CHILDREN'S CONCEPTS RESEARCH OF SELECTED COMMON PHENOMENA FROM PHYSICS AND CHEMISTRY AT ELEMENTARY SCHOOLS

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Abstract

The article deals with quantitatively oriented transversal diagnostics of pre-concepts of selected common concepts in physics and chemistry at primary schools and their genesis. The research was carried out in a sample of 60 pupils from the 5th class, 60 pupils from the 7th class and 60 pupils from the 9th class of selected primary schools in the Śstķ nad Labem Region. The applied research methods were as follows: a questionnaire, didactic test, analysis of pupils" tests and concept mapping. The objective was to monitor the affects of targeted school teaching of chemistry and physics on the creation of pre-concepts. The achieved results are discussed in terms of the possibility to integrate chemistry and physics teaching at primary schools.
Key words: *chemistry, physics, pre-concepts, quantitative research, natural science subject teaching integration.*

Children's concepts

Children's concepts are apart from individual experiences and, for instance learning styles, one of the fundamental characteristics of learning individual. It is possible to find also other terms in the literature, which can be in most cases understood as synonymous. Out of these let's point out the most frequently appearing one e.g. term preconception (with linguistic character) or children's imagination (Liu, 1998). Child's concept of certain phenomenon is characteristic especially by forming on basis of out-of-school influence (family, equals, media), which are also supplemented with school influence (teaching of given phenomenon at lower grade, interdisciplinary aspects). These influences form concept for each pupil differently according to their coverage, each pupil has then a different input level, which then strongly influences (both positively and negatively) process of goal-directed teaching realised at school (Akerson, Flick, Lederman, 2000). Children's concepts have various characteristics – from absolutely wrong concepts (so called misconceptions), through primitive concepts up to highly complex structures (Bloom, 1995).

From the above results can be seen that children's concepts are not only (mere) attainments, but they have more complex structure. It is presented in scientific works of various authors differently (Driver et al, 1994) – the following characteristics can be traced. It is possible to identify cognitive element (identification), affect element (attitude) and also sometimes conative element (executive). Elsewhere it is mentioned, for instance, external and internal elements of child's concept (Liu, Ebenezer, 2002). It is also important to appreciate the mental map, which given child's concept creates. Common to this thing is that individual elements mutually interpenetrate and influence it. Very important is also movement (genesis) of given child's concept at certain times.

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Inter subject references

Problems of inter subject references is the subject of increased interest of physicists teaching natural sciences in the past years around the world. Increased interest in inter subject references was expressed in relation to modernisation attempts of teaching process and strengthened in relation to preparation of new conception for elementary and high schools in various states. This interest is supported firstly by growing number of publications and secondly by interest which is expressed in the area of inter subject references and integrated teaching by various national and supranational institutions.

Natural science subjects on the elementary school level provide for suitable curriculum enough space in practical realisation of integrated teaching (Young, 1997) the same way, as it proceeds within project FAST in selected schools in the Slovakian Republic. Certain experience with integrated teaching comes from Germany (Lutz, 1997). One example of the proposals is school subject 'Physics/Chemistry', which concept was created in the seventies of 20th century in federal state Lower Saxony (Niedersachsen). This is an attempt of uniformed natural science view of the surrounding world. Lutz (1997) assesses the realisation of integrated natural science subject at elementary school in Germany more as joint teaching of two or more subjects rather then integrated natural science.

Despite all mentioned activities stays consistent assertion of inter subject references with some exceptions continuously on proclamation level. It is consequence of firstly still persistent creation of isolated didactic systems of teaching with corresponding structure of textbooks and secondly teachers lack of interest in curriculum of the same pertinent subjects. That requires good cooperation of individual subject teachers, educators, psychologists, branch educators and creators of curriculum and textbooks (Brown, 1994).

