DEVELOPMENT OF STUDENTS´ KEY COMPETENCES AND KNOWLEDGE THROUGH INTERACTIVE WHITEBOARD

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Abstract: The topic of the study is the issue of students´ key competence development in relation to the use of digital technologies as supportive means in teaching processes. In particular the attention is paid to the possibilities to develop students´ key competences in teaching Technology, a compulsory subject at lower secondary schools (ISCED 2) in Slovakia, based on the use of IWB in teaching/learning activities. The objective of the research, presented in the article, was creation, application and partial verification of an educational model aimed at key competences and knowledge development through IWB in the subject of Technology. The authors describe partial results of the created model verification with a research sample of students of the 6th and 8th grade (aged 12 and 14 years). The results show that the educational model contributes to the key competence development - especially interpersonal competences and class interactions, stimulates mutual communication and teamwork of students which are among the most demanded competences.

Keywords: Key competences, Lower Secondary Education, Technology, Interactive Whiteboard (IWB).

1 Introduction

The life we are living today can be characterized very well as the age of continuous information and communication technology (ICT) development. These means have become a common part of our everyday lives and they play a very significant role in every sphere of the society – i.e. in education, too. Digital technologies are implemented more and more into the educational processes on every level of education, from pre-school to higher education institutions (Brečka, 2014; Ormanci et al., 2015; Drigas, Papanastasiou, 2014; Serow, Callingham, 2011). To ensure the best learning achievements of the broad scope of students and through the achieved education to ensure adaptability of young people to both their common life in the society and the labour market requirements, development of so-called key competences is becoming more and more emphasized in most of the European countries (Pepper, 2011). That is why currently education and teaching processes in many EU and OECD member states, Slovakia not excluding, are trying to follow the key competences development (Hutmacher, 1997; Papak et al., 2015). Based on the employer survey aimed at the primary key competences in the 21st century in 500 most successful organisations worldwide, the most significant (by the employer most required) key competences, arranged in order of their priority, are these ones (Longworth, Davies, 1996): team work, problem solving skills, interpersonal skills, communication skills, listening skills, personal and professional growth, creative thinking, leadership, defining goals and motivation, writing and organization development. These skills are not specific in relation to some particular science field or school subject, they can be understood as cross-curricular, i.e. as skills which should be developed in frame of each of the school subjects. A question for educators is how to develop these skills (key competences), through which means and what activities (within a particular school subject). One of the possibilities how to support the key competence development is to use interactive whiteboards in teaching processes for this purpose. Hereinafter we present results of a research aimed at the possibilities of the key competence development by the use of these means in teaching school subject Technology.

2 Background of the research

2.1 Teaching Technology at lower level of secondary schools

Technology is a compulsory school subject taught in Slovakia at the lower level of secondary education (ISCED 2, in Slovak conditions grades 5 – 9 of a basic school) with a time allocation of 1 lesson per week in each of the grades 6 – 9). According to the State Education Program (2015) the purpose of the school subject is to form practical work habits of students, i.e. to complete their general education with a component necessary for one´s integration into the real practical life and the labour market, too. Through practice oriented activities students acquire safe work habits and learn to assess risk when working with various materials and tools. Furthermore, students acquire basic administrative and commercial skills such as time and resource management.

The main objectives of education in this subject is the development of:

- technical creativity, which Hand (1985) defines as the activity of students related to technology, characterized by the full concentration of students on the technological object of education;
- technological literacy, which has been defined by several authors including Dyrenfurth, Zoller and Toldsepp, according to whom it is the technical education minimum that should be acquired by each individual (Dyrenfuhrt, 1991);
- technical thinking (complex of thought operations, particularly the thought analysis of the work result expectations, retaining and activating previously acquired knowledge, skills and experiences, which may be used to solve a particular given problem, in construction, production process, and the synthesis of all the matters by means of which the solver reaches the project design, in other words the construction solution and processing of a product (Škára, 1993);
- spatial imagination, i.e. the ability to imagine/visualise features of three-dimensional objects – their shape, position, size, location (Tomková, 2014);
- knowledge and skills related to technology, technical materials and tools for their processing.

To teach Technology requests a great effort of Technology teachers to ensure appropriate conditions mainly for the practical activities of students. The teachers point out as the most frequent problems related to teaching this subject insufficient technical and material equipment to carry out inquire learning and practical oriented activities of students, non-functional didactic technology, out-of-date teaching aids including working tools and measurement devices and absence/lack of specialized classrooms (workrooms) for Technology teaching at schools (Hašková, Bánesz, 2015; Pavelka, 2013). The mentioned is not problem only for Slovakia, as there is evidence of this problem also in other countries (Mellingsæter, Bungum, 2015; Öz, Hüseyin, 2014; Tatli, Kilic, 2015; Redman, Vincent, 2015; Sahin et al., 2010).

On the other hand the level of ICT equipment - school ratio has been now-a-days quite satisfactory. But in this point we distinguish between the ICT equipment of schools by such "general" didactic technology means as are computers, dataprojectors, interactive whiteboards or tablets and technical equipment of schools in particular for teaching Technology (technical means and teaching aids as saws, bench planes, grippers, electronic and robotics kits etc.). So on the one hand teachers are right when they point out the problem of insufficient technical and material equipment to teach the school subject Technology but on the other hand we are witnesses of the fact that as to the equipment of schools by the ICT didactic technology, the situation is by no means so bad. But what is many times insufficient in this context, is preparedness of teachers to work with these means, i.e. their didactic technological competence. As different authors state, amount and level of ICT equipment at schools has outrun the level of the relevant professional competences of teachers´ (Higgins, Beauchamp, Miller, 2007; Smith, Hardman, Higgins, 2006; Tureková, Depešová, 2014). However, as the results of Pigová´s research show (2005), the key problem also here is that the teachers (in general, independently on the subject they teach) miss electronic teaching materials and teaching aids (relevant to their subject teaching). In particular they miss such materials which would enable them to bring into practice education changes following development of students` key competences. Despite the lack of these materials we may see effort to implement at least interactive whiteboards in education and to use these means to support students` personalities development, although the way in which this is done is not always an appropriate one (Pigová, 2005; Brečka, 2013).

