4).

Among the problems on the teacher's side, the respondents indicated that:

- It was not possible to start the tutorial video (frequency 4);
- The unclear assignment of the case study (frequency 2).

No other problems on the side of the pupils or the teacher were identified.

After their 3-year experience, pupils recommend including of the activation teaching methods in other subjects as well. Only one girl does not recommend including of these methods in teaching, however, she does not justify her answer in any way (Figure 10).

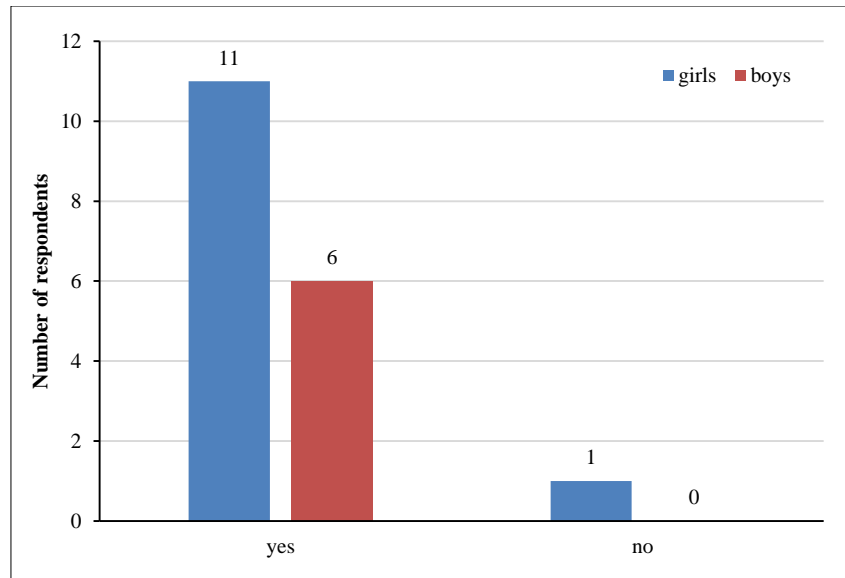


Figure 10. Recommendation to include the activation teaching methods in other subjects

Pupils recommend to include in particular:

- The video (frequency 7);
- The simulations (frequency 6);
- The excursions (frequency 5);
- The role playing (frequency 4).

100% of respondents answered yes to the question of whether pupils are satisfied with the functionality of activation teaching methods. The majority of pupils evaluated teaching using activation methods as essentially better than classical teaching. This is how 83% of pupils (100% of girls and 66.6% of boys) evaluated experimental teaching (Figure 11).

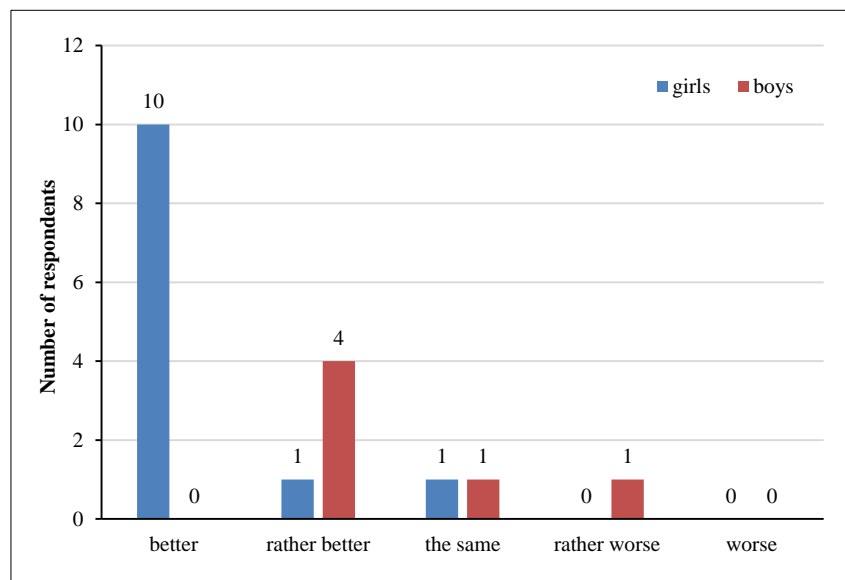


Figure 11. Overall assessment of teaching using activation methods

Below we present the evaluation of the questionnaire survey with the use of the summarization according to our chosen codes.

Code 1: Demographic data

Pupils of the experimental group, class 4.A, took part in the questionnaire survey. There was a total of 18 pupils, of which 12 were girls and 6 were boys. The number of pupils in the class and the gender structure did not change during the implementation of the pedagogical experiment.

