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THE TEACHERS' OPINIONS AND REQUIREMENTS OF BIOLOGY SKILLS

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Abstract T*he problematic of science skills of pupils and students is important to investigate, due to decreasing of attitudes and knowledge of respondents. The presented results are part of bigger investigation, which included the investigation of chemistry, biology and geography teachers on the pupils/students skills. In the study are presented results for the biology part. The aim of research was to prepare, perform and evaluate a questionnaire research, which is based on the above mentioned proposal of biology skills and which investigates the opinions and requirements of lower secondary (ISCED 2) and secondary general (grammar) school (ISCED 3) teachers on the biology skills of graduates from the lower secondary school and graduates from grammar schools. A research sample consisted of two groups of teachers. The first group were teachers from lower secondary schools (n = 53) and the second group were teachers from secondary general (grammar) schools (n = 68). As a research tool was used a questionnaire with 4-point Likert type items. Inductive statistics was used for verification of hypotheses; specifically t-test was used for the determination of differences in the answers between lower secondary and grammar school teachers. Grammar school teachers achieved higher score in the majority of cases. The recommendations are mentioned in the conclusion part*
Key words: *biology skills, inquiry-based science teaching (IBSE), pupils/students, questionnaire, teachers.*

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Introduction

In the last ten years, a number of international studies like TIMSS, PISA or ROSE have been implemented to monitor the knowledge, skills and pupils/students' interest in science subjects These studies showed that pupils/students' interest in science subjects was low, continued to decline and in most countries, pupils/students knowledge in science subjects was just below the average. The in-depth study of the current state of science education in Europe processed by Osborn & Dillon (2008) suggests that the importance of science education in the EU countries is underestimated, especially in terms of its relevance to everyday life. The authors of this study further emphasize the need for such changes to the curriculum to strengthen a science education connection with the current needs of pupils/students and also with global problems of society.

An important document that should affect teaching in the EU countries is the document adopted in 2009 by the ministers of the Member States in the field of education and training, where one of the reference levels is the level of "Low achievers in basic skills" (ET 2020, 2010). It aims to ensure that all learners will acquire an adequate level of basic skills in mathematics, reading and science subjects in the extent and quality that in 2020 the proportion of pupils aged 15 with problems in these areas will be less than 15% (Czech Ministry of Education, 2010). Great hopes are placed in this context on IBSE, since research is the essence of science. Planning, implementation and refinement of experiments are an important part of the process of acquiring key concepts. Skills associated with inquiry-based approach to teaching are being currently considered in the natural sciences as a priority. According to Carnes & DiGiorgio (2009), the system of inquiry-based skills includes questioning, planning, gathering of information, organizing of information, and

compilation of information into its final form and communication of achieved results. These six steps form a closed cycle that begins and also ends with questioning and a new cycle starts again.

Research Focus

The main objective of the research is to present the proposal of biological skills structuring, based on the requirements of IBSE, and to introduce the results of the questionnaire investigation, which monitors the teachers' opinions of lower secondary school (ISCED 2) and general secondary (grammar) school (ISCED 3) on this structuring. The analysis of their statements is one of the sources for the correction of proposed structure of skills and the subsequent identification of skills that should be acquired by pupils/students leaving lower secondary and general secondary (grammar) schools. At the same investigation allows to observe the opinion disparity among teachers at different school levels.

Theoretical Background

The essence of IBSE is that the teacher does not interpret the curriculum in the ready form, but he/she creates the knowledge through the problem solving and a system of questions ("talking education"). It is therefore a purposeful process of formulating problems, critical experimentation, and assessment of alternatives, planning, investigation and verification, drawing conclusions, information retrieval, creation of models of studied processes, debate with others and forming coherent arguments (Linn, Davis & Bell, 2004). Investigation thus gives the students a chance to not only acquire the new knowledge, but also to understand the basic nature of science. Hand in hand it means the acquisition and mastering of new concepts and research methods. Pedagogical-psychological research of the last decade has revealed that if pupils/students are expected to get more than a superficial knowledge, they need to be actively involved in education; many times to repeat the explanations of important thoughts, to keep in touch with other classmates and to draw their own conclusions based on their own experience. Therefore they are not expected to remain just passive receivers of new information from books or from teachers (Young, 1996).