Similarly, Moss et al. (2007) state that the use of interactive whiteboards at schools is considerable diverse. While most teachers use interactive whiteboards as an additional supporting factor to their prevailing teaching styles, others use interactive technology as a basis for innovation and improving their teaching methods. Moss et al. also point out that the impact of the use of interactive whiteboards varies from one subject to another one what might be caused by the uneven availability of materials for different subjects.

The presented matters evoked our intention to create a model of the key competence development and to it related materials applicable in teaching the subject Technology. To use just the interactive whiteboards as a means of the support of the key competence development resulted from the fact that interactive whiteboards allow one to create a variety of activities in which students respond to stimuli of different kinds, e.g. audio or video records, animations, simulations, playful activities etc.

2.2 Model of the Key Competence Development

To define the notion of the key competences is very difficult, as they present an intersection of multiple determining units and scientific fields. Definitions stated by various authors differ, but in general they agree the fact that key competences can be defined as the knowledge, skills and approaches which we, as individuals, need not only for social inclusion and employment but also for our personal development and contentment (OECD, 2005). It is evident that each person has a good command of a wide range of key competences in order to adapt to the fast changing world that comes with globalisation (Kudryashova, Gerasimov, 2012).

Based on the results of the available analyses (Filipe, 2006; Harlow et al., 2010; Dostál, 2009; Erbas et al., 2015; Kennewell, 2006; Liang et al., 2012; Moss et al., 2007; Pigová, 2005; Türel, Johnson, 2012) we selected key competences and skills which are on the one hand compatible with the system of competences in EU and OECD member states but which are on the other hand also in compliance with the goals and content of the subject Technology (Table 1). The model of the development of these key competences within the subject Technology is presented in a graphical form in Figure 1. The applied educational model was constructed with the intention to help students to acquire knowledge (subject matter) during the lesson (to meet the objectives of the lesson at the demanded level) and especially, to create situations and activities which support development of the selected students` key competences.

Table 1. Overview of the Selected Key Competences

Categories of Key Competences	**Selected Key Competence, Skill**	**Behaviour**	
Interpersonal	Team Work (Int.-TW)	No communication, no help	Communication, advising in pairs
	Harmonic Relationships (Int.-HR)	No communication, no mutual help	Signs of teamwork – compliancy; mutual help in work with IWB
	Efficient Work (Int.-EW)	No cooperation whilst resolving tasks, no communication, solitary work	reading information and then task resolution through communication, task division
Communicative	Reading Comprehension (Com.-RC)	Reading of the text without will to comprehend and resolve the task	Reading of the text and trying to analyse, comprehend and resolve the task.
	Speaking Skills (Com.-SS)	Abrupt expression	No problems with expression
	Writing Skills (Com.-WS)	Written expression is unclear, wrong and uncomely.	Writing down right resolutions comely
Personal	Control over Behaviour – Self-control (Per.-SC)	Partial self-control (some instances of distraction (disturbing, impatience, disorder)	Full focus on the teacher and the team – no disorder
	Honesty and Responsibility (Per.-HR)	Insecurity, turning around, seeking other classmates	Solitary, confident task resolution
Learning	Self-motivation and Motivation of Others (L.-M)	Solitary task resolution – offers no encouragement to solving or acquiring information	Mutual encouragement to task resolution and acquiring information.
	Problem-solving (L.-PS)	Cannot identify a problem, unable to draw on solutions and conclusions, no seeking other possible solutions	Can identify, analyse problems, seeks multiple solutions
	Active Participation in Task Resolving (L.-AP)	Losing interest in task resolution	Expression of excitement for task resolution
Cognitive	Critical Thinking and Evaluation (Cog.-CT)	No acceptance of information, no logical thinking	Critical evaluation of information , successful solitary work logical thinking

Figure 1. Model of the Key Competence Development

The scheme in Figure 1 presents the educational model which consists of the basic attributes of the teaching/learning activities of both subject (teacher) as well as object (student) of these activities, based on the work with interactive whiteboards (IWB). In relation to the application of IWB aimed at the development of the mentioned competences, we specified following key factors of our model:

Sharing information on IWB is a prerequisite for effective use of information, motivation, maintaining students` attention and activity. As a result of the information sharing, students discover new, often hidden dependences, which help them to seek and create new original forms of the problem solving.

A subsequent factor for student interaction is the *use of oral and written communication* in the teaching/learning activities supported by the IWB applications. Students are given a possibility to write, fill in, draw, circle the answers and at the same time they express their opinions, lead discussions and evaluate results of their work.

Another advantage of the work with IWB is that these means enable *object manipulation.* Due to different activities at which the students practicably turn the objects in a plane, order different geometric (2D) figures in the given area, change their mutual positions the students learn to manipulate with the objects. They acquire the relevant abilities and at the same time through them they develop also their spatial imagination, visual-motor coordination, shape perception and the ability to recognize objects in general. In addition to these skills and abilities the students also develop their technical imagination and become familiarized and accustomed to the use of technical terminology. Notion visualisation (as well as notion imagination) plays an important role in the process of the notion fixation. Consequently students` technical (technology) thinking is developed in practical tasks (learning activities) in solution of which the students apply the acquired knowledge.