Code 3: Current application of selected activation teaching methods*Code 3b: Application of activation methods in online teaching*

The majority of respondents, both girls and boys, reported that video-based teaching was used, then case studies and a large number of tests and worksheets were used.

Pupils rate online teaching as funnier, they watched videos and, thanks to the impossibility of writing tests or being called to the blackboard, online teaching did not stress them.

Code 3c: Pupils' reaction to teaching using activation teaching methods

The majority of respondents prefer an active approach in teaching, however, only half of the boys identified that the teaching system in the analysed subject was a little different from the teaching system in other subjects. Only girls found actively realised teaching funnier, they were more interested in activation teaching than in classical teaching, on the other hand, both boys and girls said that thanks to the activation they concentrated more on teaching and were more attentive, also due to the bigger fun of the teaching implemented in this way.

Girls more identified the use of individual activation teaching methods in the analysed subject. When identifying the application of individual activation teaching methods, boys very often chose the answer I DON'T KNOW, basically it was their most frequent answer. The question is whether the reason is that they did not want to think fundamentally about their answer when filling out the questionnaire, or whether they really do not perceive how the teaching is carried out in individual subjects. Our personal opinion is that the influence of both is visible on this result, which we judge also from the result of the answers to the next question, when 100% of the boys said that teaching using activation teaching methods has only positives, while they did not mention any positives.

92% of girls had a positive perception of teaching with the use of the activation teaching methods, with the most common positives being: the class goes by quickly, the teaching is action-oriented, we study a lot of things during the lesson. Only one negative was mentioned and that is that the class is noisy and sometimes the teaching is confused.

The majority of girls stated that thanks to the application of activation teaching methods, they took away more knowledge and information from the analysed subject than from other subjects, but the same idea is not shared by the boys, when only half of them confirmed this. Most of the girls noted that due to the implementation of activation teaching methods and the absorption of a lot of information in the lesson, their home preparation for the lesson or tests and examinations was shorter than in the case of other classes. Again, only half of the boys confirmed this statement. Overall, however, the pupils report a positive acceptance of activation teaching methods of the analysed subject. When using the activation teaching methods, there were no major problems either on the side of the pupils or on the side of the teacher. Above all, the girls found the use of activation teaching methods to be generally problem-free.

Among the more common problems faced by pupils, the respondents included:

- An unwillingness to work in a group.
- A reluctance to present prepared outputs or solutions to assigned problems and case studies.
- A dead phone that was supposed to be used to search for answers to questions in a test, case study or worksheet.

Among the problems on the teacher's side, the respondents indicated:

- The tutorial video could not be started.
- An unclear assignment of the case study.

No other problems on the side of the pupils or the teacher were identified.

100% of respondents answered yes to the question of whether pupils are satisfied with the functionality of activation teaching methods. The majority of pupils evaluated teaching using the activation methods as essentially better than classical teaching. This is how 83% of pupils (100% of girls and 66.6% of boys) evaluated experimental teaching.

Code 4: Recommendations

After their 3-year experience, the pupils recommended the including of the activation teaching methods in other subjects as well. Only one girl does not recommend including these methods in teaching, however, she does not justify her answer in any way. Pupils recommended to include in particular:

- Watching videos and answering test questions or questions in the worksheet related to the video;
- Simulation;
- Excursions;
- Role playing.

4.3. Evaluation of Key Questions

The evaluation of the key questions was carried out using the results of a questionnaire survey among the pupils of the experimental group, the observation in the teaching of the experimental and the control groups by the researcher and the results of the interview with the teacher as a part of the pedagogical experiment.

KO1: Which of the activation teaching methods is most suitable for both teachers and pupils?

This question is answered using the results of observation, an interview with the teacher and a questionnaire among the pupils of the experimental group.

Brainstorming, field trips, simulations and practical demonstrations received a positive response as part of the identification of the most suitable activation teaching methods. Teaching methods known professionally as guided discussion or problem-based methods, where applied tests, worksheets and case studies can be included in the teaching, have proved useful to the teacher. And of course, using the videos and forcing pupils to present or speak in front of the class. This choice of the teacher was essentially confirmed by the pupils of the experimental group.

KO2: How do pupils subjectively evaluate the application of the activation teaching methods in their education?

This question is answered using the results of an interview with the teacher and a questionnaire among the pupils of the experimental group.