Many authors from abroad define learning through research as a process within which students acquire the ways of scientific thinking and methods of work, e.g. Wilke & Straits (2005), Hodson (2007), and Nuangchalerm & Thammasena (2009) or Tessier (2010). Therefore the aim is not to reveal some new knowledge, but a rediscovery of the already discovered through the use of sensory apparatus of students, observing, classifying, communicating with classmates, etc. According to Krajčík, Blumenfeld, Marx, Bass & Fredericks (1998), Leonard, Spezial & Penicka (2001) or Shami (2001), investigation also supports the students' ability to formulate questions and problems, interpret a text, diagrams, shapes, models, tables, graphs, maps, to identify dependent and independent variables, collect variables, gather data and process them into generalized conclusions, present results and formulate new hypotheses. Investigation also leads to the formation of students' deep and lasting learning experience. The IBSE approach in the teaching process also brings about a more positive perception of science subjects and pupils/students have more positive attitudes to school compared with the state when only a traditional approach to teaching process is applied (Jaus, 1977; Selim & Shrigley, 1983; Shrigley, 1990) . This conception is consistent with the definition set out in the U.S. national educational standards for science subjects (NSES, 1996) or in the recommendations of the EU Council (Czech Ministry of Education, 2010), which directly define the competencies to be acquired through the use of IBSE. A similar definition can also be found in the work of Apedoe & Reeves (2006). Expert studies show a very positive effect of IBSE on attitudes, knowledge, skills and also success of students. This can be illustrated e.g. through the study aimed at the efficiency of IBSE (Chang & Mao, 1998), or the study focused on practicing and application of process skills in the teaching of biology (Padilla, Okey & Garrand, 1984). The influence of IBSE on the attitudes towards science education and skills in biology was studied e.g. in the work of Gibson & Chase (2002), Knox, Moynihan & Markowitz (2003), Wolf & Fraser (2008).

As mentioned above, a very positive impact of IBSE can be traced on the attitudes, knowledge, and success of students and also on skills development (in our case, in biology). Unfortunately, it is still

possible to come across a phenomenon that can be an obstacle for the continuous development of biology skills in relation to IBSE. The application of IBSE is narrowed down to only a limited amount of time, in most cases not exceeding a few hours within the school year, in many cases caused by researchers. Therefore, the traditional approach still persists. This phenomenon is also pointed out by Erdogan (2005) and Krajčík, Blumenfeld, Marx, Bass & Fredericks (1998).

If students are expected to have a control over all the above skills, it is necessary to create their structuring and categorization. In other countries, these issues were studied by Wilke & Straits (2005), who described science skills in terms of IBSE teaching in 4 steps. The first step is to know the content, the second stage to master general skills (questioning, drawing, measurement, evaluation, formation, communication ...). The third stage refers to scientific skills, such as the formation of hypotheses, estimation, proposal of experiments, data collection, formulation of a conclusion ... The final stage involves experimental skills, which include, for example, troubleshooting, evaluation of suitability of any material, debates, constraints ... Nikopolou (2000) created a list of skills needed for ICT, but it can be applied to all science subjects. Asking questions and hypotheses, decision making and evaluation are considered to be the most important skills. Zohar & Tamir (1993) present a group of scientific skills including: distinguishing between the results and conclusions, drawing the conclusion, assessment, check-up, expressing of assumptions, generalization, hypothesis testing, critical evaluation, group work, interpretation and evaluation. Kuhn (2010) dealt with the question of what it meant to think scientifically, and under four basic conditions she understood investigating, evaluating, inferring and arguing. Lock (1989) tested on a group of pupils/students the following skills: observation, manipulation, interpretation, planning, writing reports and self-assessment. Valentino (2000) divided the science skills into 3 groups: processing (observation, classification, measurement, communication, prediction, experimentation ...), critical thinking (analysis, evaluation, problem solving ...) and argumentation skills (questioning, data search, explaining, and respect for logic ...). Padilla (1990) divided the science skills into two groups: basic, which include observation, communication, classification, measurement, and the second group of integrated skills which include hypotheses formulation, data interpretation, experimenting, variables control. Wenning (2005) proposes a hierarchy of skills, which is based on the appropriate level of performance of inquiry-based intellectual processes.

In the Czech Republic, so far, two approaches have been used to structure the skills. The first was prepared by Kolářová, Macháček, Rojko, Čipera, Banýr, Čížková, Růžková & Koubek (1998); here the skills are classified mainly on the basis of thinking operations, i.e. the greater weight is put on the process of information processing, which takes place in the mind of the individual. The author proposed evaluation criteria, objectives and skills of pupils in science subjects in lower secondary schools (ISCED 2). Regarded as essential are 7 skill goals: Identification and proper use of concepts; Qualitative description of objects, systems and phenomena; and their classification, Explanation of phenomena, Predicting of phenomena and determining of causal connections, Observation, experimentation, measurements and estimations, Quantitative description, Application of science knowledge.

