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THE SCIENCE TEACHER IN THE SITUATION OF CHANGING EDUCATIONAL PARADIGM

Dace Namsone

University of Latvia, Institute of Education and Psychology, Latvia

Abstract. The human education paradigm is looking upon the learner as an active participant of the study process. In chemistry education, student himself discovers the world of chemical substances. The inquiry is a way human is seeking information and understanding in science education. Discovery, freedom, activity, creativity are the keywords for open learning in science laboratory. By posting hypothesis, further verifying them and analyzing the obtained results, the science process acts as a core for learning approaches. They foster learner's self-discoveries, which are to be used in such a process. The teacher is a key to open such approaches in study process of chemistry. The teacher's role changes notably. In the open study process the teacher undertakes the functions of the expert – consultant and feedback provider. The teacher has to master a series of new skills more often. Moreover, acquiring new experience makes teacher to give up stereotypes and authoritarian teaching style. To implement the education reform in science education in Latvia it is necessary to practically resolve the controversy between learner's wishes to do inquiry oriented laboratory works and teaching strategies carried out by teacher in classroom.
Keywords: chemistry teacher, inquiry oriented learning, study process.

Introduction

International comparative research in Science (TIMSS and OECD) provides evidence of a relatively low achievement standard of our pupils in Science. It thus breaks the stereotype that nothing should be changed in Science education. The researchers in Latvia conclude that the relatively low achievement of pupils in comparison with the average level of OECD countries confirms the necessity to pay more attention to the development of pupils' ability to apply the knowledge and skills they acquired in school in real life situations (Kangro, Geske, 2001, p. 90). The situation is similar in our neighboring countries, Lithuania and Russia. Analyzing the TIMSS results, Russian researcher V. Guzeyev writes that providing knowledge about the ways of the knowledge application is more important than providing the knowledge per se. Even more important is providing knowledge on how to access this information, to integrate it and to create new information (Guzeyev, 2001, p. 13). Similar ideas have been expressed by Tildsepp (2001), Remsden (1995), Hegarty-Hazel (1990), Libby (1995), and other researchers. This relates to the change of educational paradigm from direct provision of information to the pupil's own learning process, which is also emphasized in the conceptual approaches of the Latvian state basic education reform. Thus the study process in Chemistry has to be improved in a way that allows pupils at Chemistry lessons to master the skills of applying the chemistry knowledge in real life situations (i.e. to master the specific subject skills) and to simultaneously improve their learning skills.

In the 60-70ies of the XX century, an extensive research was carried out in the Western world. It focused on the ways of changing the process of learning Science to make pupils more active participants of the process. The research had been greatly influenced by the ideas of Piaget, Vigotsky, Ausubel, Gagne, Bruner, etc. The learning models were developed on the basis of the related psychological learning theories, study methods and strategies developed to promote the self-discovery learning.

The teacher is the agent of changes in the study process. It is directly dependent on him/her if the changes are to occur at all. In this article, we are going to explore some aspects of the teacher's role changing in response to the changes in the study process in Science. It implies

switching from direct provision of information to pupil's own learning, developing the science process skills as well as some problems the Science teachers face owing to these changes.

The research methods were the analysis of scientific and methodological literature on the subject of the research, a survey of teachers' opinions, experimental pedagogical activities, and interviewing teachers.

The Open Learning Process in Science.

Inquiry is taken to be a general process by which human beings seek information and understanding (Klopfer, 1990).

By acting as researchers, aside from learning the technical side of the experiment, the research procedure and scientific logics, the students also learn how to learn. The student develops his science process skills on the basis of a definite chemical theme. These skills include questioning, planning, working out an experiment, posting hypothesis, observing, making experiments, drawing conclusions, constructing scientific explanations – interpreting data. The students use skills of critical thinking and logics to find links between evidence and explanation. They formulate models, look for alternative solutions, etc. At the same time social skills are also being developed during this lesson.

This is the way in which chemistry is studied not only as a science product. Simultaneously the student is involved in the process itself by stressing development of thinking skills. Supporters of this approach say "chemistry should be studied mainly in the same way as chemistry is practiced" (Ditzler, Ricci, Coppola, Schwab, etc.).

Such a learning system appears to be open for a student. The following three basic notions are characteristic for the open (progressive) education philosophy – freedom, activity and discovery pointing out the process of studies. At the same time such concepts as education, studies, responsibility are being extended (Cohen, Manio, Marisson, p.165, 1996). The most essential problem of the progressive education is how to make the educational process open for a student.