Methodology of Research

Research was conducted on selected sample of pupils in five elementary schools in Śstķ nad Labem during period October – November 2003. Five concepts common to chemistry and physics were chosen for research of preconceptions, which are taught or mentioned in both subjects. Chosen concepts are subject of teaching in curriculum of natural science subjects at elementary schools. These are the following concepts: ***water, air, state, atom, galvanic cell***. From the methodology point of view it would be of course optimal to monitor respondents and their child's concept in the long term from 5th to 9th grade of elementary school. Due to time reasons it was not possible to run long term research, therefore traversal research was conducted, where cross section of selected child's concepts and their changes were monitored in grade 5, 7 and 9 at elementary school. The number of research participants was 60 in each grade. These grades were chosen due to inclusion of these phenomena in curriculum of physics and chemistry at elementary school. Thus in grade 5, before commencement of teaching physics and chemistry, child's concepts are created through mostly out-of-school influences, occasionally from some phenomena within curriculum on 1st level of elementary school. In grade 7 are some given phenomena already included in physics curriculum and there can be monitored the influence of physics on creation of child's concepts of these phenomena. In grade 9 are the given phenomena already included also in chemistry curriculum so it is possible to assess the share on creation of children's concepts by physics as well as chemistry, out-of-school influences and teaching in other subjects. It is also possible to trace whether teaching of physics stems out of present experience and knowledge of pupils and if teaching of these phenomena in chemistry ties to knowledge gained in physics curriculum. At the same time it is possible to define area for integrated teaching of these phenomena and implementation of inter subject references.

Two main research problems of this investigation can be formulated as follows:

1) Are there any qualitative and quantitative changes in level of children's understanding of selected concepts during 5 - 9 grade of elementary school?
2) How possible changes of children's concepts influences curriculum, concretely teaching of chemistry and physics and out-of-school influences?

In the research there have been used these methods and instruments of pedagogical research:

- content analysis of pupil's texts,
- questionnaire,
- scaling,
- didactic test,
- concept mapping,
- analysis of children's drawings (used only as additional method with text analysis).

Research Results

Due to quite large amount of research data collected it is not possible to present all gathered results here. We therefore will focus on individual research methods employed, in each with assessment of monitored phenomenon (Štastna, 2004). We assume that this process will supply sufficient view of the way of assessment and obtained results.

Content analysis of pupil's texts – phenomenon water

On the blackboard was written the word 'water' and pupils were to write on prepared blank paper all that they know about the given phenomenon. There were no further instructions; this was 'associative research'. They were only told to write everything in relation to this given phenomenon from individual subjects (physics, chemistry, biology, geography …), all they can with relation to given phenomenon think of. Content analysis was conducted through grouping and assessed on basis of element frequency within individual groups, as the following table shows:

Table 1. Frequency of pupils' answer in particular groups.

Group	5. grade	7. grade	9. grade
characteristics	76	136	82
water as condition for life	46	44	60
presence	28	34	63
sort of water	33	41	39
usage	48	32	53
ecology	15	8	3
water chemistry	5	14	46
water cycle	6	2	0
others	15	14	6
Summary	**272**	**325**	**352**

As it was expected, total number of elements increases from lower grade to higher grade. Significant increase in number of elements in the group *characteristics* is observed in grade 7 that is related to teaching of liquid characteristics (water) in grade 6 in physics. Another significant increase can be seen in group *presence*, between grades 5 and 9. That probably corresponds with geography curriculum (topic hydrosphere). Decrease can be seen among grades in the group *ecology* and group *water cycle*, where the most elements are in grade five and the least in grade nine. That can be explained by influence of natural sciences

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teaching on the first level, due to great emphasis on water cycle and ecology. Intense increase is observed in group *structure*, which is again expected result. Water chemistry is part of 8th grade chemistry curriculum, therefore the highest frequency of this element in grade nine. Occurrences in lower grades can be explained through out-of-school influence. Results of increases and decreases in individual groups match expected findings.

In all grades can be observed interesting ratio between the group *characteristics* and group *usage* or group *ecology*. As it becomes obvious from the results, pupils were able to name water characteristics rather then specify its usage or write something about connection of water with ecological aspects, which means that education is very little interconnected with practise.

By filling questionnaire pupils answered question whether they know given concept, whether they understand meaning of it and also a question where they first heard about it or how they about certain concept found out. Results are displayed in the following table with number of answers in each individual grade:

Table 2. Frequency of pupils'answer in particular groups.