The second method of skills structuring, based on the model of IBSE, primarily involves observable methods (outer circle of information processing). Skills were divided into five areas from asking questions to their answering. This scheme, thus, in a simplified form, monitors the progress in objectified knowledge (Řezníčková, 2003). In order to monitor and evaluate the results achieved in the field of biology skills obtaining in relation to the new curricular documents, it is first necessary to create a new structure and hierarchy of skills, which would correspond to current requirements and became the basis for the creation of an objective assessment tool, such as learning tasks. This theoretical approach led to the proposal of biology skills structuring (Table 1), which is being verified in our research.

Proposal of Biology Skills Structuring

For the above reasons, the authors focused on the creation of a new more detailed structure of biology skills, which reflects an objective way of learning and respects, more consistently and more systematically than in the past, the functional acquisition of general and subject-field skills, and which is based on the international experience related to these issues while respecting the requirements of

the Czech curricula. A very interesting structuring is provided in the document presenting the secondary school standards for the subject Science in North Carolina (2004), where skills are first separated and then combined with thematic units of biology. Similarly, in the document Science in New Zealand Curriculum (1993), skills are developed and structured by their nature and subsequently subdivided into four levels according to their difficulty. Moreover they show examples of how and on what topic to acquire the respective skills. These two documents have become an inspiration for the initial proposal of classification of biology skills, which should be acquired by Czech pupils/students. The intention was to raise a discussion over the structuring presented below (Table 1) and subsequently to create the skills structuring that would be generally accepted and in the future it may become a part of and a basis for the evaluation of the curriculum. Biology skills were divided into 4 consecutive categories: A) Identification of biology problems and asking questions, B) Information retrieval and their recording, C) Classification of information and their processing, D) Evaluation of results, drawing conclusions and their presentation. These categories correspond to the steps of inquiry-based approach, and each is divided into 2-4 subcategories containing specific skills.

Table 1. Structuring of biology skills.

A) Identification of biology problems and asking questions	
1. To identify a science thematic area (problem) and determine its link to other science areas	1.1 To identify (estimate), on the basis of the information submitted (also in the media - newspapers, magazines, radio, television, film, internet ...) that the given problem belongs to biology (natural science, natural history) 1.2 To include the given issue into the appropriate biology discipline and determine the relationship to other (natural) science disciplines 1.3 To describe verbally a biology problem contained in the induced situation (based on the text read, verbally described situations, own experience)
2. To interconnect the identified biology problem with previous knowledge	2.1 To determine what has been known about the given problem and what is necessary to find out
3. To be able to formulate and ask questions	1.1 To ask questions about the given topic to yourselves and also to the others 1.2 To ask an inquiry-based question about the given problem
4. To set a plan (progress) of work individually/in a group	1.1 To identify the individual steps leading to the expected result 1.2 To prepare time-scheduling of work (to estimate time required) 1.3 To set the hypotheses on which it is possible to determine the conditions for a solution, experiments, observations, ...
B) Information retrieval and their recording	
1. To collect the information from texts and graphic materials	1.1 To choose appropriate and credible sources of information to solve the given problem 1.2 To work independently with texts and graphic material (Textbook, special (popularizing) text, atlas of products of nature, designation key, pictorial material, presented graphs and tables) 1.3 To work with the Internet and obtain the required information 1.4 To make brief notes (excerpt, record)
2. To collect the information via observations and experimentation	1.1 To purposefully observe objects and phenomena 1.2 To describe the observed objects and phenomena (to distinguish between the major and minor features) 1.3 To work with basic biological instruments (dissecting kit) 1.4 To prepare objects for observation (to make cuts, simple staining techniques) 1.5 To prepare laboratory specimens (native, persistent, dry, ...) 1.6 To master the technique of microscopy 1.7 To carry out experiments according to descriptions 1.8 To independently propose an experiment 1.9 To identify appropriate methods and tools for the realization of the experiment 1.10 To record the results during the observation and experiment (both verbally and graphically)