Pupils subjectively evaluated the application of activation teaching methods very positively. They especially highlighted the excursions, simulations and role-playing. The teacher confirmed that these methods were essential for teaching the analysed subject. The pupils themselves stated that they were impressed by the activation teaching, although this was basically confirmed only by the girls, who rather identified and noted a change in the system of teaching the analysed subject towards activation. They even stated that thanks to the activation they absorbed more information and their home preparation for exams or papers and tests was easier and shorter. Pupils confirmed the application of activation teaching methods even in online teaching and evaluated it very positively, describing it as "more fun".

KO3: When applying the activation teaching methods, are pupils more drawn into the lesson, are they more motivated, do they find the lesson more interesting?

This question is answered using the results of observation, an interview with the teacher and a questionnaire among the pupils of the experimental group. Yes, pupils reacted to activation teaching methods rather positively, they showed more attention in teaching, both face-to-face and online teaching. This is confirmed not only by the teachers, but also by the pupils themselves.

KO4: Does the application of activation teaching methods have a positive effect on the classroom climate?

This question is answered using the results of observation, an interview with the teacher and a questionnaire among the pupils of the experimental group. Classroom climate is probably unrelated to the application of specific teaching methods. Rather, it correlates with the personality of the teacher and his ability to arrange the calmness, order, attention and to inspire the natural respect, but without the fear felt on the part of the pupils to communicate openly with the teacher.

KO5: Do pupils learn the subject matter faster and easier when activation teaching methods are applied?

This question was answered using the results of an interview with the teacher and a questionnaire among the pupils of the experimental group. Yes, the teacher of the analysed subject confirmed that, thanks to the activation, the pupils learnt the subject matter more easily and it was better fixed.

Furthermore, the evaluation of the subject both on the certificate and during the school year in all three monitored years, when the pedagogical experiment was implemented, confirms that the pupils of the experimental group, i.e., the class where teaching using activation teaching methods was applied, achieved better school evaluation. Better school success is especially noticeable in the era of online teaching, when activation probably clearly led to the acquisition of deeper and better fixed knowledge or perhaps more motivated pupils to more responsible preparation at home for tests, five-minute tests and control work.

KO6: Is it possible to apply the activation teaching methods without reservation also within the framework of the online teaching?

This question is answered using the results of observation, an interview with the teacher and a questionnaire among the pupils of the experimental group. Yes, it is definitely possible. Due to the activation, pupils in the experimental group achieved better school results and better fixation of the subject matter than pupils in the control group during online teaching. In addition, they described teaching realised in this way as more fun. In the experimental group, mainly case studies, tests and worksheets were applied during the online teaching period, i.e., essentially problem-based methods, videos were often and successfully used as a basis for getting to know the studied issue.

From the evaluation of the key questions, it clearly follows that in the experimental group, both during the face-to-face and the online teaching, mainly case studies, tests and worksheets were applied, i.e., basically problem-based methods, as a basis for getting to know the studied issue, it was often and successfully used videos and PowerPoint presentations, while the study materials were presented to the pupils for home preparation.

4.4. Evaluation of Hypotheses

As a part of our research, we are based on the premise P: The implementation of the activation teaching methods and their targeted application has a long-term positive effect on pupils' knowledge of technical subjects at secondary vocational schools, which is objectively reflected in their results and assessment.

For a more detailed evaluation of the given premise, we will use the evaluation from the premise and the research aim resulting research hypotheses. We will use mathematical-statistical methods, namely pivot tables, arithmetic mean and the Pearson's chi-square (χ^2) test.

Hypothesis H1: The average assessment of pupils in the analysed subject at the end of the 1st semester of the 2019/2020 school year, whose teaching was carried out using the activation teaching methods, will be higher than the average assessment of pupils whose teaching was carried out in a frontal way without activation. To evaluate the hypothesis H1, we will use the pivot tables and compare the control and experimental groups. The result of the comparison is shown in Table 2, from which it is evident that the statistical significance is low, therefore it is not possible to confirm the correlation between the compared groups.

Table 2. Evaluation of the hypothesis H1 using the comparison of analysed variables in the control and experimental groups

Statistic	Value	Sig. (2-tailed)
Pearson Chi-Square	0.64	0.888
Likelihood Ratio	0.65	0.886
Linear-by-linear	0.15	0.700

For a more detailed evaluation of the H1 hypothesis, there is no need to use the Pearson's chi-square (χ^2) test, we will use the arithmetic mean as one of the methods of descriptive statistics. We accept the hypothesis H1, because pupils in the experimental group achieved a lower arithmetic mean of the subject assessment ($M_{E2} = 2.111111$), i.e., a higher average assessment of the subject after the implementation of the activation teaching methods than pupils in the control group, who had a higher arithmetic mean ($M_{K2} = 2.235294$). therefore, a lower subject assessment.

$$M_{K2} = 2.235294 > M_{E2} = 2.111111 \quad (1)$$

$$M_{K2} - M_{E2} = 0.124183 \quad (2)$$

The difference between the control group and the experimental group in terms of arithmetic means is 0.124183, that is, the experimental group with activation teaching had a better arithmetic mean by 0.124183 than the group with the frontal method of teaching without activation. It can therefore be concluded that the activation teaching improved the average assessment of the subject of the experimental group.