Group	5th grade	7th grade	9th grade
at school from teacher	0	48	52
at home from parents or siblings	9	4	1
from friend	0	0	1
by myself from book or magazine	12	1	1
by myself from TV or radio	9	3	2
do not remember	0	1	0
do not know this concept	23	0	0

In grade 5 knows the concept of atom 62 % of pupils, but only 37 % pupils know, what this concept means. In grade 7 and 9 are identical results, the concept of atom knows 100% and only 5 % of pupils do not know, what this concept means. This fact can be justified by explanation of concept of atom in 7th grade in physics curriculum. In grade 5 the most numerous group was according to expectations *do not know this concept*. But there were found answers also in other groups. Since there was no answer in group *at school from teacher*, we can assume that pupils found out about the atom thanks to out-of-school influences. Seventh and ninth grade are just about comparable in this area. There is a definite school influence.

Scaling –phenomenon atom

On the principal of interval scale was investigated the attitude of pupils towards given phenomenon. The purpose of scaling was to capture the affect element of child's concepts. Respondents rated their attitude towards given phenomenon on five interval scales: bad – good, I am afraid – I trust, do not like it – like it, not popular – popular, dangerous – safe. Each scale was constructed as five-point scale, with additional sixth point with selection 'N ', which was chosen by pupils who could not express their attitude or they had no attitude towards this phenomenon, because they did not know it. From values of each individual scale was calculated arithmetical average, which offers certain representation about the total level of affect dimension of given phenomenon. Evaluation of affect dimension of atom is illustrated in the following diagram:

Questionnaire – phenomenon atom

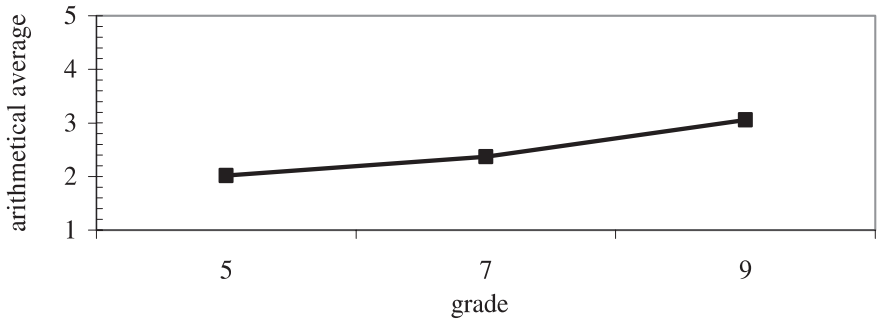

Figure 1. Arithmetical averages of values-affect dimension for individual grades.

In grade 5 and 7 is notable negative reference to atom; in grade nine is average value close to neutral value of 3. Among individual grades there is expected increase of affect dimension level gathered as arithmetical average from individual assessment scales. This increase is due to teaching of natural sciences subjects. In lower grades is atom to pupils unknown, children manifest even their naļve children's concepts about harmfulness of atom (atomic bombs, nuclear power plants). For pupils in higher grades is not the concept of atom unknown, they are learning about its structure and practical importance.

Didactical test – phenomenon galvanic cell

Didactical test represents common and easily accessible research method, which is used most frequently for determining and assessing of teaching results. Some tasks within tests and some types of tests can also be used for determining of pupil's concepts. Didactical tests used to determine children's concepts should not only correct pupil's answers, but also mistakes, so even pupil's misconceptions could be documented. Chosen standard interval must also include negative values, which serve to express mistaken concepts (Doglike, Kodak, 2003). Applied didactical test included one task from physics and one task from chemistry for the monitored phenomena. This enabled monitoring of increase in level of knowledge in individual grades as well as in the whole test. Acquired results were statistically assessed by Fischer LSD-test on significance level į = 0, 05. Results of didactical test for phenomenon galvanic cell are shown in the following table:

Table 3. Arithmetical averages and results of LSD-test.

Grades	Arithmetical averages of test results		
	Chemistry test	Physics test	Tests total
5. grade	-0,05	0,17	0,12
7. grade	0,08	0,43	0,51
9. grade	0,43	0,90	1,33
	Differences of arithmetical averages LSD-test		
5. – 7. grade	0,13	0,27*	0,4
7. – 9. grade	0,35*	0,47*	0,82*
Total 5. – 9. grade	0,48*	0,73*	1,22*

Asterisk marked data are statistically significant increases of arithmetical average values among individual grades. Among grades 5 – 7, there is not statistically significant increase of results in

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chemistry task, which could be expected, especially because chemistry is taught as a subject from grade 8 only. Totally higher increases of rough count were achieved in physics task. Curriculum related to galvanic cells is simpler in physics and has above all close relationship to practical life, as against chemistry, where galvanic cells are included into relatively difficult and abstract subject matter of reducing and oxidative processes.