The most dominant factor of the model is the factor of the *multimedia support* related to the teaching and learning activities. At the work with IWB this factor means mainly possibilities of interaction and influence of students in a multi-sensory way (acquiring of information repeatedly through different sense-organs, e.g. a student at first hears the information and then s/he reads it). This multi-sensory repetition of the information is typical for multimedia, the application of which increases the possibility of catching, understanding and long-lasting retaining of the information (Oblinger, 1991; Bohony, 2003).

Further factor of the model is the *dynamics of the interactive environment* of the IWB. This dynamics enables to present different movements and developments of the investigated phenomena. The dynamics changes the static attitude towards the presented matters to a dynamic response possibility. A teacher´s objective, when working with an interactive system, should be an active participation of students in the ongoing activities. Particular activities within the model of the key competences development are designed to enable the students to process and select information, formulate answers and construct meanings. Students remain active throughout the whole teaching process due to various different activities such as reading, writing, discussion, desire for success, self-evaluation etc.

Despite the above-mentioned factors of the presented model, in the process of the key competence development the *teacher* still plays the most important role. As a guide and organizer, preferring open communication with the students, the teacher helps the students to be independent and active, helps them to seek new available information, to use and apply the acquired knowledge and supports their activity, responsibility and self-assessment. The teacher`s task is to manage the teaching process with a maximal use of the IWB and teaching materials developed and elaborated with the respect to the designed model.

2.3 Implementation of the designed Model of the Key Competence Development

Investigation of the possibilities to implement the designed model of the key competence development into the lower level of secondary education and verification of the possibilities to develop the students` key competences by the means of the use of the IWB within teaching school subjects of STEM (natural sciences, technology, engineering and maths) became the intent of a national research project carried out with a financial support of the Cultural and Educational Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic during the period of the years 2013 – 2015. At the project experts from three Slovak universities were involved in. One of the expert teams was from Constantine the Philosopher University in Nitra (Faculty of Education) and its responsibility was to verify the possibilities to develop the students` key competences by the means of the use of the IWB just within the school subject Technology. The other two expert teams were from University of Prešov (Faculty of Humanities and Natural Sciences) and Matej Bel University in Banská Bystrica (Faculty of Natural Sciences). These expert teams were responsible for verification of the created model in relation to the school subject physics and mathematics.

So the task of our expert team (Constantine the philosopher University in Nitra) was to develop a teaching strategy model aimed at the development of the key competences of students within the school subject Technology through IWB and to verify whether the proposed model and teaching strategy applied in certain topics of the subject Technology in selected grades of the lower secondary schools will create conditions which will contribute to the development of the key competences of the students. The main objective of the research was to confirm the suitability of the teaching materials designed and elaborated with respect to the constructed model for teaching Technology, to verify the draft of the teaching model using the IWB means and to observe possible impact of the relevant teaching/learning activities based on the use of IWB means on the development of the students` key competences.

3 Methodology of the Research

3.1 Description of the designed teaching materials

The first step of the research was development and elaboration of the teaching/learning materials for Technology teaching with respect to the created model of the key competence development. The relevant materials were elaborated in focus on the (curricula) topics and consisted of IWB presentations, methodological guide (workbook) for the teacher, worksheets for students and observation sheets. Below the materials to the (curricula) topic Wood, Its Significance, Properties and Use is presented.

The IWB presentation consists of three parts and includes in all 12 slides:

- Introduction part – presents information on the topic, objectives and lesson organization.
- Main part – contains subject matter of the given topic processed within particular teaching/learning tasks (activities). The number of the tasks is irrelevant. The kinds of the tasks vary (choosing the right answer, completion – writing, drawing). It is important that each presentation presents such situations which enable the students to develop their knowledge and key competences.
- Conclusion – serves the teacher as information on resources.

Slide 1: contains the name of the taught topic and a motivational picture relevant to the presented topic.
Slide 2: contains information on the lesson goals, use of the IWB in the subject matter acquisition and on the work of the students, their work in couples using the worksheets.
Slide 3: contains the first task (T1) in which the students are asked to divide trees into the right categories.
Slide 4: informs the students about the macroscopic composition of wood and presents the second task (T2) in which the students have to put the right name to each part of the cross-cut wood.
Slide 5: informs the students about various shapes of wood cores and presents the third task (T3) asking the students to make right pairs out of the pictures, shape of the wood-core + tree, on the IWB.
Slide 6: informs the students about ligniperdous insect and presents the fourth task (T4) asking the students to put the right insect name to the pictures.
Slide 7: informs the students about woodworking tools and the students are given a task (the fifth one T5) to indicate the right answer.
Slide 8: gives the student the sixth task (T6) to write the right names of the presented woodworking tools below their pictures.
Slide 9: contains a revision exercise (the seventh task T7) asking the students to choose and mark a picture of a chisel.
Slide 10: contains a video by means of which the teacher provides further information about wood and woodworking.
Slide 11: contains information (mainly for the teacher) about resources used for the presentation.
Slide 12: is the final slide, which contains acknowledgement addressed to the students for their work and gives them instructions how to calculate in a team work the gained scores (achieved number of points) for the tasks they solved.

To each of the presentations a workbook for the teacher was worked out. The workbook serves as a methodological guide according to which the teachers manage the lesson course. It contains information on all organizational and material requirements put on the given topic teaching. It specifies total number of the lessons devoted to the particular topic, grade in which the (curricula) topic is taught, the lesson content relevant to the taught (curricula) topic, lesson objectives and learning outcomes, and mainly students` key competences which should be acquired or developed during the lesson by means of the IWB and solving the particular tasks involved in the (to the given topic) relevant presentation. The workbook informs the teachers also about the time intervals necessary/recommended for solving each of the tasks involved in the presentation and about the number of points which the students can obtain for their correct solutions.

