R&E-SOURCE *https://journal.ph-noe.ac.at*
Online Journal for Research and Education
Special Issue 18, June 2020, ISSN 2313-1640

Constructivism in experimental academic work

How to teach teachers

Cestmir Serafin[1]

Abstract

The current concept of education and modern methods and procedures aim to take an active approach. Educational activities, which today are in most cases supported by modern information and communication technologies, focus in particular on innovative practices known to the present generation and enable them to better manage the broad areas of knowledge and skills they need to acquire.
In our information (digital) society, it is necessary to develop a general concept of information literacy in all areas of knowledge. This concept requires an appropriate adaptation of the education of future teachers, the basic means of communicating knowledge to younger generations. Without these modern approaches, quality training would be unthinkable.
The paper presents a view of the field of constructivist approach in the education of future teachers of technical subjects in the context of their future constructivist approach in teaching practice.

Konstruktivismus in der experimentellen akademischen Arbeit

Wie man Lehrer unterrichtet

Zusammenfassung

Das derzeitige Bildungskonzept sowie moderne Methoden und Verfahren zielen auf einen aktiven Ansatz ab. Bildungsaktivitäten, die heute in den meisten Fällen durch moderne Informations- und Kommunikationstechnologien unterstützt werden, konzentrieren sich insbesondere auf innovative Praktiken, die der heutigen Generation bekannt sind, und ermöglichen es ihnen, die breiten Wissens- und Kompetenzbereiche, die sie erwerben müssen, besser zu verwalten.
In unserer (digitalen) Informationsgesellschaft ist es notwendig, ein allgemeines Konzept der Informationskompetenz in allen Wissensbereichen zu entwickeln. Dieses Konzept erfordert eine angemessene Anpassung der Ausbildung künftiger Lehrkräfte, der grundlegenden Mittel zur Wissensvermittlung an jüngere Generationen. Ohne diese modernen Ansätze wäre ein qualitativ hochwertiges Training undenkbar.
Das Papier bietet einen Überblick über das Feld des konstruktivistischen Ansatzes bei der Ausbildung zukünftiger Lehrer für technische Fächer im Kontext ihres zukünftigen konstruktivistischen Ansatzes in der Unterrichtspraxis.

Keywords:	*Schlüsselwörter:*
Constructivism	Konstruktivismus
Teacher training	Lehrertraining
Teaching methods	Lehrmethoden
Education	Bildung
Information society	Informationsgesellschaft
Information literacy	Informationskompetenz
Technical education	Technische Erziehung

[1] Faculty of Education, Palacký University in Olomouc, Zizka sq. n. 5, 774 01 Olomouc, Czech Republik.
Corresponding author. E-mail: cestmir.serafin@upol.cz

1 Introduction

The current concept of education, as well as modern methods and procedures, aims to take a proactive approach. Educational activities, nowadays supported by modern information and communication technologies in most cases, focus mainly on innovative procedures which are familiar to the current generation and allow it to better handle the vast areas of knowledge and skills it needs to acquire.

In our information (digital) society, it is necessary to develop the general concept of information literacy across all areas of knowledge. This concept requires an adequate adjustment of the education of future teachers, the fundamental vehicles which mediate knowledge to young generations. Without these modern approaches, quality training would be inconceivable.

Constructivism is a wide range of behavioural and social science theories, one which emphasises both the active function of the subject, and the importance of the subject's interactions with their environment and the society as such.

Constructivism is based on the process of actively constructing one's knowledge through their own activities and by sharing it with other individuals. Thus, the individual forms new experiences on the basis of their previous ones and as a part of their interaction with the environment. This creates a pattern which allows the individual to understand these new facts and incorporate them into previous structures. The constructivism's main starting points are (Nezvalová, 2005):

