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ACQUISITION OF PHYSICS IN COMPREHENSIVE SCHOOL: ACCENTS OF CONSTRUCTIVISM APPROACH

Jānis Dzerviniks, Jānis Poplavskis
Rezekne Higher Education Institution, Rezekne, Latvia
E-mail: Janis.Dzerviniks@ru.lv

Abstract

Nowadays in general education the emphasis is put on a pupil and his/her activity in learning. Gradually there are deepened pedagogical theories considering a pupil as an active constructor of knowledge. As the process of learning natural sciences at school is essential in the world cognition and it is needed to increase the effectiveness of learning natural sciences, including physics, as well as facilitate the attractiveness of these subjects, it is important to identify and evaluate contemporary didactic standpoints and opportunities for their application in the teaching and learning process. In the article the author analyzes the theoretical ideas of constructivism in the aspect of learning physics. The aim of the theoretical research is to evaluate the didactic standpoints of constructivism, put forward and describe the main principles of constructivism to be implemented in comprehensive secondary education. Within the research reflected in the article there is performed the analysis of scientific literature, analytical judgments are based on the previous empirical researches and using authors' personal pedagogical experience.
Keywords: *communication, construction, constructivism, context, cooperation, understanding, emotional experience, responsibility.*

Introduction

Already in the middle of the past century there were formulated scientific cognitions about the active nature of human's cognition and transfer of accent to pupil's purposeful activity in the learning process. It is an idea about transition to a pedagogical paradigm which can be called a pupil's action based paradigm. Gradually the old views on a pupil as a passive recipient of knowledge vanish and new views on a pupil as an active constructor of knowledge appear. In various cognitive theories there is expression an opinion that people are purposeful individuals searching for knowledge and having a highly developed ability to organize information. One of these theories, which formed in the 1990's, is constructivism that can be perceived as a set of freely related cognitive views. These views are based on the opinion that knowledge is constructed those who learn and develop it through experience. Knowledge can be received, accumulated and stored, but the strongest and deepest knowledge is formed when an individual actively constructs meanings in the interaction with physical and social environment. If pupils are viewed as active, not passive participants of the learning process, it means that learning more often is oriented to activating thinking, but not filling their minds with knowledge. According to the ideas of constructivism pupils shall be given an opportunity to test new ideas, explore information, solve daily riddles, find new answers in various situations Learning to solve problems pupils explore problem situations and it develops their thinking and motivates learning. Pupils cooperate and learn to contest each other's thoughts (also teacher's thoughts) to come to a joint conclusion. As regards the significance of constructivists' ideas in the

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acquisition of physics, they urge pupils to use in learning "discoveries", help pupils construct their knowledge by themselves identifying differences between their prior knowledge and new experience. It ensures the acquisition of notions and understanding of principles through personal discoveries.

For a long time Latvia as a former republic of the USSR had the impact of Soviet pedagogy paying insufficient attention to pupil's own activity in construction of knowledge. Since the 1990's in Latvia the pedagogical activities have been reoriented towards application of active forms of learning, development of pupil's learning skills, learning by research and discovery.

Overall the scientific cognitions of the constructivism theory are applied in the implementation of the learning process. However, in the didactics of physics the basic standpoints of the constructivism theory are not sufficiently explored and characterized, their implementation can ensure better development of pupils' competence and learning skills. Thus, the authors have conducted a theoretical research analyzing the theoretical ideas of constructivism in the aspect of learning physics, putting forward and describing the main principles of constructivism, tracing the main elements of learning, evaluating context-oriented learning of physics and working out the theoretical model of creating the content of physics as a subject. Research object is the learning process of physics. Research subject is learning physics in the framework of the constructivism theory. Theoretical research methods are analysis of scientific literature and modelling.

Basic Standpoints of Constructivism in the Learning Process of Physics

Constructivism is a theory based on the view that knowledge is constructed following one's experience and mind activity. Prior constructed knowledge has a crucial role. A pupil creates new knowledge basing on his/her experience, receiving teacher's support, implementing various activities. Learning is meaningful if pupils have thinking activity (Brooks & Brooks, 1994). The main principles of constructivism are summarized in Table 1.