Students´ worksheets contains the task assignments and relevant instructions for their solving on the IWB. Students solve the tasks by the means of IWB and consequently they check correctness of their solutions in the given worksheet. In term of the key competence development, the IWB provides variable multimedia visualisation elements (Fig. 1). And it makes much easier to incorporate a wide use of multimedia resources in lessons such as text, pictures, video, sound, diagram, and online websites (Johnson, 2002). This means that solving the given tasks on the IWB was the crucial matter with reference to the carried out research.

All the designed teaching/learning materials were consulted with in-service teachers at schools where their verification was going to be observed (i.e. their drafts, to enable to make contingent modification before their application into the teaching practice).

3.2 Verification of the designed teaching materials and their possible contribution to the students` key competence development

The second step of the research was verification of the draft of the teaching model using the IWB means and confirmation of the designed teaching materials` suitability for the created model application to Technology teaching with respect to the possible impact of the relevant teaching/learning activities based on the use of IWB means on the development of the students` key competences (i.e. verification of the educational model and its applicability and contribution to the specified students` key competence development through the created methodological materials).

The verification was done at schools located in Nitra and Trnava region, namely in five classes of the 6th grade and one class of 8th grade. The total number of the students engaged in the research sample was 85.

Lessons, during which the materials were verified, in all of the schools and grades included in the research sample consisted of the same standard structure (motivational part, exposition part, fixation part and diagnostic part) apart from the fact that they were focused on the work with IWB means as the teaching process supporting element.

In the introduction parts of the lessons the teachers informed students about the objectives, arrangement and methods going to be used during the lesson. The main part of each of the lessons was focused on the use of IWB and the relevant teaching/learning activities based on their use (solving the relevant tasks), given in the particular presentation, both on the board and in the worksheets. Prior to solving each of the tasks the teachers motivated the students through a short discussion aimed at the appropriate issue. Consequently the teachers called a pair of the students to the IWB to solve the task. The rest of the pairs solved the task in their worksheets. During the solution of the particular tasks the pairs of students took turns step by step at the IWB. The students checked correctness and accuracy of their solutions in the worksheets and noted down the number of the points they gained. At the end of the lessons, the students counted their total scores achieved in the worksheet and the teacher evaluated the lesson.

Verification of the designed teaching materials and their possible contribution to the students` key competence development was based on observation. For the purpose of the presented research there was used direct short-term structured observation (6 lessons) done by a trained observer. There was also an intention to record videos of the lessons to increase exactness of the research data records but most of the schools rejected to provide an agreement on this possibility.

The observer`s task was to note down the occurrences of the situations in which the students manifested use of some of the relevant key competences in the performed learning process. The observer took a place in the classroom before the start of the lesson in a position from which he could flawlessly see the selected observed pairs of the students (each time only two pairs were observed, see below). To record the data he had an observation sheet at disposal. The structure of the observation sheets was similar to the students` worksheets. The similarity of the structures of these two kinds of sheets ensured the observer`s orientation in the progress of the lesson, what eliminated appearances of his possible mistakes. The observer recorded the occurrence of the observed phenomena into the observation sheet by means of "yes" or a vertical line, for each task separately. He recorded each time occurrence of the manifestation of the students` key competences always only for two randomly selected pairs of the students to ensure maximal objectiveness and accuracy of the research data he recorded to the observed phenomena. The teaching pedagogue was asked in advance to call to the board to solve the tasks predominantly the students of the selected focus groups. At the end of the observation sheet, in a summary table the observer counted the overall key competence occurrence rate.

For statistical processing of the obtained research data methodologies of several authors (Stranovská et al., 2013; Kapusta et al., 2010; Záhorec et al., 2010) were used. Within the data processing the main attention was paid to:

- identification of possible interrelations between the results (scores) reached by the students and occurrence of manifestation of the key competences.
- comparison of the results achieved at the given tasks in the particular classes,
- comparison of results achieved at the particular tasks solutions in dependence on the grade of the observed students,

and two working hypotheses H0 were tested:

- H0: The obtained scores are not dependent on the selected key competence occurrence.
- H0: There is no significant difference in the achieved scores of the tasks among the students of the particular classes, i.e. the score is not dependent on the class.

To test these hypotheses the nonparametric correlation - Kendall's Tau coefficient and the nonparametric Kruskal-Wallis test were used.

In addition to the verification of the educational model and its applicability and contribution to the specified students` key competence development through the created methodological materials there was tested also a working hypothesis:

H0: There is no significant difference in the achieved scores between the students of the 6th and 8th grade, i.e. the score is not dependent on the grade.

To test this hypothesis the nonparametric Mann-Whitney U test for testing was used (Table 9) and multiple comparisons was used to prove the statistically significant differences between the particular (6th and 8th) grades.

4 Main Results of the Research

4.1 Identification of the Relationships between the Obtained Scores and the Key Competence Occurrence

In this part of the research the working hypothesis H0: The obtained scores are not dependent on the selected key competence occurrence was tested. Also here the stated hypothesis represents four particular hypotheses. This means that the hypothesis was tested repeatedly, each time for another of the given key competences, which in particular were:

- interpersonal competences,
- learning competences,
- communication competences,
- personal and cognitive competences – critical thinking.

The results are presented thereinafter again for one after another.

Figure 2 shows the matrix diagrams of the relationships between the obtained scores and the occurrence of the interpersonal competences (frequency of their occurrence). In each of them a direct proportional of the observed two variables was identified. As the diagrams show anomalies, consequently Kendall's Tau coefficient (nonparametric correlation) was used to estimate the strength of their relationship (Table 2).