1. The individual being educated actively constructs their knowledge. Learning is not a passive activity.
2. Learning can be both an individual, and social matter.
3. Learning is a self-regulating process. Each individual learns differently, depending on their own internal dispositions and on external factors.
4. Learning is a process of management which allows people to understand the world. From the constructivist point of view, equilibration brings stability and the internal cohesion of one's system of knowledge. New information may be subject to assimilation, i.e. new knowledge is incorporated into the existing pattern. Alternatively, if the new knowledge does not conform to the individual's experiences or original concepts, the process of accommodation takes place, i.e. a new pattern is created which is in line with the new information.
5. The function of knowledge is to organise the world of one's own experiences, not objective reality. Truth is viable, i.e. subject to a person's adaptation to the world. It helps one to survive in this world without necessarily being valid. The goal of learning is to organise and understand the world of one's experiences.
6. Reality means interpretation. Information is absorbed by the individual and reaches them through their own interpretation, not as an intact "truth about the world". This truth is created by the individual themselves; they construct it within.
7. Learning is a social-contextual activity, developed in a stimulating environment. The reconstruction of one's own knowledge, and discovery of one's own patterns can take place with the support from others.
8. Language plays an important part in the process of learning. Thinking takes place as a part of communication. Constructivists emphasise the role of language as a tool which allows us to connect what we have already learned in the past with the results of learning, i.e. the very construction process which results in individual knowledge.
9. Motivation is a key learning factor. Rewards and punishments are considered external means of motivation. For constructivists, the chief source of motivation can be found in the internal (individual) need to understand the world and one's own knowledge.

The constructivist approach emphasises the following (Nezvalová, 2005):

- the pupil's active participation is crucial;
- learning is the process of cognitive construction;
- the most effective way learning can happen is by actively handling objects, their models, etc.;
- any new learning begins by updating previous knowledge;
- learning is best induced in a stimulating, complex environment;
- creating significant problem situations supports the meaningfulness of learning and the motivation of pupils;
- social and cultural context is important if matters and phenomena are to be understood.

There are more constructivist schools of thought. The main ones include (Nezvalová, 2005):

a) Cognitive constructivism is based on Piaget's and Dewey's conclusions that an individual who is in the process of acquiring knowledge connects parts of the information from the external environment into meaningful structures and performs mental operations which correspond to their own level of cognitive development.
b) Social constructivism (according to Vygotsky) emphasises the irreplaceability of social interaction and culture in the construction of knowledge. Education is a social process that takes place on the basis of human communication.
c) Radical constructivism includes everything that exceeds the world of the individual's experiences. The individual can form only subjective images of the world which reflect their own experiences, not any communicated truth about the world which they themselves have not experienced.
d) Personal constructivism states that there is no such thing as a passive receipt of knowledge, only active receipt as a part of the subject's learning.

Methods of pre-graduate preparation and the content of various disciplines on one hand, and the teachers' ability to systematically and clearly update the presented curriculum on the other place great demands on contemporary teachers in terms of expert knowledge and subject didactics. Such demands can be met only by highly competent teachers who have been prepared for their occupation by the tenets of modern pedagogy, one of them being the constructivist approach mentioned above.

Teacher competence requirements increase in proportion to the number of disciplines which are considered relevant to the teacher's occupation. A teacher must have undergone a quality theoretical and practical preparation not only in expert matters; they must also be psychologists as studying (especially when it comes to studying disciplines related to natural sciences or technical issues) places great intellectual and manual demands on pupils. The teacher's task is to combine a pupil's motivation with their individuality.

J. Vašutová (Vašutová, 2001) defines subject competence as a single whole where a teacher should master systematic knowledge of their specialisation to the extent and depth adequate to primary or secondary school needs; they should be able to transform knowledge of relevant scientific disciplines into the educational content of school subjects; they should be aware of methods to incorporate interdisciplinary knowledge and conduct cross-curriculum relationships; they should be capable of researching and processing information with the use of modern information and communication technology; and finally, the teacher should know how to transform the learning methodology of their own field into the way their pupils think. The future teacher can acquire this competence by studying their specialisation and its methodology, didactics, pedagogical psychology, and informatics.