Table 1. The main principles of constructivism.

Principles of constructivism	Description of principles
Construction	Formation of knowledge by activity, action, problem solution
Understanding	The learning process is focused on thinking and formation of understanding
Context	Problems are solved, tasks are approximated to the real life and professional activity
Cooperation	Mutual assistance in problem solution, evaluation of ideas
Communication	Development of communicative skills through communication in group work, projects, formulating own ideas, asking questions
Responsibility	A pupil feels responsible for his/her learning from the moment when his/her learning is based on his/her questions, discoveries, and solutions
Transfer	Discovering own learning principles a pupil can apply them in other learning situations
Emotional experience	Emotional experience causes activity of cognitive processes, urge mind activity. Emotional experience is created by application of diverse, active forms of learning

Accumulation of knowledge is a dynamic process requiring active pupils' action (Holzer, 1994). Learning is not passive reception of information; it is active construction of new knowledge basing on experience (Nanjappa, Grant, 2003). A great role shall be attributed to prior knowledge and conviction about some truth or values (Rauste-von Wright, 1999; Simons, 1993). In the pupil learning oriented pedagogical process a pupil has a significant role in acquiring

knowledge. Understanding is considered to be a significant feature of learning which is related to personal meaning and significance when the meaning and understanding of the learnt content are formed in pupil's individual conscience. In the learning process thinking is directed towards possibly deeper understanding of new knowledge. Understanding is structuring the existing part of experience with new information (Žogla, 2001). To understand phenomena, processes, objects means to reveal the essential aspects abstracting from unessential ones. Understanding can be expressed as knowing things and phenomena and their involvement into some group. Pupil's ability to find out the internal structure or action mechanism principle, discover causes and consequences, perceive regularities, relate observed phenomena and processes to general physical notions prove a higher degree of understanding.

The basis of understanding is pupil's prior experience, thus in the apprehension process along with highlighting the significant features prior experience is also actualized and new cognitions are included into the system of prior knowledge. If a pupil has understood the idea correctly, s/he can express it in his/her own words. However, not always the skill to express oneself independently proves the needed understanding. Generalized cognitions shall be used in definite situations – pupils shall be able to name examples on their own, solve tasks, and make experiments. It means that understanding is based on the inseparable links between abstract and specific, general and special. It includes transition from definite and specific to abstract and general (revelation of essence) and vice versa. It is impossible to understand the essence without it. The broader and mire flexible these mutual relations are, the deeper the understanding. Thus, pupils' knowledge is broadened and deepened. At the same time pupils' thinking is induced and developed because understanding takes place in a complex thinking process where diverse thinking operations form individual stages (Dzerviniks, 2005).

Knowledge people do not apply or cannot apply is useless, thus, in knowledge acquisition it is essential not only to reach stability and profoundness, but also the ability to apply knowledge in practice. Application of knowledge facilitates its freer acquisition, increases learning motivation revealing the practical significance of learnt issues, makes knowledge closer to real life and understood really, not abstractly. A teacher shall organize the process of knowledge application competence formation gradually moving pupils from knowledge application according to the sample to independent creative activity teaching pupils themselves to control the course of solving a task, analyze the causes of success and mistakes.

Pupils' knowledge application competence shall be formed gradually; inducing thinking operations a teacher shall try to develop pupils' skills to apply knowledge in non-standard situations. Such level of knowledge application competence is typical for productive learning where a pupil is ready to solve problems, discover objectively new relations, formulate generalized conclusions and transfer knowledge to solve new tasks. In interpretative learning this competence is demonstrated by the ability to apply the knowledge by analogy or in well-known situations. Operating with known assumptions pupils define relations, use facts to explain and prove. The lowest level of knowledge application competence is typical for reproductive learning where knowledge is applied according to the sample. Quite often knowledge is remembered mechanically, thus making it difficult to be applied in solving tasks and in real life (Dzerviniks, 2008).