C) Classification of information and their processing	
1. To classify the information according to the set criterion	1.1 To classify the information according to their significance (main and supplementary) 1.2 To classify the information according to their mutual relations (structuring of information from the easiest to more advanced) 1.3 To estimate the significance of the information in terms of their practical use 1.4 To classify and categorize objects and phenomena by distinguishing features
2. To process the information according to the set criterion (written and graphic form)	1.1 To formulate the obtained information (text) in own words 1.2 To transfer the information from tables and graphs into text format and vice versa 1.3 To identify mutual links by means of conceptual (thought) maps 1.4 To write a protocol / work progress 1.5 To make and describe the general layout / diagram, table, graph 1.6 To use simple mathematical procedures for information processing 1.7 To perform basic descriptive statistics 1.8 To process the information on PC (in the form of table, graph, protocol)
D) Evaluation of results, drawing conclusions and their presentation	
1. To assess work/ experiment	1.1 To critically evaluate the newly acquired information (my work and the work of others) 1.2 To estimate the errors or weaknesses of my observation and experimentation 1.3 To propose any other alternatives of solution (to formulate an alternative explanation) 1.4 To comment on my own findings (results) and compare them with already known results
2. To formulate answers and conclusions	1.1 To formulate and explain my results 1.2 To summarize my results in survey tables, charts, graphs ... 1.3 To critically evaluate the results with respect to assumptions (hypotheses) 1.4 To formulate and write a conclusion (using the information from various literature sources and experiments) 1.5 To define new challenges on the basis of the obtained results
3. To present the results	1.1 To choose the appropriate form to present my results 1.2 To present my results in logical sequence 1.3 To independently answer the questions related to the topic concerned 1.4 To defend my results (to argue) 1.5 To discuss and accept justified criticism

Methodology of Research

General Backround of Research

The aim of research was to prepare, perform and evaluate a questionnaire investigation, which is based on the above mentioned proposal of biology skills and which investigates the opinions and requirements of lower secondary (ISCED 2) and general secondary (grammar) (ISCED 3) school teachers on the biology skills of graduates from the lower secondary schools and graduates from general secondary (grammar) schools. The analysis of statements of teachers at both levels of schools and their comparison is one of the bases for the correction of the proposed structure of skills and the subsequent identification of skills that should be acquired by pupils leaving primary schools and by students leaving grammar schools. At the same time, the aim of the research is to observe the disparity in opinions among teachers of different school levels.

Research Questions and Hypotheses

The basic research question was whether there were differences in opinions and requirements between lower secondary school teachers and grammar school teachers on pupils/students mastering of the proposed categories of skills when leaving the respective level of school.

Based on the research question, two hypotheses were established; these were being verified within the respective categories of skills:

Hypothesis № 1:

The opinions of lower secondary school teachers and general secondary (grammar) school teachers vary as for the mastering of the respective categories of skills by lower secondary school pupils.

Hypothesis № 2:

The opinions of lower secondary school teachers and general secondary (grammar) schools teachers vary as for the mastering of the respective categories of skills by general secondary (grammar) school students.

Participants

A research sample consisted of two groups of teachers. The first group were teachers from lower secondary schools (n = 53) and the second group were teachers from general secondary (grammar) schools (n = 68). The selection of teachers was intentional so that the research sample in both groups could consist of respondents from all regions of the Czech Republic. It was the purpose to obtain the teachers from every region of the Czech Republic. In the Czech Republic is 14 regions, so there was the effort to obtain from every region two teachers from lower secondary schools and two teachers from grammar schools. Nearly all schools from every region of the Czech Republic were addressed. So, in the research sample are included the teachers, whose answered on the challenge.

Instrument and Procedures

As a research tool was used a questionnaire of our own design that was divided into two basic parts. The first part included demographic items, namely gender, respondents' age and duration of teaching experience. The second part contained a system of skills divided into four basic categories, each containing from two to four subcategories filled with specific items (Table 1). Likert type items were 4-staged, scale-type with two positive and two negative options. As the aim was to find out the opinion of teachers on the skills that should be, according to these teachers, required from the pupils leaving the lower secondary school (ISCED 2) and from the students leaving the general secondary (grammar) school (ISCED 3), the respondent expressed for each item his/her opinion in terms of both lower secondary and general secondary (grammar) school level. A total number of items were 49; all of them were formulated as positive.

Construct validity of the research tool was ensured by feedback from experts in science subject education (expert on the construction of questionnaires, biology teacher from lower secondary school, biology teacher from general secondary (grammar) school). All of them were asked for anonymity. Based on their comments, the items were adapted into final form. Reliability of the research tool was determined using the Cronbach alpha coefficient, the value of which ($\alpha = 0.94$) points to the high reliability of the research tool. For each category, the value of reliability was as follows:

1. Identification of biology questions and problems – $\alpha = 0.80$
2. Information retrieval – $\alpha = 0.85$
3. Information processing – $\alpha = 0.85$
4. Evaluation of results and drawing of conclusions – $\alpha = 0.91$

The research tool was created in electronic and printed form. Its final form was sent to the e-mail addresses of biology or the questionnaires were sent to teachers of lower secondary schools by regular mail. The response rate from the teachers of lower secondary schools was 66.25%. A similar situation was also in the general secondary (grammar) schools where the total response rate was 80.95%. The questionnaire was designed in the way that to fill it did not take more than 20 minutes. All questionnaires that teachers sent back were in such a fashion that they could be included in the analyses.