Let us delve into practical competence which is closely related to subject competence and emphasises the specificity of teaching natural sciences and technical subjects. This specificity manifests itself when theoretical knowledge is connected with the practical (experimental) testing of its validity. That is why there is so much emphasis put on the application nature of individual disciplines, as well as on the skills of those who will one day teach specialised technical subjects or disciplines with a focus on natural sciences – an ability to independently and skilfully apply theoretical knowledge is of paramount importance. From this point of view, it is also very important to include disciplines which combine subject didactics with laboratory equipment. On one hand, this helps teachers develop their own psychomotor skills, and on the other introduces practical rules and points out problems which can be typically encountered when conducting specific experiments.

In terms of developing one's own thinking and the concept of creativity, the constructivist approach, based on motivated activities of those who study teaching, aims to invoke situations where students actively get involved in "reactions" with individual preconceptions. This mostly concerns an attempt to raise awareness of an issue, to invoke a sense of tension between an existing notion and a new piece of information or experience. However, this necessitates that the individual's intuitive ideas about a given phenomenon be first diagnosed, and experiences which cognitively clash with the idea then presented. In order for the cognitive conflict to be resolved, the individual must construct or discover new solutions. This can be very easily applied to the area of experimental work in school laboratories. The issue of "comprehension" is very important in this context, namely the processes which cause such comprehension to emerge. In the constructivist context, comprehension can be viewed as an interpretation of new information in view of existing knowledge (Grecmanová, Urbanová, & Novotný., 2000), and also as a process where an individual mentally constructs the meaning and sense of what they know and perceive (Fontana, 2017). Thus, comprehension means reworking and expanding a mental construct in view of so-called preconceptions, i.e. of one's experiences, knowledge, attitudes, and mental structures (Kropáč & Plischke, 2009).

Teaching can be successfully implemented only if there are suitable conditions for establishing a complex educational environment where a pupil or student can and wants to successfully learn and where their accomplishments motivate them to continue studying. Establishing a complex educational environment is an educator's fundamental competence, one which conditions and expresses their professional proficiency and constitutes a part of the subject competence of future educators.

Therefore, it is necessary to prepare teachers of technical subjects or natural sciences in a way that is based on the synergy of specialised and pedagogical-psychological disciplines. If such a preparation is combined with the student's creative experimental work, it facilitates the optimisation of acquiring a didactic awareness of the teaching's content.

In the constructivist approach, the effort to combine the theoretical and practical parts of teaching often leads to the use of modern tools based on information and communication technologies, for example virtual on-line laboratories.

Remote experiments are a modern tool for conducting real-life school laboratory experiments, most often controlled on the internet, i.e. on-line (Fig. 1). Compared to their traditional laboratory counterpart, these experiments have several, rather notable advantages (Látal, 2018):

- free access to a "remote" laboratory (anytime, anywhere);
- no need for aids, measuring tools, and other technical equipment;
- the possibility of repeating the experiment multiple times;
- work with real-life measuring tools, real-life data;
- quick and graphic data processing;
- no danger, no risk of injury;
- can be used for preparation at home, for distance education.