The name of the constructivism theory indicates a practical conception, an action-oriented and modifying view (Ryan & Cooper, 2004). The advantage of learning physics is the fact that pupils can relate the content of the subject to their life and thus become more motivated. In the learning process there are acquired knowledge which can be applied in real life situations and one can learn physics analyzing these situations. Basing on the view mentioned above the scientists (Rayner, 2005; Benckert, 1997; Filkenstein, 2001) have put forward a cognition that the content of physics shall be considered in context. It means that the content of the subject is related to daily phenomena, possible future career, developments of technical equipment or

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observing it in the historical context of physics, its impact on the development of technologies, society and its achievements in culture. The word 'context' has originated from the Latin word 'contexere' which is translated as 'to weave together' or 'that which gives coherence to its parts' (Cole, 1996). Interweaving and interrelating the subject content with various real life events, pupils' and teachers' everyday life, professional activity and career learning physics becomes exciting and meaningful, it urges pupils to be active and self-motivated for learning. Learning is a social activity and it is context related. Context is a fundamental basis supporting pupils' learning. Context shows the application of the principles of physics in various situations, thus providing more specific and authentic reflection of knowledge in practical life. In context learning the subject and social content of professional activity is modulated by didactic means, forms and methods in the learning process.

The theory of constructivism also considers the standpoints relating to human's behaviour in the learning process (Rauste-von Wright, 1999; Simons, 1993). The representatives of radical constructivism do not see social interaction in the learning process because it is personal and individual; however, the representatives of social constructivism emphasize the social dimension of constructing knowledge.

Any knowledge as a basis for perception of reality, however, is constructed and consolidated as a result of social interaction (Берген, Лукман, 1995). Communication and cooperation shall be put forward as significant principles in a constructive learning process in physics. Communication is related to the exchange of pupils' opinions, discussion about gathered information, made experiments, procedure and results of the research, physics as a science and expression of physical regularities in everyday life and technologies. Cooperation shall be implemented by the exchange of ideas, experiments, researches, project planning and implementation in team work.

Learning is a process of interaction where pupils also acquire independent work skills and they become responsible for their learning (Klafki, 1999). According to the basic standpoints of constructivism the learning process becomes subjective when a pupil more and more takes responsibility for his/her learning. Pupils' responsibility forms when they actively involve in creative activities where they have an opportunity to ask, discuss, conduct researches, implement projects and get the joy of discovery showing their initiative and contribution. As S.M.Holzer emphasizes pupils are responsible for their education, but teachers are responsible for creating effective learning environment (Holzer, 1994). The question is how a teacher can create creative learning environment facilitating active learning. According to the scientists' views active learning includes:

- empirical learning (Kolb, 1984; Laws, 1991);
- cooperative learning (Beichner, 1993);
- context-based learning (Lumsdaine, Voitle, 1993);
- information and communication technologies based learning (Laws, 1991; Shneiderman, 1993).

Each pupil has his/her individual learning scheme because each one constructs his/her learning and a common learning mechanism cannot be distinguished (Reich, 2002). Learning is a journey, not a destination. Each opinion is a temporary intellectual stop on the way to increasing knowledge (Brooks &Brooks, 1993). However, for each pupil it is essential to understand the principles of his/her own learning to transfer them to new learning situations and skilfully apply. It is also significant to enrich learning by teacher's or peers' shared experience.

The effectiveness of acquiring physics to a large extent depends on the level of pupils' emotional sphere development. Emotions influence human's behaviour, work skills, increase or decrease his/her activity (Dzerviniks, 2010). Emotional experience is a condition and kind of emotions and feelings one has experienced. The type of emotional experience and its depth

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influence the attitudes towards phenomena, actions and objects. In the process of acquiring physics pupils' interested attitude and signs of emotional expression can be observed:

- in various activities based on real life situations;
- acquiring new information including surprising moments;
- implementing expressive experiments;
- discovering expressive solutions of problems, seeing visual attraction of equipment and models;
- listening to persuasive judgments;
- working on constant researches leading to the joy of discovery.