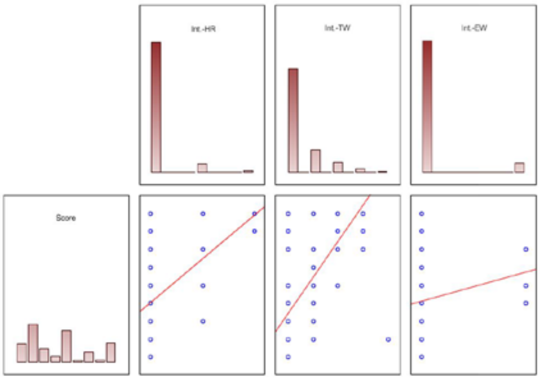

Figure 2. Matrix diagram of the relationships between the obtained scores and occurrence of the interpersonal competences

Table 2. Correlations of the obtained scores and the interpersonal competence occurrence

Pairs of Variables	Valid N	Kendall Tau	Z	p-value
Score & Int.-HR	168	0.239513	4.60862	0.000004
Score & Int.-TW	168	0.528026	10.16008	0.000000
Score & Int.-EW	168	0.162817	3.13287	0.001731

As it is clear from the presented data, the hypothesis H0 was rejected at the 1 % significance level. A small degree of correlation with the achieved scores was identified in terms of harmonic relations and work efficiency. This could arise from the fact that whilst the overall atmosphere in the classroom was pleasant, the students have worked inefficiently and have often cheated, what resulted in low values of the achieved scores. In many cases, at the 8th grade students (mainly boys) no harmonic relations among the students were recorded. Therefore also no efficient work was recorded in these cases.

Opposite to harmonic relations, in case of the interpersonal competence of the team work, the relationship of them with the values of the obtained scores was estimated on a strong level. This is supposed to be just due to the efficient team work of the students and their effort to achieve a good common result (to obtain a high score).

Figure 3 and Table 3 show the relationship between the obtained scores and the learning competence occurrence. In all cases with the exception of the case of problem-solving competence a direct proportionality was identified.

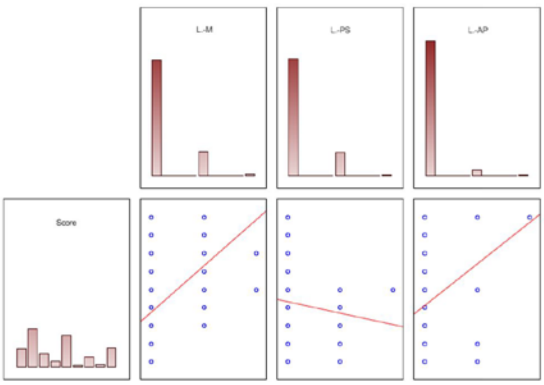

Figure 3. Matrix diagram of relationships between the obtained scores and occurrence of the learning competences

Table 3. Correlations of the obtained scores and the learning competences occurrence

Pairs of Variables	Valid N	Kendall Tau	Z	p-value
Score & L.-M	168	0.380429	7.32007	0.000000
Score & L.-PS	168	-0.032152	-0.618655	0.536144
Score & L.-AP	168	0.142876	2.749168	0.005975

The hypothesis H0 was rejected at the 1 % significance level in case of the obtained score and the skill of self-motivation as well as in case of the score and learning competence – active participation in task solving. Between the obtained scores and motivation competences a medium correlation was recorded, and between the score and learning competence active participation in task solving there was recorded at least a low correlation.

The hypothesis was proved for the skill to solve problems. The relationship between the obtained score and this competence was trivial and inversely proportional. The fact that the relationship was identified as a trivial one means, that the relationship between the two observed variables was not proved. This can be explained by the fact that an active participation in a problem solving does not ensure (bring) an effective problem solution (i.e. need not to contribute to it). On the contrary, in classes where mutual motivation of the students was observed, there was recorded also a directly proportional relationship in terms of the obtained scores.

Figure 4 and Table 4 show the relationship between the obtained scores and the communication competence occurrence. There was identified a directly proportional relationship at each of the three observed communication competences.

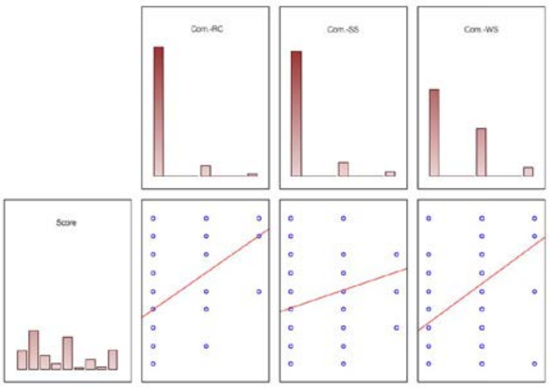

Figure 4. Matrix diagram of relationships between the obtained scores and occurrence of the communication competences

Table 4. Correlations of the obtained scores and the communication competence occurrence

Pairs of Variables	Valid N	Kendall Tau	Z	p-value
Score & Com.-RC	168	0.221888	4.26949	0.000020
Score & Com.-SS	168	0.170632	3.283229	0.001026
Score & Com.-WS	168	0.414741	7.980299	0.000000

The hypothesis H0 was rejected at the 1 % significance level. However the correlation between the obtained score and the communication competences, such as reading with understanding (reading comprehension) or speaking, was only at a weak level. This is because although the students of all classes communicated and read with comprehension (analysed pictures, adduced reason for equipment functions, parts of wood, etc.) only some of them reached the maximum score. From the results of the observation we can state that in this area there was an eminent lack of knowledge because the objective of many tasks was to indicate the right answer amongst others, and despite that, the students could not answer. In terms of the obtained scores and writing competence there was a medium relationship observed. This arises from the fact that the students of both grades, however, particularly the students of the 8th grade, have not only better but also more willingly expressed themselves orally.

Figure 5 and Table 5 show the relationships between the obtained scores and occurrence of the personal and cognitive competences – critical thinking. With the exception of the personal competence self-control in all other cases the indirect relationship between the obtained score and the observed particular competence was identified. In case of the self-control its relationship with the obtained score was not proved.