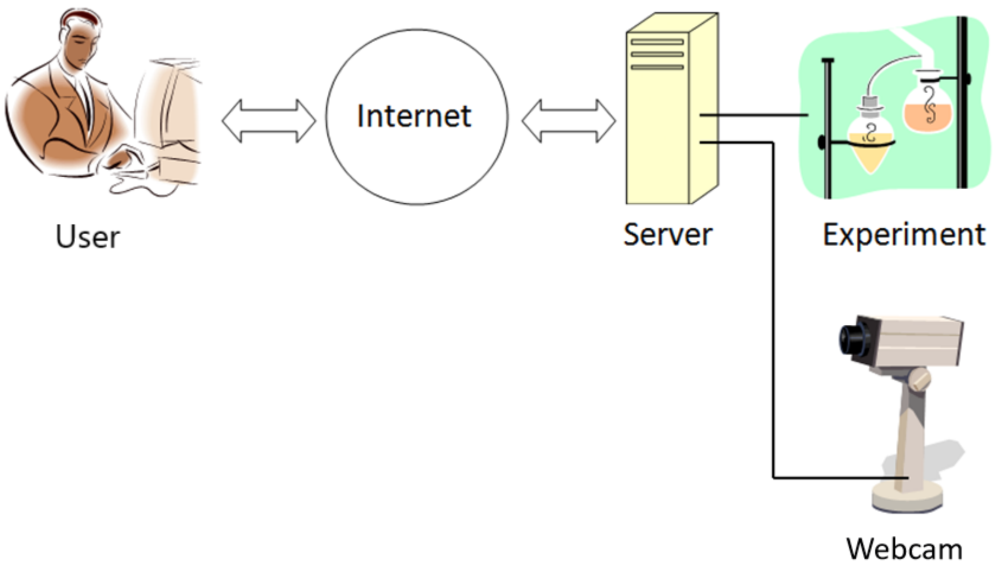

Fig. 1 Solving virtual systems – remotely controlled experiments[2]

Ch. Levert and S. Pierre (Levert & Piere, 2003) present their own methodology, a general concept and modelling of virtual laboratories which must be safe, inter-operational, with quality services, and have to function in different configurations as well as on different platforms. At the same time, however, we cannot omit to mention that this must also include a model for educating future teachers that addresses their individual needs and is based on the goals and needs of future teachers–users.

The development of technical thinking is a fundamental goal of teaching technical subjects, regardless of their special focus. E. Franus (Franus, 2003), a Polish psychologist, analysed the important term *technical thinking*: "Technical thinking is the process of reflecting and using physical laws as well as technical principles in technical creation and technological processes." This definition accurately describes the two related aspects of technical thinking – namely cognitive processes which are of a predominantly analytical nature, and creative or construction processes where synthesis prevails.

[2] *Source: https://commons.wikimedia.org/w/index.php?curid=36909652*

The above-mentioned aspects of technical thinking should also be taken into account when experimental activities for technical subjects are being designed. When it comes to experimenting in technical subjects, the fundamental logic and focus of cognitive processes is similar to those which are at play in natural sciences, though they must respect the broad social (economic, psychological, etc.), natural, and of course technical context (thus, abstraction is made more difficult). That is why current trends in designing natural science experiments serve as an inspiration to technical subjects. Here, attempts to exercise an explorational approach strongly manifest themselves. Studies with such a focus have been published, among others, by D. Nezvalová (Nezvalová, 2010), Č. Serafín (Serafín, 2018), and others. Undeniably, these attempts continue applying the constructivist approach to teaching. Experiments witch an explorational focus position pupils as "scientists or researchers". According to D. Nezvalová (Nezvalová, 2010), over the course of education with an explorational focus or during experiments, pupils – based on situations invoked by the teacher – ask questions with an explorational focus; look for evidence; formulate explanations based on the evidence; evaluate explanations with the possibility of using alternative ones; communicate and verify the explanations.

The above-mentioned fully applies to the issue of experimenting in technical subjects. Such experimenting, however, wouldn't be perfect; rather, it would only support cognitive activities aimed at discovering usually basic, general technical context and relationships. Over the course of experimenting, mental creative or construction processes which constitute the second part of technical thinking are connected with situations, activities, outputs, or products that are more specific. What actually takes place here is, therefore, an application of synthesis of acquired knowledge to "a new quality of solutions" (at least from the pupil's point of view) and its experimental verification. In this case, nevertheless, situations should adequately include stages of the life of technical equipment, namely: recognising the need, designing, construction, programming (e.g. ensuring production by technological means), creation, use, and disposal (Furmanek & Walat, 2002).

Including pupils' cognitive activities and creation processes, as well as the solution to educational situations which consists in meeting the legitimate needs of an individual or a group, to the full extent of the creation, use, disposal of technics – all of that is generally the point of teaching technical subjects and should be supported by the pupils' experimental activities.

In accordance with the transformation of contemporary schools which emphasises, among other things, the teaching's focus on activities and experiences, it can be concluded that it is important to strengthen this concept in preparing those who study the teaching of general technical subjects, with the goal of better preparing them for their future occupation as educators. The starting point for making changes in the concept of teaching subject didactics in regard to vocational training is therefore a critical analysis of the current concept of teaching, performed by evaluating the level and quality of competence acquired by students of vocational training.