It is easier for a pupil to learn, learning activity is more productive is positive emotions domineer. On the background of a positive emotional attitude, episodic failures and disappointment still causes willingness to learn, eliminate mistakes, prove oneself and others one's abilities. Optimal balance between positive and negative emotional experience, when positive ones dominate, but negative ones lead to persistence, strong will, etc. is the reserves for increasing the productivity of pupils' intellectual activity (Dzerviniks, 2010).

Basic Elements of Learning Physics

It has already been emphasized that acquisition of physics is done by involving pupils in construction of knowledge. Experience, prior knowledge and skills are also essential in learning. It means that in learning physics the following elements are crucial:

1) active action;
2) prior experience;
3) learning content (see Table 2).

Table 2. Description of the most essential elements in learning physics.

Active action	Pupil's learning activity is related to active participation in the learning process where a pupil acquires content researching and experimenting, asking and searching for answers, putting forward ideas and discussing them.
Prior experience	Pupil's prior experience is formed by a set of practically acquired knowledge, skills and attitudes. In the cognitive process experience is broadened. Experience considers learning as interaction between pupil's characteristics and external conditions, between acquired and accumulated knowledge. Pupils add new information to prior knowledge creating new links with the existing knowledge.
Learning content	Learning content includes definite knowledge and skills, action and social experience, values, conviction and attitude formation experience what a pupil gets in the learning process. Fundamental researches and technical developments, abstraction and contexts interlink in the content of physics.

Learning is a purposeful cognitive process to enrich experience. Pupil's activity in learning is facilitated by external stimuli, encouragement and support, emotional experience, success, development of independence, mastering of creative skills and development of learning skills. Prior researches have revealed that pupils like practical work and discovering links between subjects of natural sciences and daily life. In the learning process physics shall also be revealed as an intellectual activity and a basis for research and technical fields.

Context-based Learning Physics

In order to acquire physics qualitatively there shall be used diverse learning. A teacher shall create learning environment where pupils could experiment, conduct researches and

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discover, mutually cooperate, use information and communication technologies, acquire subject content in context with natural phenomena, technological achievements and possible future activity in research or technical fields.

Context is the platform for acquiring physics to facilitate pupils' involvement, provide them extensive learning experience and help develop skills to solve real life problems. However, it is not simple to find and use good context for the content of physics to be acquired. Many real life phenomena are complex and dependant on many factors pupils are not aware of. It means that in the learning process a pupil together with a teacher shall solve problems within the context using their prior experience. The content of physics can be successfully acquired only if in the context there are used samples known to pupils, observed in daily life or technologies which are specific, interesting and clearly reflect the phenomenon.

Learning has a need to use various contexts because it is necessary to relate the subject content to various life situations or apply acquired knowledge in the exploration of these situations.

Context-based learning might face a problem that pupils will not be fully able to generalize the acquired knowledge without context where the knowledge have been mastered. It means that the acquisition of the subject content, formation of experience are implemented not only through senses (in a sensory, inductive way), but also in an indirect, symbolic form (in a conceptual, deductive way). There can be used two approaches to transfer experience by observation and contemplation as well as by action, active experimenting. Actually everything mentioned above is related to D. Kolb's model of empirical learning including four stages: 1) feeling (concrete experience); 2) watching (reactive observation); 3) thinking (abstract conceptualization); 4) doing (active experimentation) (Kolb, 1984). Thus, learning physics is a process involving one or several kinds of learning mentioned above.

Formation of Learning Content in Physics

Subject content is a significant component of the learning process. It is a set of information, tasks and exercises a pupil shall acquire in a certain period of time. The subject content is mental values a pupil gets by teacher's help. The content of physics is formed of the theories of physics and expressions of real life (see Fig.1).