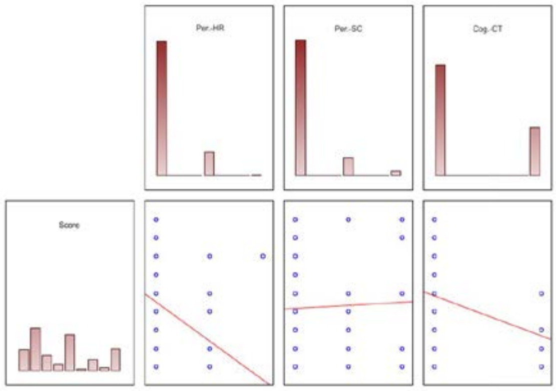

Figure 5. Matrix diagram of relationships between the obtained scores and occurrence of personal and cognitive competences – critical thinking

Table 5. Correlations of the obtained scores and the personal and cognitive competences – critical thinking occurrence

Pairs of Variables	Valid N	Kendall Tau	Z	p-value
Score & Per.-HR	168	-0.353012	-6.79253	0.000000
Score & Per.-SC	168	0.038108	0.73326	0.463402
Score & Cog.-CT	168	-0.294216	-5.66119	0.000000

The hypothesis H0 was rejected at the 1 % significance level in case of the personal competence honesty and responsibility, where a moderate correlation was identified. Figure 5 shows that this correlation matches inverse proportional relationship, i.e. the higher scores the students obtained, the lower range of the given competences they manifested (in terms of the competence occurrence frequency). This inverse proportion can be deduced from the observation results based on the fact that in the effort to obtain high scores mostly the students of the 6th grade copied often wrong answers from classmates.

The hypothesis was proved in case of the personal competence – self-control, where the relationship is trivial. The behaviour of the students, mainly those of the 8th grade, during the task solving was often affected by outside influences which have led to disturbance, impatience, lack of discipline. By the end of the lesson there was observed even a higher degree of the lack of self-control as well as dishonesty - copying answers or complete dismissing of the tasks.

In case of the relationship between the obtained scores and cognitive competence of critical thinking the hypothesis H0 was rejected. The relationship was identified as low and inverse proportional, i.e. the higher scores the students achieved the lower occurrence of the given competence was recorded. It is probable, that this fact has arisen from the students` fear of obtaining low scores what can be connected also with the above-mentioned honesty and responsibility.

4.2 Comparison of the results of the given tasks achieved by the students in the particular classes

Verification of the working hypothesis H0: There is no significant difference in the achieved scores of the tasks among the students of the particular classes, i.e. the score is not dependent on the class.

Meant to test the hypothesis H0 seven times, each time for a different task, i.e. each time to test the hypothesis for one of the seven given tasks T1 – T7. The results are presented thereinafter for one after another.

At the task 1, based on the Kruskal-Wallis test (H (5, N = 85) = 5. 912252, p = 0.3149) the hypothesis H0 was accepted, what means that there are no statistically significant differences among the students of the concerned classes grades. All the classes obtained a similar value of the task 1 score.

Similarly, no statistically significant differences among the scores were found in case of the tasks 5, 6 and 7, i.e. the hypothesis was confirmed also for these tasks.

We suppose that statistically insignificant differences arise from the fact that the content of the tasks 1, 5, 6, and 7 was based on the compulsory curricular topics of the subject Technology, incorporated in the theme Wood, Its Importance and Use, which the students of the 6th grade as well as of the 8th grade had been familiarized already several times during their previous school attendance. Another reason can be a low difficulty of the tasks, because most of them demanded no more than one answer which the students have chosen from several alternatives.

As to the task 2, following the results of the Kruskal-Wallis test (H (5, N = 85) =14.83204 p = 0.0111) the hypothesis was rejected. The multiple comparison (Table 6) proved significant differences among the concerned particular classes. These differences were identified in case of the classes number 5 and 6 (Figure 6) which were the weakest class of the 6th grade and one class of the 8th grade. This task demanded from the students to apply higher cognitive processes and this might be a reason of a higher fruitfulness of the 8th grade students. In case of the 6th grade students a lack of the competence to read with understanding was recorded but as it was found out later, this was in consequence of a bad quality of the used picture (low readability of the picture resulted into the cases in which the students did not understand the assignment or they did not complete the task solution).

Table 6. Multiple comparisons of the scores obtained by the particular classes at the task 2

T2	1 R:34.036	2 R:41.538	3 R:54.536	4 R:44.071	5 R:28.938	6 R:56.786
1		1.00000	0.41973	1.00000	1.00000	0.22108
2	1.00000		1.00000	1.00000	1.00000	1.00000
3	0.41973	1.00000		1.00000	0.06894	1.00000
4	1.00000	1.00000	1.00000		1.00000	1.00000
5	1.00000	1.00000	0.06894	1.00000		0.03072
6	0.22108	1.00000	1.00000	1.00000	0.03072	

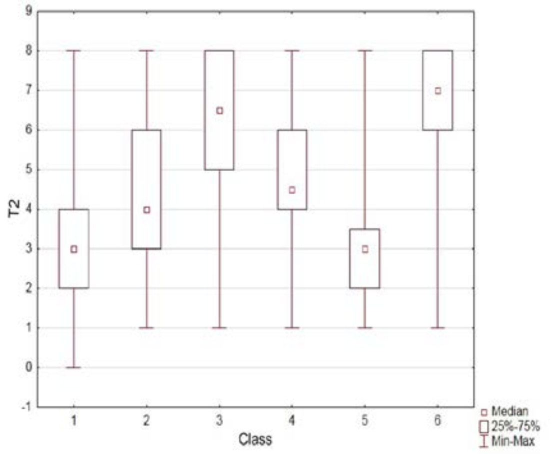

Figure 6. Interquartile range of the task 2 scores obtained by the particular classes

On the basis of the Kruskal-Wallis test results (H (5, N = 85) = 23.41024, p = 0.0003) and multiple comparison results (Table 7) the hypotheses H0 for the third task (T3) at the 1 % significance level was rejected, i.e. there are statistically significant differences among the compared observed classes (Figure 7). In particular significant differences were proved between the class number 1 and number 2, and between the class number 1 and number 6.