Data Analysis

The obtained data were transferred after their receipt into a numerical form from 1 (definitely disagree) to 4 (definitely agree). Data processing was then developed in two ways. Inductive statistics was used for verification of hypotheses; specifically t-test was used for the determination of differences in the answers between lower secondary and general secondary (grammar) school teachers. Another aim was to determine in which item there was a largest difference between the teachers of lower secondary schools and the teachers of general secondary (grammarň schools. Items were compared using the difference in the average score.

To compare the two groups, general secondary (grammar) school teachers and lower secondary school teachers, it was necessary to find out whether the data in the two groups were normally distributed. As the sample was in both cases $n > 50$, the Kolmogorov-Smirnov test was used to determine normality. The data obtained from the lower secondary school teachers showed the normal distribution ($d = 0.09$, $p > 0.20$). The normal distribution was also found from the data of general secondary (grammar) school teachers ($d = 0.10$, $p > 0.20$).

In the result part are used symbols: x – mean score, SD – standard deviation, t – t-test, p – level of significance.

Results of Research

Skill Category A: Identification of biology questions and problems

- *Teachers' view of the skill "identify biology questions and problems" - pupils of lower secondary school*

When assessing the skills aimed at identifying of biology questions and problems that should be acquired by pupils at the end of lower secondary school, a difference was revealed between teachers of grammar schools and teachers of lower secondary schools ($t = 2.25$, $p < 0.05$). Teachers from grammar schools ($x = 3.02$, $SD = 0.37$) achieved a higher score compared to lower secondary school teachers ($x = 2.87$, $SD = 0.35$) (table 2). The difference means that teachers from grammar schools give a greater weight to the identification of biology questions and problems among the pupils of lower secondary schools than teachers from lower secondary schools. Negative scores were found in both types of teachers only in the item "Pupils should be able to set hypotheses on the basis of which it is possible to determine the conditions for solutions, experiments, observations ....". Grammar school teachers showed the score ($x = 2.41$) and teachers from lower secondary schools ($x = 1.55$). These values imply that neither group of teachers considers the above-mentioned skill to be important for pupils of lower secondary schools. A significantly negative evaluation ($x = 1.87$) from lower secondary school teachers also appeared with the item "Pupils should be able to ask a research question related to the given problem." Although the teachers from grammar schools achieved higher scores, some of the skills were considered to be more important by lower secondary school teachers compared with teachers from grammar schools.

- *Teachers' view of the skill "identify biology questions and problems" - students of grammar school*

Similarly, for the same category of skills, which, in this case, should be acquired by students of grammar schools, a significant difference was revealed ($t = 4.15$, $p < 0.001$). Grammar school teachers achieved a higher score ($x = 3.69$, $SD = 0.25$) compared with teachers from lower secondary schools ($x = 3.49$, $SD = 0.29$) (table 2). None of the items showed a significantly negative score, only lower secondary school teachers rated the item "Students should be able to set hypotheses on which it is possible to determine the conditions for solutions, experiments, observations ...." slightly negatively ($x = 2.28$). An interesting finding is that lower secondary school teachers accomplished a higher score in some items than teachers of grammar schools (A.1.1, A.1.2, A.4.1, A.4.2). This means that lower secondary school teachers consider the above-mentioned skills to be more important for grammar school students than grammar school teachers themselves.

Table 2. Mean score and values of t-test in the category "Identification of biology questions and problems".

	Lower secondary school teachers (x)	Grammar school teachers (x)	t	p
pupils of lower secondary schools	2.87	3.02	2.25	< 0.05
students of grammar schools	3.49	3.69	4.15	< 0.001

Skill Category B: Information retrieval and their recording

- *Teachers' view of the skill "retrieve the information and record them" - pupils of lower secondary school*

When evaluating this group of skills that pupils should possess at the end of lower secondary school, a significant difference was revealed in results ($t = 6.16$, $p < 0.001$). Teachers from lower secondary schools achieved higher scores ($x = 3.54$, $SD = 0.17$) compared with teachers from grammar school ($x = 3.24$, $SD = 0.32$) (table 3). The difference means that teachers of lower secondary schools give a greater weight to information retrieval by pupils in lower secondary schools than teachers from grammar schools. Almost all skills were assessed positively, which means that the lower secondary school pupils should have mastered them, by the two groups of teachers, except for the item "Pupils should be able to propose an experiment independently" where the teachers from grammar schools evaluated the given skill as more important ($x = 2.33$) for lower secondary school pupils than the teachers from lower secondary schools ($x = 2.09$). Apart from this item, the grammar school teachers achieved a higher score in only two other items (B.1.1 and B.1.2). The score was approximately balanced in all items, the highest difference was detected in the item "Pupils should be able to prepare the objects for observation (make cuts, simple staining techniques)", where lower secondary school teachers considered this skill to be more important ($x = 3.72$) for lower secondary school pupils than teachers from grammar schools ($x = 2.88$).