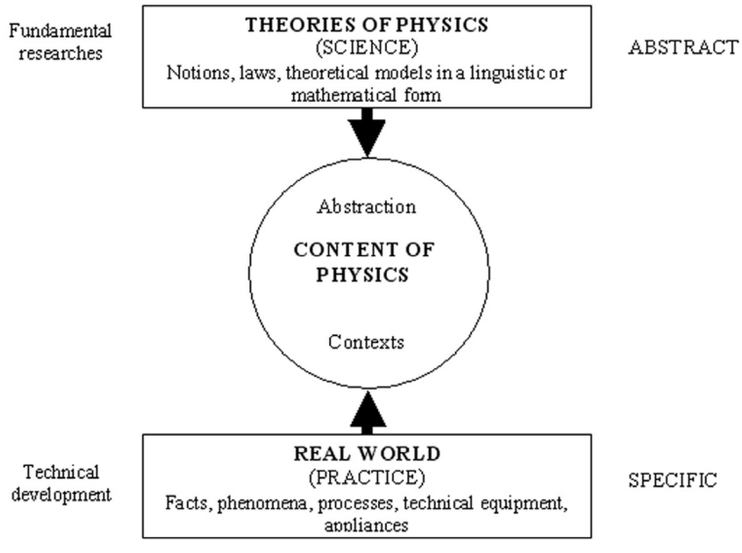

Figure 1: Model of formation of learning content in physics.

The theories of physics with abstract models, laws, notions provide the abstract part in the content of physics, but the real world with facts, phenomena, processes, equipment and appliances forms contexts in the learning content.

Conclusions

If considering the constructivism as a didactic theory, studying is an active process, where the student develops new ideas, which are based upon own experience. However, the teacher, by using study resources, concentrates on the promotion, support of student's studying, allowing student to reveal basic principles of sciences independently. Nowadays the acquisition of physics can be promoted by implementation of study process by comprehension, accenting the solving of problems, research work, ability to study and independent, responsible work.

Students have to notice, that studying of physics is attractive and meaningful, that physics has an important role in their life and, possibly, for their future career. It requires integrated study work with contexts, which are related to everyday life and professional activity. Context-based study of physics is a platform of social and cultural experience, ensuring the acquisition of physics.

Constructive study process is pointed also towards development of students' social skills. It is promoted by study environment, where there is accented students' social interaction, which expresses itself within communication and collaboration, discussing the study content, new ideas, performing researches, working in team and within projects.

Student's intellectual development is closely related also to emotional development. Emotions promote intellectual development, but intellectual skills stimulate the creation of more complicated emotions. During the studies of physics, emotional experiences can become apparent, if student experiences the social consequences of studies, achievements of intellectual activity, results of self-analysis, extension of intellectual skills, independence during cognition, practical usage of results of intellectual results.

Active action, prior experience, learning content are main elements in learning physics. The content of physics is formed of the theories of physics and expressions of real life. The theories of physics with abstract models, laws, notions provide the abstract part in the content of physics, but the real world with facts, phenomena, processes, equipment and appliances forms contexts in the learning content.

References

Beichner, R. J. (1993). A Multimedia Editing Environment Promoting Science Learning in a Unique Setting a Case Study. In: *Educational Multimedia and Hypermedia Annual. Charlottesville*, VA: Association for the Advancement of Computing in Education, p.60-67.

Benckert, S. (1997). *Conversation and Context in Physics Education*. Retrieved 12/01/2012, from http://gupea.ub.gu.se/bitstream/2077/18144/1/gupea_2077_18144_1.pdf

Brooks, J. G., & Brooks, M. G. (1993). *The Case for Constructivist Classroom*. Alexandria, VA: Association for Supervision and Curriculum Development.

Brooks, J. G., & Brooks, M. G. (1994). *In Search of Understandings: The Case of Constructivist Classrooms*. Alexandria, VA: Association for Supervision and Curriculum Development.

Cole, M. (1996). *Cultural Psychology: a Once and Future Discipline*. Cambridge, MA: Havard University Press.

Dzerviniks, J. (2005). Improving Methodology of Demonstration Experiments for Development of Pupils' Knowledge, Comprehension and Skills. *Journal of Baltic Science Education*, 2 (8), 15-25.

Dzerviniks, J. (2008). Development of Pupils' Knowledge, Comprehension and Skills in Natural Sciences at Comprehensive School. *Innovations and Technologies News,* 1, 43-53.