Hypothesis H2: The average assessment of pupils in the analysed subject at the end of the 2021/2022 school year, whose teaching was carried out using the activation teaching methods, will be higher than the average assessment of pupils whose teaching was carried out in a frontal way without activation. To evaluate the hypothesis H2, we will use the pivot tables and compare the control and experimental groups. The result of the comparison is shown in Table 3, from which it is evident that the statistical significance is low (lower than for hypothesis H1), therefore it is not possible to confirm the association between the compared groups.

Table 3. Evaluation of the hypothesis H2 using the comparison of analysed variables in the control and experimental groups

Statistic	Value	Sig. (2tailed)
Pearson Chi-Square	0.54	0.910
Likelihood Ratio	0.55	0.909
Linear by linear association	0.39	0.531

For a more detailed evaluation of the H2 hypothesis, there is no need to use the Pearson's chi-square (χ^2) test, we will use the arithmetic mean as one of the methods of descriptive statistics. We accept the hypothesis H2, because the experimental group using activation teaching methods achieved a lower arithmetic mean ($M_{E4} = 2.277778$), i.e., a better assessment of the subject than the control group ($M_{K4} = 2.470588$), whose teaching was carried out frontally without the activation.

$$M_{K4} = 2.470588 > M_{E4} = 2.277778 \quad (3)$$

$$M_{K4} - M_{E4} = 0.19281 \quad (4)$$

The difference in the arithmetic means of the two analysed groups is 0.19281. It shows us that the experimental group scored 0.19281 lower, i.e., better, in the arithmetic mean than the control group.

Hypothesis H3: The average assessment of pupils in the analysed subject at the end of the 1st half year of the 2019/2020 school year, whose teaching was implemented using the activation teaching methods, will be lower than their average assessment at the end of the 1st half year of the 2021/2022 school year.

We reject the hypothesis H3, because the experimental group, whose teaching was implemented in an active way, achieved a lower arithmetic mean ($M_{E2} = 2.111111$), i.e., a better assessment in the 1st half year of the 2019/2020 school year, compared to the end of the 2021/2022 school year, when it achieved a higher arithmetic mean, i.e., a worse assessment ($M_{E4} = 2.277778$).

$$M_{E2} = 2.111111 < M_{E4} = 2.277778 \quad (5)$$

$$M_{E2} - M_{E4} = 0.1666668 \quad (6)$$

The difference between the assessment in the 1st half year of the 2019/2020 school year and the end of the 2021/2022 school year is 0.1666668, so it can be stated that the pupils in the experimental group at the end of the 1st half year of the 2019/2020 school year were 0.1666668 away from the arithmetic mean better than at the end of the 2021/2022 school year. At the same time, the Pearson's chi-square (χ^2) reached significance ($p=0.006$), which is less than our 5% significance level. We can thus state that there is a statistically significant difference between the arithmetic mean of the experimental group at the end of the 1st half year of the 2019/2020 school year and the end of the 2021/2022 school year. At the same time, with statistical significance ($p=0.006$), we can state that there is a correlation between these two variables.

To evaluate the hypothesis H3, we will use the pivot table, when we will compare the analysed variables, i.e., the end of the 1st half year of the 2019/2020 school year and the end of the 2021/2022 school year, first together for the control and experimental groups (Table 4), then only the control group (Table 5) and finally the experimental group (Table 6).

Table 4. Evaluation of the hypothesis H3 using the comparison of analysed variables in the control and experimental groups together

Statistic	Value	df	Sig. 2-tailed
Pearson Chi-Square	45.08	9	0.000
Likelihood Ratio	31.42	9	0.000
Linear-by-linear Association	15.23	1	0.000

Table 5. Evaluation of the hypothesis H3 using the comparison of the variables of the control group only

Statistic	Value	df	Sig. 2-tailed
Pearson Chi-Square	21.99	9	0.009
Likelihood Ratio	17.53	9	0.041
Linear-by-linear Association	8.17	1	0.004

Table 6. Evaluation of hypothesis H3 using the comparison of observed variables only in the experimental group

Statistic	Value	df	Sig. 2-tailed
Pearson Chi-Square	23.24	9	0.006
Likelihood Ratio	13.56	9	0.139
Linear-by-liner assoc.	6.46	1	0.011

We conclude that the presented hypothesis H3 is statistically significant and can be associated with the entire population and the analysed variables, i.e., M_{E2} and M_{E4} depend on each other. Statistical significance and dependence are high ($p=0.000$). We admit that the rejecting of the hypothesis H3 leads to the fact that the premise P of the research is not confirmed. Thus, we could and should formulate the claim that the implementation of the activation teaching methods does not increase the knowledge of pupils in the analysed subject, which is reflected in a higher average assessment of the subject.