Table 7. Multiple comparisons of the scores obtained by the particular classes at the task 3

T3	1 R:24.071	2 R:59.077	3 R:49.464	4 R:38.571	5 R:33.688	6 R:55.607
1		0.00346	0.09732	1.00000	1.00000	0.01085
2	0.00346		1.00000	0.46505	0.08804	1.00000
3	0.09732	1.00000		1.00000	1.00000	1.00000
4	1.00000	0.46505	1.00000		1.00000	1.00000
5	1.00000	0.08804	1.00000	1.00000		0.22850
6	0.01085	1.00000	1.00000	1.00000	0.22850	

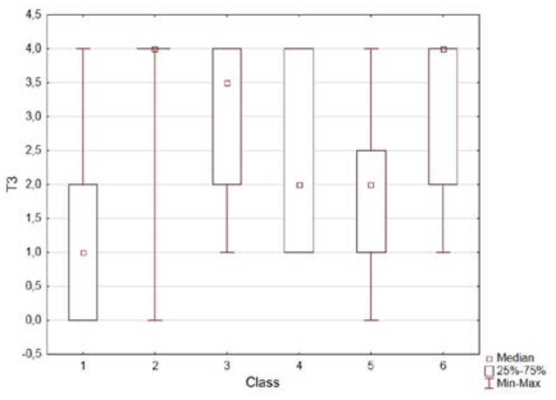

Figure 7. Interquartile range of the task 3 scores obtained by the particular classes

Figure 7 also shows the scores obtained in particular classes in task 3. In this task, students were supposed to connect the shape of pith to a proper tree. The comparison of the class number 1 and number 2 (6th grade students) clearly shows a respectful fruitfulness of the class number 2, due to a higher level of team work and communication in this class.

At the task 4 the most diversified scores were recorded (mutual comparison of the particular classes` results). Following the results of the Kruskal-Wallis test (H (5, N = 85) = 33.54325 p = 0.0000) and multiple comparisons (Table 8) the hypothesis H0 for this task was rejected at the 1 % significance level.

Table 8. Multiple *comparisons of the scores obtained by the particular classes at the task 4*

T4	1 R:23.071	2 R:55.692	3 R:47.893	4 R:55.036	5 R:22.813	6 R:57.286
1		0.00900	0.11694	0.00917	1.00000	0.00367
2	0.00900		1.00000	1.00000	0.00540	1.00000
3	0.11694	1.00000		1.00000	0.08237	1.00000
4	0.00917	1.00000	1.00000		0.00540	1.00000
5	1.00000	0.00540	0.08237	0.00540		0.00203
6	0.00367	1.00000	1.00000	1.00000	0.00203	

Figure 8 shows that statistically considerable differences occurred more times, in particular between the class number 1 and 2, number 1 and 4, number 1 and 6, number 2 and 5, number 4 and 5 and number 5 and 6.

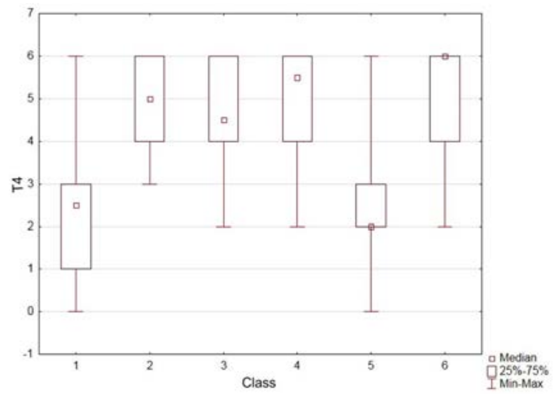

Figure 8. Interquartile range of the task 4 scores obtained by the particular classes

Task 4 was aimed at distinguishing wood-destroying insects which the students were supposed to name. Similarly to task 3, also the results of this task show a difference between the obtained scores by the students of the class number 1 and 2, what we have connected with a low degree of team work and communication among the class members. The most successful solution of the task 4 was recorded again in case of the class number 4 (due to a higher degree of team work and communication skills). As regards this class, also a higher degree of mutual motivation of the students, which arose from the feeling of previous success, was recorded. The differences between the classes number 1 and 6 first have been discussed in frame of the results of the tasks 2 and 3, although a higher motivation was observed in case of the students of the class number 1.

Significant differences were proved also among the results (task 4) of the class number 2 and 5, too. In the class number 2 a higher degree of interpersonal competence occurrence was recorded, particularly team work and mutual motivation.

Further significant differences occurred between the class number 4 and five, the class number 5 was less successful. Similarly to previous comparisons, it was observed that the students of the class number 5 lacked teamwork. Also a very low degree of mutual motivation was observed, opposed to class number 4, where the degree of motivation was the highest (and most frequent).

Interesting findings arose from the comparison of the classes number 5 (6th grade students) and 6 (8th grade students). In terms of scores, the class number 5 repeatedly proved itself to be the weakest one, however, in terms of comparison of the key competence frequency a better (more successful) class was just this one (to compare with the class number 6).

Following the obtained findings, it can be stated that 6th grade students in comparison with the 8th grade students are more open to new forms of learning, like to participate actively in interesting and dynamic activities, what results in a higher work efficiency than students of the 8th grade. Students of this age (6th grade) are more open to team activities (team work, working in pairs etc.), by contrast of the students of the 8th grade who demonstrated not only a low level of the relevant competences (team work and team communication) but even troubles they have with this kind of work. However a higher degree of communication competences, in particular speaking skills, in the 6th grade was recorded not due to the teamwork, but due to the effort of the students to find the right solution of the given task.