Dzerviniks, J. (2010). Students' Emotions in the Development of Natural Sciences and Technology Competence. *Education Reform in Comprehensive School: Education Content Research and Implementation Problems.* Rēzekne: Rēzeknes Augstskola, p. 44-54.

Filkenstein, N. D. (2001). *Context in the Context of Physics and Learning*. Retrieved 18/12/2011, from http://lchc.ucsd/nfinkels/perc.context.pdf

Geidžs, N. L., Berliners, D. C. (1999). *Pedagoģiskā psiholoģija*. Rīga: Zvaigzne ABC.

Holzer, S. M. (1994). From Constructivism to Activ Learning. *Innovator,* 2. Retrieved 15/01/2011, from http://www.succeed.ufl.edu/innovators/innovator_2/innovator0002.html

Klafki, W. (1999). Die bildungstheoretische Didaktik im Rahmen kritisch-konstruktiver Erziehumgswissenschalf. In Gudjons, H. & Winkel, R. *Didaktische Theorien.* Hamburg: Bergmann &Helbig. S. 13-34.

Kolb, D. (1984). *Experiential Learning*. Prentice Hall, Englewood Cliffs, NJ.

Laws, P. (1991). Workshop Physics: Learning Introductory Physics by Doing It. *Change*, 23, 20-27.

Lumsdaine, E., Voitle, J. (1993). *Contextual Problem Solving in Heat Transfer and Fluid Mechanics*. AIChE Symp. Ser.89.

Nanjappa, A., & Grant, M. M. (2003). Constructing on Constructivism: The Role of Technology. *Electronic Journal for The Integration of Technology in Education*, 2, 1. Retrieved 15/01/2011, from http://www.pedagogy.ir/index.php?option=com_content&view=category&layout=blog&id=47&Itemid=71

Piažē, Ž. (2002). *Bērna intelektuālā attīstība*. Rīga: Pētergailis.

Rauste-von Wright, M. (1999). *A learning based teacher training project: the first two years. Paper presented in the 8th European Conference on Learning and Instruction*, Goteburg, Sweden.

Rayner, A. (2005). *Reflections on Context-based Science Teaching: a Case Study of Physics for Students of Physiotherapy*. Retrieved 19/01/2012, from http://sydney.edu.au/science/universe_science/pubs/procs/wshop10/2005Rayner.pdf

Reich, K. (2002). *Systemisch – konstruktivistische Pedagogik, Einfuhrung in Grundlagen einer interaktionistisch-konstruktivistischen Padagogik*. Luchterhand Verlag (Neuwied), 4. Auflage.

Ryan, P. G., & Cooper, J. (2004). *Those Who Can, Teach.* New York: Houghton Mifflin Company.

Shneiderman, B. (1993). Eduacation by Engagement and Construction: Experiences in the AT&T Teaching Theater. *Proceeding of Ed-Media 93 Word Conference Multimedia and Hypermedia*, Orlando, Florida. p. 471-479.

Simons, P. R. J. (1993). Constructive learning: The role of the learner. In T.M. Duffy, J.lowyck& D.H. Janassen (Ed.), *Designing environments for constructive learning*. NATO ASI Series. London: Springer – Verlag. p. 291-313.

Žogla, I. (2001). *Didaktikas teorētiskie pamati*. Rīga: RaKa.

Берген, П., Лукман, Т. (1995). *Социальное конструирование реальности: Трактат по социологии знания*. Москва: Академия –Центр: Медиум.

Advised by Laima Railienė, University of Siauliai, Lithuania

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Jānis Dzerviniks	Dr.paed. Associate Professor, Rezekne Higher Education Institution, Rezekne, Atbrivosanas aleja 115, Rezekne, Latvia. E-mail: Janis.Dzerviniks@ru.lv
Jānis Poplavskis	PhD Student, Rezekne Higher Education Institution, Atbrivosanas aleja 115, Rezekne, Latvia. E-mail: janis.poplavskis@inbox.lv