However, in this context, we further state and prove that there was a fundamental error in the formulation of the hypothesis H3. As analysed variables of the H3 hypothesis we indicated the average assessment of the subject at the relative beginning of the pedagogical experiment, i.e., in the 1st half year of the 2nd school year, i.e., in the 1st half year of the 2019/2020 school year, and at the relative end of the pedagogical experiment, i.e., in the 2nd half year of the 4th year, i.e., in the 2nd half year of the 2021/2022 school year. However, we note that the end of the pedagogical experiment of the average assessment of the analysed subject at the end of the 1st half year of the 4th grade, i.e., at the end of the 1st half year of the 2021/2022 school year, should have been listed as the second analysed variable.

The unequivocal reason is the implementation of the matriculation exams in the period February - May 2022, when in the 2nd half year of the matriculation year the morale, attendance and motivation of pupils to complete 100% of the tasks assigned in individual subjects clearly decrease, as the absolute concentration is focused on the fulfilment of tasks related to successful passing of the matriculation exams. Although the analysed subject is a matriculation subject, in the 2nd half year the content of the subject is relatively peripheral topics that fundamentally do not interfere with the topics and content of the matriculation exam in the given subject. Therefore, for both the control and experimental groups, there is a relatively sharp deterioration in the average assessment of the subject at the end of the 2nd half of the 4th year, i.e., the school year 2022/2022.

We are also aware of the fact that during the 2nd half of the 4th grade, the teaching observation was not carried out, it was not responsibly checked whether the selected and analysed activation teaching methods were actually included in the teaching. In fact, this half-year is generally considered to be the graduation half year for all subjects and in most secondary schools, with an absolute orientation towards the completion of tasks related to the passing of the graduation exam. This fact was not taken into account when formulating the premise and aim of the research and the resulting hypotheses, and it becomes a fundamental limit of our research.

The worsening of the assessment of the subject in the context of the above cited fact also occurs in the control group.

$$M_{K2} = 2.235294 < M_{K4} = 2.470588 \quad (7)$$

However, if we consider the average assessment of the subject at the end of the 1st half year of the 4th grade as the end of the pedagogic experiment, i.e., at the end of the 1st half year of the 2021/2022 school year, which logically and essentially should be, we can unequivocally confirm the hypothesis H3.

$$M_{E2} = 2.111111 < M_{E41} = 1.777778 \quad (8)$$

From the average assessment of the subject, it can be seen that at the end of the analysed period, i.e., at the end of the 1st half year of the 4th year, i.e., at the end of the 1st half year of the school year 2021/2022, there is a sharp reduction in the arithmetic mean in the subject assessment, i.e., the subject is evaluated on average with higher grade and therefore better. The difference in the arithmetic mean is 0.333333.

$$M_{E2} - M_{E41} = 0.333333 \quad (9)$$

We can therefore probably make the statement that the implementation of the activation teaching methods improves the average assessment of the subject by more than 30%, so we can also assume that the pupils of the experimental group have 30% more or 30% better knowledge of the analysed subject. Confirmation of this statement was not and is not the aim of this research, but it is a proposal for further investigation of the implementation of activation teaching methods in technical subjects at secondary vocational schools. It follows from the subject assessment in the newly established period of the pedagogical experiment in the control group that the classic frontal teaching did not have a significant effect on improving the evaluation of the analysed subject.

$$M_{K2} = 2.111111 > M_{K41} = 1.777778 \quad (10)$$

Thanks to the arguments mentioned above, we can claim that the targeted and the systematic activation has a positive effect on the achievement of the educational results, which is manifested by a better assessment on the certificate.

Hypothesis H4: The application of the activation teaching methods even during the online teaching in the period of lockdown and quarantine due to the COVID-19 pandemic has a positive effect on the attractiveness of the teaching implemented in this way.

We confirm the hypothesis H4.