4.3 Comparison of the particular tasks success rates achieved by the students in the 6th and 8th grade

As it is above-mentioned there was formulated and consequently tested a working hypothesis H0.

H0: There is no significant difference in the achieved scores between the students of the 6th and 8th grade, i.e. the score is not dependent on the grade.

We have used the nonparametric Mann-Whitney U test for testing H0. Results of its testing are presented in Table 9.

Table 9. Success rates of the 6th and 8th grades at particular tasks

Tasks	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value
T1	2955.000	700.0000	399.0000	-1.1551	0.248014
T2	2860.000	795.0000	304.0000	-2.2807	0.022564
T3	2876.500	778.5000	320.5000	-2.0852	0.037046
T4	2853.000	802.0000	297.0000	-2.3636	0.018094
T5	2920.500	734.5000	364.5000	-1.5639	0.117831
T6	2882.000	773.0000	326.0000	-2.0201	0.043374
T7	2948.000	707.0000	392.0000	-1.2381	0.215671

In case of the tasks 2, 3, 4 and 6 the hypothesis was rejected at the 5 % significance level. At these tasks occurrence of statistically significant differences between the obtained scores of the 6th grade and 8th grade students was approved. We suppose that the concerned tasks were more difficult for the 6th grade students than for the 8th grade students, because in some cases they called for several solutions or correct answers, what resulted in varied numbers of points acquired by the students of the particular grades.

At the tasks 1, 5 and 7 the students of the 8th grade obtained the maximum score in both cases, whilst the median of students of the 6th grade occurs on the same level as of the students of the 8th grade what confirms the statistically insignificant differences. This confirms our hypothesis for these tasks. Majority of the tasks called for cooperation of the students. We suppose that this resulted in successful solution of the tasks by most of the students of the 6th grade classes. Based on the carried out observation it is possible to state that the cooperation among the 8th graders absented, but despite that, they were equally successful in solution of the given tasks. This can be result of fact that the students of the 8th grade showed a higher level of their cognitive (critical) thinking what resulted in a more effective processing of the acquired information (mainly in case of boys) used for the task solution (analysing, deduction).

5 Conclusion

Successful application of the created model into the practice brings a more effective IWB use and, as it was proved in frame of the presented research, development of interpersonal competence of teamwork at lower secondary education. We consider this finding as a very important one as this competence is understood as the key one in relation to adaptability of young people to the life in society and to the increase of their employment as it has been mentioned in the introduction of this study (The Definition and Selection of Key Competencies, 2005).

Based on the results of the carried out observations, we can claim that through the created educational model application the students of the observed classes developed their skills of working in a team, learning with others, creating progressive relationships, cooperation, tolerance, responsible behaviour towards others, etc. Among the students who have improved their interpersonal competences, we have observed improvement also in terms of communication and group integration, what resulted in better and more effective results of their work (observed in the worksheets). Some similar as well as other examples of improved social relations, tolerance and mutual communication can be found in research results of Harlow, Taylor, Forret (2011), according whom the teachers were very surprised by positive social changes observed in the research sample of the students educated using IWB (i.e. through IWB supported teaching). To the key aspects of the work with IWB, which corresponds with the issue of our research, was the e fact that the IWB ensured a whole-class interaction and kept the attention of the students paid to the given task solution even when the teacher occured himself elsewhere. Based also on our findings, we agree with the mentioned authors that sharing information on IWB creates a number of advantages for teamwork and group discussion (Harlow, Taylor, Forret, 2011), enables teamwork (Somekh, Haldane, 2007), knowledge sharing (Hannessy et al., 2007) and joining the whole-class discussion.

It is obvious that some competences might be developed through traditional conventional means such as pen and paper (workbooks), however, through the IWB teaching materials were more easily shared and modified within the whole class, what increased also the overall motivation to learn. Similarly to Warwick, Mercer (2010), also in our research the assumption, that IWB support different kinds of interactions which help to create common, dynamic dialogue (mainly by multimedia means, which affect on several senses at once), was proved. Based on this we deduce that by means of the teaching strategy (model) created by us, it is possible to achieve both personal as well as cognitive development of the students. The tasks used in the worksheets led the students of each focus group to a close cooperation, as a result of which new skills appeared, what was confirmed by the teachers.

Considering that the presented research was an initial one of the concerned focus, the achieved results, i.e. their validity, cannot be generalized. The intention of the research was to point at the practicality of the educational model, and validity of its results can be taken as proved only at the level of the research sample. The issue of the development of the key competences of students at lower secondary education in the area of technical subjects is a relatively new area, which requires further deeper analysis in the future.

In our opinion teachers should create models of teaching supported by the IWB, aimed at problem-solving using learning within a group, self-evaluation of students, discussions with students, self-expression of the students and exercises containing certain game elements (as it has been done in case of the teaching model created by us) in order to develop key competences of the students from the all society point of view.

The partial results of the pilot research aimed at the development of the key competences of lower secondary school students through IWB in the subject Technology show that active use of this teaching model and implementation of the relevant teaching materials focused on the work with IWB are well founded within the methodology of the school subject Technology (technical subject methodology). The stated follows from the fact that these tasks definitely contribute to the development of the given key competences and skills of the students. The tasks encouraged mainly the development of interpersonal and communication competences, and on a certain level (a lower one) also the development of personal and learning competences. So it can be deduced that this model of teaching can ensure complex development of personality of the student, in terms of cognition, psychomotorics and socio affective aspects (Sahin et al., 2010).

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Primary Paper Section: A

Secondary Paper Section: AM