- *Teachers' view of the skill "retrieve the information and record them" - students of grammar school*

A significant difference was found out even in determining the importance of the given group of skills for grammar school students ($t = 4.11$, $p < 0.001$). Teachers from lower secondary schools achieved higher scores ($x = 3.88$, $SD = 0.11$) compared with teachers from grammar schools ($x = 3.75$, $SD = 0.21$) (table 3). Each item was evaluated by these two groups of teachers positively, and similarly to the evaluation of skills important for lower secondary school pupils, higher scores were achieved by grammar school teachers in only two items (B.1.1 and B.1.2). This score was balanced in all items; differences were not so marked as when evaluating the importance for lower secondary schools.

Table 3. Mean score and values of t-test in the category "Information retrieval and their recording".

	Lower secondary school teachers (x)	Grammar school teachers (x)	t	p
pupils of lower secondary schools	3.54	3.24	6.16	< 0.001
students of grammar schools	3.88	3.75	4.11	< 0.001

Skill Category C: Information processing

- *Teachers' view of the skill "process the information" - pupils of lower secondary school*

When evaluating the skills focused on processing the information which should be acquired by pupils at the end of lower secondary school, the difference was found among the teachers of grammar schools and the teachers of lower secondary schools ($t = 2.57$, $p < 0.05$). Teachers from grammar schools ($x = 3.16$; $SD = 0.39$) achieved a higher score compared with the lower secondary school teachers ($x = 2.98$, $SD = 0.33$) (table 4). The difference means that teachers from grammar schools give a greater

weight to the skills related to information processing by lower secondary school pupils than teachers of lower secondary schools. A negative score was found in three items and it was always detected in lower secondary school teachers; this means that they do not consider these skills to be important (C.1.3, C.2.3., and C.2.7). This category revealed a large difference in the skill "Pupils should be able to perform basic descriptive statistics (maximum, minimum, arithmetic mean)"; grammar school teachers consider the given skill as important (x = 3.03), in contrast to lower secondary school teachers who consider it as unimportant for lower secondary school pupils (x = 1.72).

- *Teachers' view of the skill "process the information" - students of grammar school*

Similarly, for the same category of skills, which, in this case, should be acquired by students of grammar schools, a significant difference was revealed (t = 3.13; p < 0.01). Grammar school teachers achieved a higher score (x = 3.73, SD = 0.28) compared with teachers from lower secondary schools (x = 3.59, SD = 0.21) (table 4). None of the items showed a negative score, which means that both groups of teachers consider the skills included in the category related to the processing of information to be important for grammar school students. The largest difference in scores was found, similarly to the skills assessment for lower secondary schools, in the item "Pupils should be able to perform basic descriptive statistics (maximum, minimum, arithmetic mean)"; grammar school teachers consider it important (x = 3.68), teachers from lower secondary schools as less important (x = 2.72).

Table 4. Mean score and values of t-test in the category "Information processing".

	Lower secondary school teachers (x)	Grammar school teachers (x)	t	p
pupils of lower secondary schools	2.98	3.16	2.57	< 0.05
students of grammar schools	3.59	3.73	3.13	< 0.01

Skill Category D: Evaluation of results and drawing conclusions

- *Teachers' view of the skill "evaluate results and draw conclusions" - pupils of lower secondary school*

When evaluating this group of skills that pupils should possess at the end of lower secondary school, a significant difference was revealed in results (t = 3.35, p <0.01). Teachers from lower secondary schools achieved lower scores (x = 2.86, SD = 0.43) compared with teachers from grammar school (x = 3.13, SD = 0.44) (table 5). This difference means that teachers from grammar schools give a greater weight to the skills related to information processing by lower secondary school pupils than teachers of lower secondary schools. Negative scores were found in four items and it has always been detected in lower secondary school teachers, which means that they do not consider these skills to be important (D.1.3, D.1.4, D.2.3 and D.2.5). The most significant difference was found in the item "Pupils should be able to critically evaluate the results with respect to assumptions (hypotheses)" where the respective skills are given more importance by teachers from grammar school (x = 2.86), compared with teachers from lower secondary schools (x = 1.72). Interesting sounds the finding that in case of lower secondary school pupils almost all teachers of lower secondary schools (x = 3.91) give a high importance to the skill "Pupils should be able to present the results in a logical order". Grammar school teachers achieved a lower score (x = 3.33).