Concept mapping – phenomenon air

For each concept were selected number of concepts from physics and chemistry, which are related to the main concept (they are in connection to given concept mentioned during tuition). Further there were added concepts, which do not correspond directly to given concept; they have affected character and empty boxes for adding concepts. Total of added concepts to main concept was 15. These words with empty boxes were cut up and placed into envelope. Pupils were given empty sheet of paper format A4, envelope with concepts and glue. Their task was after initial briefing to create concept map by gluing concepts to the main concept, eventually add words into empty boxes, which according to their knowledge belong to the main point and were not listed here. Further they were asked to mark connections among individual concepts using arrows. Each concept map was assessed individually. Assessment criteria were, how many given pupil used from subject matter of chemistry (CH), how many from physics (F), how many from others (O) and how many words were added. It was also determined how many connections were represented in the concept map with use of arrows or connecting lines. Acquired results were partially quantified and statistically assessed by Fischer LSD-test on significance level $\alpha = 0,05$. Results of concept mapping for phenomenon air are shown in the following table:

Table 4. Arithmetical averages of results.

Grades	Arithmetical averages				
	Ratio F:CH	*Ratio F+CH: O*	*Added words*	*Total number of words*	*Number of contextures*
5. grade	0,42	1,64	0,67	9,80	7,67
7. grade	0,62	1,71	0,77	12,43	11,50
9. grade	0,71	2,18	1,27	13,33	10,67
	Differences of arithmetical averages LSD-test				
5. – 7. grade	0,20*	0,07	0,10	2,63*	3,83*
7. – 9. grade	0,08	0,47	0,50	0,90	-0,83
Total 5. – 9. grade	0,29*	0,54*	0,60	3,53*	3,00*

Asterisk marked data are statistically significant increases of arithmetical average values among individual grades. In group *ratio F: CH* is recorded statistically significant increase between 5th and 7th grade and between 5th and 9th grade, which does not correspond with expectations. There should be more demonstrated influence of teaching chemistry, but the gathered results do not support this. Statistically significant is increase in group *ratio F+CH: O* between 5th and 9th grade, which corresponds to expectations. In group *total number of words,* there is recorded increase between 5th and 7th grade, between 5th and 9th grade is also recorded increase. Increase in total number of words confirms expectations. In group *number of contextures* recorded statistically significant increase between the same grades as in group *total number of words*. Air is widely discussed topic – there is reflected also influence of natural science, geography and out-of-school influences. It is widely discussed topic even from the point of view of ecology and climatology. What is interesting that there is statistically no significant change between 7th and 9th grade in any of monitored parameters. It shows that concept map is at this time relatively rigid and teaching of chemistry has no marked influence on its changes.

Conclusion

Pieces of knowledge obtained during conduct of this research study are possible to summarise into the following points:

- children's concepts are possible to be examined through various methods a instruments,
- diagnostics of pupil's concepts are not systematically executed in practice, event. children's concepts are learned by teachers only intuitively,
- in many children's concepts it is not possible to grasp their origin (water, air), with some the origin is quite obvious (galvanic cell – tuition of chemistry and physics),
- pupils have quite extensive opportunities when searching for information at present (internet, multimedia equipment), however, most of information they acquire through school curriculum,
- out-of-school influences can become important source of misconceptions,
- large volume of information leads to neglecting affect element within educational process,
- during goal-directed education at basic schools there is increase in cognitive dimension level in individual child's concepts,
- goal-directed education probably does not pay sufficient attention to creating connections between pupil's new pieces of knowledge and existing knowledge,
- during diagnostics was proven little clasp of 'school' pieces of knowledge with common daily life of pupils,
- pupils do not come into contact with some concepts with explicit formulation very often in common daily life, they do not know what is meant by given concept, although they have individual experience with concrete phenomenon or object (state, galvanic cell).

Work with child's concepts of certain phenomena, which are taught in various subjects, should be an important aspect when attempting integrated education of similar subjects. Mainly child's concepts and its genesis show the best where the optimal area for integrated education is, but it also shows whether education is really integrated or just joint education.

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