In order to characterize the difference between an open inquiry-oriented and closed (Hegarty-Hazel, 1990) laboratory work in science, consider two examples for the same small item in organic chemistry – "physical properties of fat". In the traditional laboratory work, a student receives a task: "A drop of fat (oil) is placed in a test-tube, diethyl ether is added, then the test-tube is shaken and we observe that fat is dissolved". The inquiry level here is equal to zero as the task itself, the means, the methods, and the result are already defined. The system is closed for the student. The problem for the open experiment, which simultaneously develops the skill important for everyday life, would sound as follows: "Remove the oil stain from the piece of cloth". The task is defined giving freedom for a student (and responsibility at the same time) to choose means and methods for solving the problem, to forecast and determine the results. It is a problem for students as they are not aware of the solution algorithm (level 2b, Hegarty-Hazel).

The pupil can make a discovery in Science on conditions that the pupil has a choice (freedom) how to carry out on his/her own (activity) a creative task (creativity). Estonian researcher
Tõldsepp shows it in a chart (Fig.1).

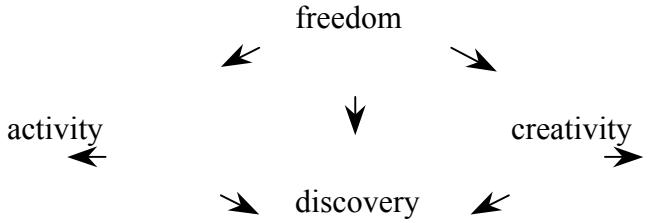

Figure 1. The conditions for student's discovery in science (Tõldsepp, 1999.)

Simultaneously with the freedom the teacher delegates to the pupil the responsibility for the pupil's learning, in contrast to traditional taking that responsibility upon himself/herself. Traditionally the teacher determines how and by what means the pupil is going to complete a concrete task.

Thus, in order to improve the science process skills of pupils, it is important not only to provide pupils with opportunity to carry out experiments on their own. The entire approach to laboratory assignments must change, one should gradually train pupils to be researchers responsible for their learning.

The pupil's learning Chemistry as inquiry promotes the motivation of studying Chemistry. Tasks that have research/inquiry elements in Organic Chemistry were designed as small, easy laboratory assignments that do not require specific equipment and complicated reagents but are closely related to real life. For example, the determining of glucose in grape juice, the exploration of the properties of polyethylene, the comparing of the properties of rubber and gum elastic. Not waiting for methodological materials, each teacher can change the traditional laboratory assignments on his/her own to make them open to pupils. Titova especially advises to do so on the basic school level (Titova, 1999).

The Change of the Role of the Teacher in an Open Learning Process

The pupil's "discovery" differs from the scientist's discovery in that the pupil discovers once again something that has already been discovered. Discovery learning as an approach to the study process means that the pupil acts as a researcher. In the same way as scientist, s/he proposes a hypothesis, proves them by his/her own and makes conclusions, as opposed to simple accepting the statements of the teacher as the truth. Approaches promoting self-discovery provide pupils with an opportunity to construe a body of knowledge that is personally meaningful for them, which has more internal motivation than when somebody else provides information.

Already F.A. Diesterweg differentiated between learning ready knowledge and the pupil's independent discovery and analysis of phenomena. J. Dewy wrote that in that case the pupil not only receives the knowledge but also acquires it using his/her experience and proving hypotheses. In Latvia such an approach in Science education was known already in the 20 – 40ies of the XX century. Already in 1920 the approaches of the Ministry of Education were as follows: The pupils should not be given ready-made information; they have to be encouraged to observe, analyze, compare, combine, make conclusions. Thus the task of the teacher is to guide, help and educate (Izglītības ministrijas mēnešraksts, 1920). The influence of J. Dewy and other leading researchers of that period was felt in Latvia up to the 40ies of the XX century. Laboratory and research methods were topical, as well as the Dalton plan, project method, research paper method. J. Ģirupnieks mentioned that all of the above methods to certain extent include an independent research component. The child follows the road that is covered by a scientist, a researcher, in pursuing the discovery. The child's path differs only in that it is shorter (Ģirupnieks, 1931).

In an open study process the teacher's role changes notably. In such a study process the traditionally used "miracle method" to cover all the material – the lecture/demonstration method-loses its importance. At least it does in part, since it is impossible to master science process skills only through observation or listening.