- *Teachers' view of the skill "evaluate results and draw conclusions" - students of grammar school*

Similarly, for the same category of skills, which, in this case, should be acquired by students of grammar schools, a significant difference was revealed (t = 2.93; p < 0.01). Grammar school teachers achieved a higher score (x = 3.67; SD = 0.28) compared with teachers from lower secondary schools (x = 3.51; SD = 0.29) (table 5). None of the items showed a negative score. Differences in individual skills between groups of teachers were not as large as in the evaluation of the importance of skills for lower secondary school pupils. The largest difference in the score was, as in the previous case, in the skill "Pupils should

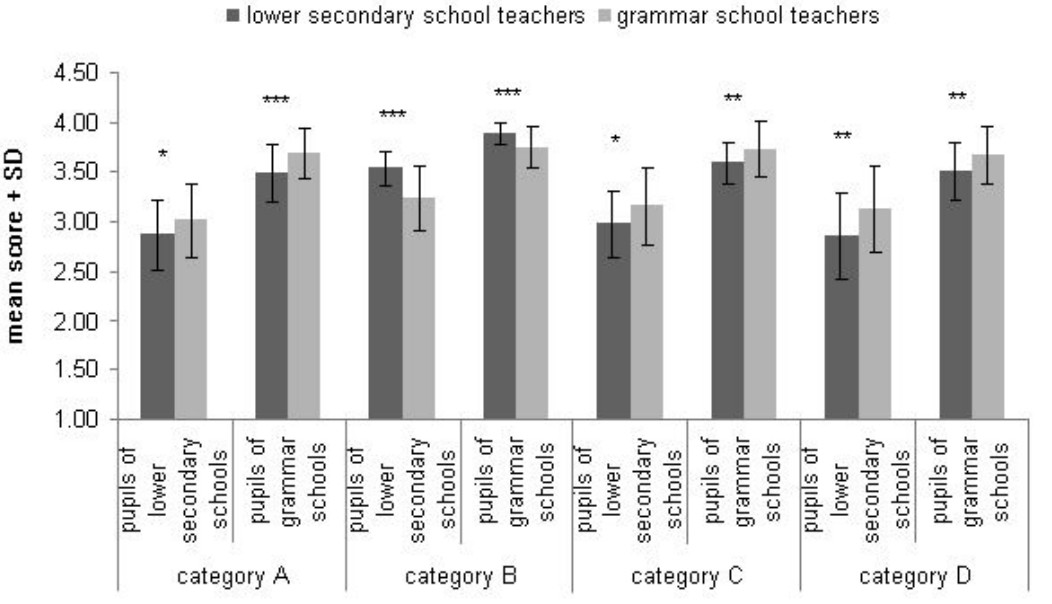
be able to critically evaluate the results with respect to assumptions (hypotheses)", where teachers from grammar schools achieved higher scores (x = 3.57) than teachers from lower secondary schools, who did not consider the given skill so important for grammar school students (x = 2.45).

Based on further detailed analyses, modifications in skills structuring and follow-up specifications were carried out for the respective school levels. A final version of this structuring will be published on the project website.

Table 5. Mean score and values of t-test in the category "Evaluation of results and drawing conclusions".

	Lower secondary school teachers (x)	Grammar school teachers (x)	t	p
pupils of lower secondary schools	2.86	3.13	3.35	< 0.01
students of grammar schools	3.51	3.67	2.93	< 0.01

In the figure 1 are summary of the basic results.



** p < 0.05; ** p < 0.01; *** p < 0.001*

Figure 1: Mean score for each category.

Discussion

Research focused on verifying the two hypotheses concerning the opinion of teachers from lower secondary and grammar schools as for the four categories of biology skills that should be mastered by pupils/students leaving the lower secondary or grammar school. The first hypothesis can be accepted because the skills in each category revealed significant differences among teachers of lower secondary and grammar schools in their view of mastering these skills by pupils/students.