Online teaching was implemented for 3 half years. It started in the 2nd half of the 2nd year of the 2019/2020 school year, and finished at the end of the 2nd half of the 3rd year, i.e. the 2020/2021 school year. The difference in the arithmetic mean is 0.222223 and is therefore significant.

$$M_{E2} = 2.055556 > M_{E3} = 1.833333 \quad (11)$$

$$M_{E2} - M_{E3} = 0.222223 \quad (12)$$

Thus, we can state that during the implementation of the online teaching, the application of the activation methods had a positive effect on the acquisition of knowledge of the analysed subject, and therefore the assessment of the subject at the end of the 3rd year was higher than the assessment of the subject in the 2nd half year of the 2nd year.

Within the compared data of the experimental group, we found statistical significance at the level ($p=0.151$), which is not statistically significant. We cannot state that the information found is statistically significant. At the same time, we state that for the reasons of statistical significance mentioned, this hypothesis cannot be generalized to the entire population. This is also confirmed by the evaluation using the arithmetic mean, as the control group's assessment of the subject also improved during the online teaching period. Although this improvement is not as striking as in the experimental group. The difference in the arithmetic mean is only 0.117647.

$$M_{K2} = 2.294118 > M_{K3} = 2.176471 \quad (13)$$

$$M_{K2} - M_{K3} = 0.117647 \quad (14)$$

Therefore, we can assume that the improvement of the subject's assessment after the completion of the online teaching is not influenced by the application of activation teaching methods, but rather by the form of teaching itself. However, the confirmation of this statement is not the aim and subject of our research, and may be the subject of further research or other pedagogical experiments.

To evaluate the hypothesis H4, we used pivot tables, when we compared analysed variables, i.e., subject assessment at the end of the 1st half year of the 2019/2020 school year and at the end of the 2020/2022 school year, first together for the control and experimental groups (Table 7), then only the control group (Table 8) and finally the experimental group (Table 9).

Table 7. Evaluation of hypothesis H4 using the comparison of analysed variables in the control and experimental groups together

Statistic	Value	df	Sig. (2-tailed)
Pearson Chi-Square	20.33	9	0.016
Likelihood Ratio	21.62	9	0.010
Linear-by-linear assoc.	7.40	1	0.007

Table 8. Evaluation of the hypothesis H4 using the comparison of the analysed variables of the control group only

Statistic	Value	df	Sig. (2-tailed)
Pearson Chi-Square	15.40	9	0.081
Likelihood Ratio	15.48	9	0.079
Linear-by-linear assoc.	2.26	1	0.133

Table 9. Evaluation of the hypothesis H4 using the comparison of the analysed variables of the experimental group only

Statistic	Value	df	Sig. (2-tailed)
Pearson Chi-Square	13.28	9	0.151
Likelihood Ratio	15.50	9	0.078
Linear-by-linear assoc.	5.31	1	0.021

Hypotheses H1, H2 and H4 were unequivocally confirmed, but not for the entire population, however only for the observed group of the pedagogical experiment, i.e., pupils of Secondary School XY studying the subject Integrated Rescue System taught in the field of Security and Legal Activities (code 68-42 -M/01).

Although the hypothesis H3 as it was formulated was not confirmed, we identified a fundamental error in its formulation, which became the limit of the research. After removing the error, we can claim that this hypothesis H3 was also confirmed, however, again only for the observed group of the pedagogical experiment, i.e., pupils of Secondary School XY studying the subject Integrated Rescue System taught in the field of Security and Legal Activities (code 68-42-M/ 01).

In the context of the above cited facts, we can therefore claim that the effectiveness of the application of the activation teaching methods in the teaching of technical subjects was demonstrated for the pupils of the Secondary School XY studying the subject Integrated Rescue System taught in the field of Security and Legal Activities (code 68-42-M/01), when, using the mathematical-statistical methods, we demonstrated the effectiveness in improving the average assessment of the analysed subject at the end of the pedagogical experiment compared to the assessment at the beginning of the pedagogical experiment. Thus, we proved the confirmation of the premise and the fulfilment of the aim of our research.

4.5. Comparison of the Theory and the Practice

Effectiveness is a current phenomenon in all areas of human action [64]. In the field of education, it is a complex and extensive concept [65]. Moreover, this term is relatively new in the Czech literature on education [33]. The situation in the professional literature on the effectiveness of education and teaching methods is very bad [66]. This fact was also confirmed in the case of the effectiveness of activation teaching methods in the teaching of technical subjects at secondary vocational schools. It was not possible to find answers to the key questions, premise or hypotheses formulated by us in the professional literature. Although we have demonstrated the effectiveness of the application of activation teaching methods with certain limits, we do not have enough data available to compare our findings with the results of other studies and research.