While in the direct studies the teacher passes on a certain amount of information and controls receiving it, in the open studies the teacher undertakes the functions of the consultant and feedback provider. Different to the "direct studying" the most effort in the teacher's work goes to the planning and preparing of the lesson. At the lesson the teacher directs the study process imperceptibly, involving the pupils in an active study work. For the study process to function like that, the teacher not only has to master a series of new skills. Conducting the discovery learning includes creation of and solving problem situations, foreseeing, listening to and

supporting assumptions, opinions and views of pupils as well as the directing of the practical activities of pupils. It requires a different approach to evaluating/grading, the skills of developing co-operation with pupils, of creating an environment conductive to studies, etc. More often than not the acquiring of the new experience makes the teacher to give up stereotypes and overestimating their own role, as well as to give up the authoritarian teaching style, which sometimes is not even possible.

The key to open studies is co-operation. Both teachers and pupils are involved in the developing of the co-operation relationship. In developing the co-operation relationship, the role of the teacher changes dramatically. The teacher loses the role of dominating figure and becomes an expert, a consultant. After the monologue-centered lesson, when starting to promote discovery learning in the study process, it is advisable to first develop a dialogue between the teacher and the pupils. The interaction between the pupils and the teacher will grow in a gradual process. At that time the teacher and the pupils are accumulating experience and an active task-based learning can happen (see Fig.2). Here the teacher acts as an expert while pupils work in pairs or small groups.

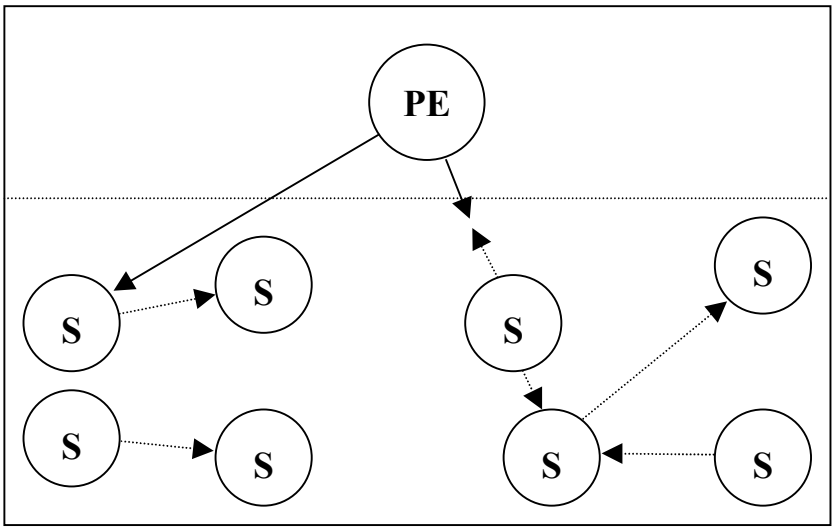

Figure 2. Active, task-based learning (Cohen, Manion, Marisson, 1998), S – student, PE – teacher/expert

A higher level of interaction is in a situation characterized by independent planning and self-directed pupils' work the way it happens when pupils carry out a research task (see Fig. 3).

If a dialogue between the teacher and the pupils, or among pupils or active research work in pairs or small groups is successful, a beneficial and creative study environment is being developed. If the teacher is successful in creating a conductive learning environment, pupils acquire skills and knowledge applicable in real life. Such approach to the study process is definitely justified. Both the teacher and the pupils get satisfaction and pleasure from the study process.

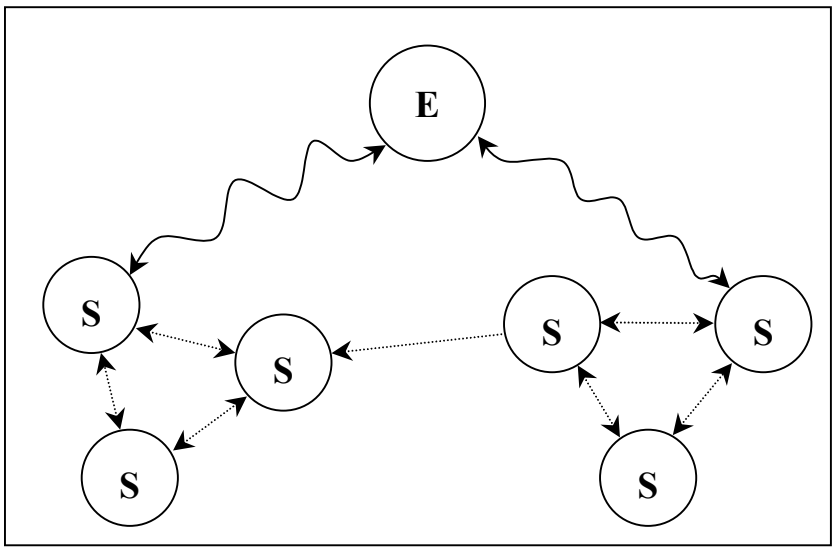

Figure 3. Independent planning, self-directed learning (Cohen, Manion, Marisson, 1998), S – student, E –expert