In the first category, a higher score was achieved by teachers from grammar schools, which may be caused by the fact that pupils coming from lower secondary schools to grammar schools have a low level of acquisition of skills concerning the identification of biology questions. It is an incentive for

lower secondary school teachers to pay more attention to this issue. The second category, information retrieval and their recording, is considered to be more important for lower secondary school pupils by teachers from lower secondary schools in contrast to teachers from grammar schools. This is probably due to a greater emphasis of lower secondary school teachers on acquiring the skills related to gathering the information from different sources and their further recording. The emphasis is definitely also put on mastering the work in practical tutorials, work with a microscope and other laboratory equipment. Lower scores of teachers from grammar schools are probably due to the expectation that students coming from lower secondary schools to grammar schools have already acquired the given skills. In the third category of skills related to information processing, a higher score was achieved by grammar school teachers, who expected that pupils from the lower secondary school would have these skills, as opposed to lower secondary school teachers who see the given group of skills as somewhat too demanding for their pupils and probably think that students can learn these skills in greater detail later at the grammar school. As concerns the fourth category of skills, more significant scores were achieved by grammar school teachers. The reason could be - similarly to previous cases - that grammar school teachers already expect from pupils leaving the lower secondary school the skills related to the assessment of results and their presentation. However the lower secondary school teachers do not expect these skills from all the pupils; not all of them will continue to study a higher stage of school. For this reason, these teachers do not consider these skills to be so important though the assessment of results at the appropriate level should be mastered by all the pupils.

The second hypothesis can also be accepted because the view of teachers from lower secondary schools and grammar schools is different as for the skills of grammar schools students.

In the first category concerning the identification of biology questions and problems, a considerably higher score was achieved by grammar school teachers. The result is probably caused by the requirements of grammar school teachers on their students who should have already known how to work with biology information in an independent manner and also how to plan the work progress. Lower secondary school teachers do not expect such an extent of independency even with grammar school students; therefore they finally reached a lower score. The second category of skills related to information retrieval and their recording showed a higher score of lower secondary school teachers. However, with a more detailed view of the results, it is obvious that both groups of teachers put a great emphasis on this group of skills and consider these skills to be very important for grammar school students not only in terms of their secondary school studies but also in terms of their further study and everyday life. The third category is considered to be more important for grammar school students by grammar school teachers. However, similarly to previous cases, both groups of teachers evaluated the given group of skills as very positive. The result was more or less expected since the information obtained by the students must be further processed and evaluated. If they were not able to do it, information retrieval would lose its importance. In the last category of skills, significantly higher scores were achieved by teachers from grammar schools. The result is perhaps caused, as in the first category, by higher requirements of grammar school teachers on their students when evaluating their results and their presentation. Teachers from lower secondary schools apparently consider these skills to be too difficult even for grammar school students.

As mentioned in the theoretical part of the study, the number of publications on the opinions of teachers related to the mastery of biology skills by pupils/students at the individual levels of education is very low - almost zero; therefore it is very difficult to raise a deeper discussion over the results. It is possible to indirectly focus on what could lead to higher levels of acquisition of the proposed skills. As shown in many studies (e.g. Gibson & Chase, 2002), a positive development of biology skills is affected by IBSE. However it is important to regularly integrate IBSE into biology lessons all the year round. Requirements of Czech curricula are very demanding in terms of knowledge; the emphasis is still put on memorizing so a regular application of IBSE by teachers is unrealistic due to lack of time.

The analysis of foreign literature also offered an interesting finding that research investigations were largely conducted among secondary school students (Chang & Mao, 1998; Gibson & Chase, 2002; Knox, Moynihan & Markowitz, 2003; Padilla, Okey & Garrand, 1984). Application of IBSE and development of relevant skills should, however, be shifted in a larger extent towards younger pupils as well as research investigations in this area.

It is important to realize that, like almost every study, even this one has its limits. Research investigation was carried out in the Czech Republic; therefore the question arises of implementation of research investigation in other countries, with a similar educational system, to determine whether there are conditions to achieve similar results presented in this work. It would also be interesting to find out not only the view of teachers from lower secondary and grammar schools but also the opinion of academic staff that prepare the curricula and also, last but not least, the opinion of pupils/students.

Conclusions

The present study ranks among the first of its kind, where the opinions were investigated of lower secondary and grammar school teachers as for the skills that pupils/students should have mastered when leaving the lower secondary or grammar school. The categories, subcategories and individual skills referred to in this work are not finite because after the completion of the study it will be necessary to modify the proposed categorization of skills, which is one of the main objectives of this research. The study presents only the first results focused on comparing the opinions of lower secondary school teachers and grammar schools teachers. Further analyses will focus on detecting the influence of other variables, such as gender, age, etc., which can affect the results. One of possible further analyses is to carry out the analysis in other science subjects for the purposes of mutual comparison. This study, at least partially, will cover the gap, which is present in the given type of research investigation.

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