The effectiveness of the activation teaching methods at secondary vocational schools is dealt with by several studies, which confirm our premise and that the activation teaching methods increase the effectiveness of teaching expressed by the improvement of knowledge expressed by a higher assessment of an analysed subject (a better grade on the certificate). Among these studies with this confirming conclusion, we include the work of Zemanova & Knight (2021) [67], which is focused on the effectiveness of terrain teaching in the teaching of geography at a grammar school. Terrain teaching is one of the activation methods, so we can compare the conclusions confirming the effectiveness of terrain teaching with our conclusions.

Most final theses and available research and studies are always oriented towards one specific activation teaching method, while we focused on proving the effectiveness of the entire range of activation methods as a whole.

During the secondary analysis of information sources focused on the application of instructional videos in teaching and their effectiveness, we came across a scientific article by Havráňková (2021) [68], which described the hitherto unknown concept of the "flipped classroom model". The fundamental theme of this model is the implementation of the digital tools in school teaching. The research of Havráňková (2021) [68] is based on the premise confirmed by many researches and studies, for example Abbot (2003) [69], Fu (2013) [70] or Hernandez (2017) [71], that these technologies primarily have a real potential for fundamental way to increase the quality and effectiveness of teaching in each field, which is also claimed by Wang (2015) [55]. These digital tools are able not only to increase pupils' interest in the topic being discussed, but also to ensure their active involvement in teaching, improve their study results and motivate them to take further interest in the field even outside the school environment. The best form of teaching using digital tools, i.e., not only videos, but also presentations, is the flipped classroom model [68].

The aim of this chapter was not to carry out a detailed comparison of theory and practice, it is not even possible, rather, with the use of a secondary analysis of information sources, both Czech and foreign, to focus on the evaluation of our stated premise that the use of the activation teaching methods in the teaching of technical subjects at secondary vocational schools is effective with an emphasis on identifying specific elements of teaching, the implementation of which clearly increases the effectiveness of teaching.

4.6. Suggestions and Recommendations

As a part of the pedagogical experiment we implemented, we evaluated the effectiveness of activation teaching methods in the teaching of technical subjects at a secondary vocational school. It has been verified that the chosen activation teaching methods really increase the effectiveness of teaching; pupils are more satisfied, more motivated, and acquire better knowledge, which is subsequently positively evaluated in the case of examinations, papers, and tests. On the basis of a semi-structured interview with the teacher, a questionnaire survey among pupils, and personal observation, the problem method was identified as the most effective activation method, where pupils were forced to solve a specific problem in the form of a worksheet, test, or case study. Pupils could use ICT to solve the problem.

ICT has become a fixed part of everyday pedagogical practice [72]. It is no longer only on the fringes of teachers' interest [68]. They already absolutely routinely use the Internet and videos from YouTube to search for information and study materials, as was the case with the pedagogical experiment we implemented, and prepare various presentations. The application of ICT in teaching is better able to keep the attention of pupils because they use the Internet and smart mobile phones or various social networks in their daily practice, proving that these technologies have a real potential to fundamentally increase the quality and effectiveness of teaching in every field [55, 73]. ICT is able not only to increase pupils' interest in the topic being discussed but also to ensure their active involvement in teaching, improve their study results, and motivate them to take further interest in the field even outside the school environment [55].

However, it is essential that every teacher be able to use these tools effectively and in a way that will help him fulfill his pedagogical goals. The most important thing is not the tools themselves but, above all, the method of their processing and involvement [72]. Therefore, even modern information technologies cannot be superior to pedagogy itself but can be smart "*weapons*" in the hands of experienced and conceptually capable "*learning managers*" [68].

In the context of the pedagogical experiment implemented by us, an educational video or PowerPoint presentation served as the basis for solving the problem, while the pupils had these teaching aids available in advance, so the study

materials were brought forward and the flipped classroom model was applied. Due to the demonstrable effectiveness of this model, we propose its application as a suitable model for the implementation of activation teaching methods, specifically problem-based methods, in the teaching of technical subjects at secondary vocational schools.

The flipped classroom model is based on the maximum use of the time allocated for face-to-face or synchronous teaching, which is achieved by moving the presentation of new subject content to home preparation, i.e., an asynchronous environment. This procedure was also applied within the framework of the pedagogical experiment we implemented.