The Results and the Problems for a Discussion

In the course of the experiment pupils conducted laboratory assignments with elements of inquiry in Organic Chemistry. Pupils like to conduct research experiments with everyday substances and materials. The results of experimental pedagogical activities confirm that if the teacher provides an opportunity to carry out such assignments, pupils work with enthusiasm and improve their science process skills. In turn, the teacher derives satisfaction with the achieved results (Namsone, 2002). The teacher J. emphasizes that *during the time the pupils were carrying out the laboratory assignment, an especially easy atmosphere was felt in the classroom. Pupils like to conduct experiments. If pupils like what they do, the teacher is happy, too.*

Approaches promoting learning motivation are especially important to bring about positive changes in the study process. The survey of the opinions of Chemistry teachers shows that more than a half of teachers (143 respondents) believe that the main problem in their work is the lack of interest (motivation) of pupils to study Chemistry. The process of developing inquiry learning has been modeled working with Chemistry teachers while their in-service training courses in more than ten districts of Latvia. Generally, teachers understand the importance of such learning, especially in promoting the pupils' motivation. However, the experimental results highlight several problems related to the practical work of teachers in the classroom. This causes some concern as to possibility of more extensive use of this approach in the study process.

In the study process, which emphasizes the pupil's own work and responsibility, activation of his/her thinking and work, providing opportunities for expressing assumptions, opinions, etc., the teacher professionalism plays a key role. The teacher has to be able to follow the pupils' thinking, to help them in accentuating the most important aspects and discarding the irrelevant ones, to provide pupils with feedback. For instance, in searching for possible solutions both suitable and poor hypotheses can appear – pupils propose different products of possible reactions, implementation schemes, etc. When starting to work in a new way, the teacher cannot always foresee what assumptions pupils have, what hypotheses they could propose – although this helps to achieve the desired result. The teachers should have regular professional meetings with their colleagues in order to get acquainted with their experience of handling pupils' wrong assumptions, hypotheses, and opinions. It is important that teachers can discuss the best ways to organize pupils' notes, to separate the process of developing ideas from the result, etc.

Simultaneously the discovery promoting approach should not become a self-contained goal. The teacher should not lose the role of facilitator and consultant. In conducting laboratory assignments, it is necessary to have both pre- and post-work discussions about the course of the experiment. The experimental results show that both the teachers and the pupils have to acquire

the experience of such learning gradually, considering the insufficiency of prior experience and knowledge. The teacher L., trying to use the approaches promoting self-discovery at each lesson, overestimated both her own and her pupils' abilities, shifting the work to the pupils' shoulders too much, thus sometimes failing to reach the planned result.

According to teachers, one of the problems in creating an inquiry-based study process is the necessity to use a ready compilation of laboratory assignments, since the teachers are not professionally prepared to develop creative tasks.

At the same time we must note that it is not sufficient merely to prepare descriptions of such assignments. The main issue is whether the teacher chooses to organize a lesson as laboratory work, to provide pupils with an opportunity to work independently and to choose how to carry out work. The research confirmed the assumption that teachers not always acknowledge the importance of pupils' own work in a laboratory. However, if we want pupils master the science process skills, they have to acquire experience of practical work (Trowbridge, Bybee, 1996, p.65).

Teachers seem to acknowledge the importance of laboratory work, for example, *pupils like laboratory work best of all* (teacher M.), *this is the strongest attraction of Chemistry, which has to be used* (teacher P.), etc. However, the research confirms the contradiction between the wishes of pupils and the teacher-designed study process in real classrooms. An earlier conducted teacher opinion survey shows that only approximately half of teachers who participated in the survey use laboratory work as a study method systematically and often. Commenting on, they listed shortage of reagents**,** demands for work safety, concerns that some assignments may fail, an excessive number of pupils in a classroom, etc. Thus a considerable number of pupils enjoy only fragmented opportunities to explore the transformations of chemical substances, to acquire experience of practical activities.

In the course of the research, not taking into consideration the proposed plan of the lesson, teacher I. preferred *I show and explain to the pupils* approach. However, after the experiment was done, nearly half of the pupils of that school, when asked what they would change in the Organic Chemistry lessons, pointed out that they would like to have more laboratory work. Justifying her actions, the teacher argued: it takes up too much time, psychological factors (the teacher is afraid of what might happen when all the pupils are working with chemical substances), practical considerations (no carbide) or others.