On the basis of teaching materials created by the teacher, for example, in the form of videos or presentations, the pupils familiarize themselves with the content of the subject at home even before the actual teaching. The latter then builds on the home preparation and further develops the discussed content through other methods of active teaching (e.g., work in groups, role plays, and discussions) [74]. Putting flipped teaching to use videos or presentations is considered by experts to be a procedure significantly in line with modern trends. According to these trends, the way in which today's youth absorb new stimuli is significantly based on visual and cinematic elements [55, 68]. The format of the flipped classroom is often used primarily in the natural sciences [75], but its effectiveness is gradually being confirmed across subjects.

Thus, based on the study of information sources focused on the effectiveness of the application of the flipped classroom model, for example Mehring (2016) [76] or Diehl (2020) [77], taking into account the fact that this model was basically applied in the pedagogical experiment we implemented, we state, that it is clearly possible to apply this model also within the teaching of technical subjects at secondary vocational schools.

4.7. Limits of Research

The implementation of a pedagogical experiment as a method of pedagogical research brings with it quite a few risks and limits. Among the limits of the research, we can clearly identify:

- Pupils will welcome the departure from classic frontal teaching, but they will not initially consider the application of activation teaching methods as an innovation in teaching or as a benefit in teaching, but as a time to rest and lose concentration.
- The actual ability of the teacher to correctly apply a specific activation method can be controversial due to the absence of an observer or controller.
- The impossibility of constant supervision during the implementation of the pedagogical experiment, which may lead to a distortion of the results.
- Biased evaluation of the results achieved by the investigated groups.
- Badly chosen beginning or end of the pedagogical experiment.

5. Conclusion

"Excellent teachers have always counted on the cooperation of pupils to a certain extent, although in general this was not the case and is still not the case" [78].

Activation teaching methods came to the fore of schools and teachers' interest only in the period of reform pedagogy at the beginning of the 20th century as a response to the solution to the rigid concept of education at the time, which attributed to pupils the role of passive recipients of communicated information. However, nowadays, activation methods and their applications are on the rise. The reasons are not only pedagogical and psychological but especially social. The current society is referred to as a modern society of knowledge and information, whose distinctive feature is a huge increase in information and in which information and knowledge are the main driving forces of its development.

This "explosion of information" puts pressure on the school to handle the increase in knowledge through the methods that have prevailed so far, i.e., memorization. However, the pupil can no longer assimilate this flood of information in this way because it becomes ballast that has no use; it only overloads and disgusts the pupils. It is absolutely necessary to look for new ways to guide the pupils to activities and to help them sort and use information. In this context, there is talk of the need for a new culture of teaching and learning [79]. And it is here that activation-based teaching methods and pupil activity come to the fore. "Pupil activity means increased, intensive activity, on the one hand based on internal inclinations, spontaneous interests, emotional drives, and life needs, and on the other hand on the basis of conscious effort" [80].

However, pupils' activity in itself is not the goal of education. Activating of pupils in the educational process means focusing on the growth of their competences and the development and improvement of the pupil's personality. Such an activity is realized by the independent work of the pupils, when the pupil, albeit under the supervision of the teacher but gradually without outside help, manages the educational situations with the aim of relatively complete freedom from direct guidance and influence.

"Activation teaching methods should rightly have significant application in the educational work of the school, because they are not limited to the cognitive area, but enable the "connection of the head, heart and hand" [79].

However, it is challenging for teachers to involve pupils in an active participation in teaching, because activity cannot be induced by directive interventions and instructions, but it is necessary to look for ways to stimulate, to inspire, to motivate and sensitively to guide pupils to find their own way [81]. It must also be taken into account that activation teaching methods have their limits and pitfalls.

The primary aim of the presented paper was to demonstrate the effectiveness of activation teaching methods in the teaching of technical subjects at secondary vocational schools through pedagogical research using a pedagogical experiment. This aim has been fulfilled.

The expected output of the presented paper was to present a professional text that will offer a comprehensive understanding of the defined issue by evaluating the application of activation teaching methods in the teaching of technical subjects at secondary vocational schools. This output has been achieved. We proved through a pedagogical experiment of a longitudinal nature that activation teaching methods are really effective in teaching technical subjects at secondary vocational schools, while within the framework of that pedagogical experiment it was proved that it is possible to apply activation teaching methods very effectively in the so-called flipped classroom model, which we present as a suitable for effective activation teaching of secondary school pupils.

6. Declarations

6.1. Author Contributions

Conceptualization, G.G. and S.Č.; methodology, G.G. and S.Č.; investigation, G.G.; resources, S.Č.; writing—original draft preparation, G.G. and S.Č.; writing—review and editing, G.G. and S.Č. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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6.4. Acknowledgements

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6.5. Institutional Review Board Statement

Not applicable.

6.6. Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

6.7. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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