It is the teacher's choice to give or not to give laboratory assignments to pupils. The threat to the possibility of changes in the study process is exactly in the teachers' attitude. It is up to the teacher, whether the study process will get more open to the pupil, since it is unquestionably easier and more comfortable "to show and to tell". Already J. Greste said that these methods demand a lot from the teacher – they demand knowledge, work, time, materials and resources (Greste, 1931).

We often come across a teacher stereotype that experiments at Chemistry lessons must be like those in chemical scientific laboratories. Teachers feel unsure, giving pupils ordinary and simple assignments, which simultaneously promote a link to the real everyday life (they do not want to "trifle"). Teacher J. admitted that only experimental results persuaded her that the stereotype was wrong – since the pupils were working with enthusiasm, using ordinary materials, substances and equipment.

Actually changing the teacher's role happens in quite a complicated way. The teacher has to gradually accumulate the experience of such work, to learn to become an expert and pupils' consultant. It is not a skill that can be acquired at first lessons. "Unnoticeable teaching" requires the skills of facilitating and overseeing the process. Interviewing teachers proves that especially at first lessons, while pupils work independently, the teacher does not know what to do. *I was walking around the class and thinking what I had to be doing then*, said teacher E. after the experiment. The same was admitted by other teachers as well.

In the situation of changing the educational paradigm, the simultaneous co-existence of various methods, approaches and styles in the practical activities of the teacher in the classroom

can be observed. When developing a study process open to the pupils, one can notice a curious controversy. Concurrently with pupils' active work in pairs or small groups, the teacher's authoritarian orders are issued or negatively directed evaluation is applied. Co-operation is only possible when partners can accept one another as equals. The teacher opinion survey data show that about one third of Chemistry teachers are the "tough hand" supporters and their teaching style remains authoritarian.

Generally, we have to conclude that actual use of open studies in Science will be dependent on the attitude and actions of the teacher: if the teachers will discover the advantages of a free and creative learning, developing an open-to-pupils study process in Science.

Conclusions

The use of inquiry-based tasks should be started gradually, substituting closed tasks for open ones in laboratory assignments, so that both pupils and teachers can gradually acquire the experience of such learning. To that end it is necessary to help teachers in developing such assignments, offering models of such assignments and lesson plans through in-service training courses. There should be opportunities of regular experience exchange among teachers, who use such approaches practically.

The normative documents and their drafts pertaining to the state basic education reform envisage the acquiring of science skills by pupils. To implement the reform, it is necessary to solve in practice the controversy between the wishes of pupils and the study work carried out by teachers. Already in the nearest future the teachers, to comply with the requirements of the basic education standard in Chemistry, will have to include the self-discovery approach in their methodological repertoire. The change of the teacher's attitude to the activities of pupils in the laboratory and the promoting of the teachers' professional growth can help to implement the open-to-pupils study process, in which the teacher works as a consultant and advisor.

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Резюме

УЧИТЕЛЬ ЕСТЕСТВЕННЫХ НАУК В СИТУАЦИИ ИЗМЕНЕНИЯ ОБРАЗОВАТЕЛЬНОЙ ПАРАДИГМЫ

Даце Намсоне

Сравнительно низкие результаты наших учеников как и учеников соседних стран на международных сравнительных исследованиях по естественным наукам указывает на необходимость перемен в этой области. Новые педагогические парадигмы ставят в центре учебного процесса развитие личности учащихся. Воспринимая на ученика как активного участника учебного процесса, который собственными силами открывает мир химических веществ, выдвигая и проверяя гипотезы, наблюдая и анализируя результаты и т.д. меняется роль учителя - дающего информацию к роли консультанта - эксперта. Исследовательский подход к обучению требует от учителя иных навыков ведения учебного процесса, ломки существующих стереотипов, отказа от авторитарного стиля преподования. Существует противоречие между интересом учащихся выполнять лабораторные работы исследовательского характера и лекционно демонстрационным способом используемым учителем в классе как универсальное средство для "покрытия материала" но не способствующим привитию исследовательских навыков у учащихся. Решающим звеном для осуществления перемен в учебном процессе химии является качественное усовершенствование квалификации учителей, способствующее изменению отношения учителей к ключевим понятиям отрытой системы обучения - открытие, свобода, действие, творчество.

Ключевые слова: учителя химии, открытое обучение, квалификация учителей.

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Dace Namsone
Master degree in chemistry
Institute of Education and Psychology,
The University of Latvia, Kronvalda bulvaris 4
LV- 1010 Riga, LATVIA
E-mail: dacen@mail.sfl.lv ; namsons@latnet.lv