2 Technical thinking

Humans change and shape their environment mainly by means of technics. At the same time, they look for, discover, create, improve, and expand their environment and options (although the opposite can be true sometimes). They place an artificial environment, a material culture between themselves and the nature (Stoffa, 2000). All of this requires specific technical approaches, procedures, and methods of thinking.

The term *technical thinking* and methods of developing technical thinking in teaching are an important issue for the didactics of technical subjects (Vaněček, 2016). Theories which focus on the issues of technical thinking can be encountered in the foreign didactics of technical subjects, rather than in the Czech one. Nowadays, however, attention is predominantly paid to the term *creativity* or *technical creativity*. The term *technical thinking* is less common.

Technical thinking is a specific form of thinking; a term with a broadly defined content (naturally, since *technical* itself is a broadly defined concept). In practical situations, technical thinking and the related requirements must have a more precise definition. In our opinion, a pupil's technical thinking should be generally defined in accordance with the term *technical literacy*; this term was presented in the works of J. Kropáč (Kropáč, 2004), for example. Based on the nature of technics, technical thinking has a variety of specificities. An unbroken continuity of theoretical and practical components is one such specificity; another basic one lies in the means–end relationship (finality), or in determining which means should be employed in order to meet a specific end. Here, one other fundamental aspect of technics and thinking is of importance – complexity, as no significant context can be omitted when working with technical equipment, regardless of whether such context is of a technical or non-technical nature. It is also clear that different means or technical options can be used to meet a specific end or fulfil a specific goal. In this case, the ability to engage in critical and evaluative thinking asserts itself.

Technical thinking includes such operations as analysis, synthesis, abstraction or concretisation, classification, and analogy. In connection with technical imagination, this mainly concerns analysing the notion of a product; activating one's existing knowledge, skills, and experiences which can be used to solve the interim issues of constructing and creating products; and finally synthesizing all applicable realities by means of which the researcher creates a project, i.e. arrives at the complete solution of constructing and creating a product. In this context, the works of a prominent Polish psychologist E. Franus (Franus, 2003) are worth mentioning. Franus defines technical thinking as a process which reflects and uses physical laws and technical principles in technical subjects and technological processes.

German authors B. Hill and B. Meier (Hill & Meier, 2004) also describe technical thinking as a mediated and generalised reflection of reality. It is characterised and predetermined by a close relationship between conceptual, visual (notional), and practical components of technical activities. It is indisputable that technical thinking consists of cognition and creation, of mental operations with the ideal reflections of objective reality. One characteristic feature of technical thinking is that it involves not only existing objective reality, but also options based on the system of social cognition. This can have different degrees and forms, from creating brand new objects or procedures, to their improvement or finding failures in them.

According to L. Tondl (Tondl, 1998), the above-mentioned definition suggests that technical thinking has two related aspects:

- the cognitive aspect, which is an activity during the course of which we familiarise ourselves with the structure and function of new technical creations and drawings. This takes place during assembly or disassembly as well (the activity is therefore primarily of an analytical nature);
- the construction (creative) aspect, meaning a mental process focused on such creative activities as designing, improving, inventing, or solving technical tasks and processes (the activity is primarily of a synthetic nature).

Both of the above-mentioned aspects manifest themselves in the relationship to electrotechnical kits since the cognitive as well as construction aspect are an integral part of working with any electrotechnical kit.

When solving problems, cognitive thinking always has an auxiliary function of preparing one's intellect for a creative synthesis (Franus, 2003). Creative thinking thus picks up on the "content" of cognitive thinking. Both processes play a part in resolving problems, though they are not identical. If analysis is a fundamental attribute of cognitive processes in science and technology while synthesis is a basic characteristic of creative processes, it means that there is a psychological barrier between cognitive and creative processes which take place when we think; between analysis and synthesis, both in scientific and technical thinking. This is a permeable, transitional barrier which divides the process of thinking into two parts: the cognitive, analytical part, and the creative (construction) part. The permeable transitional barrier is sort of a Rubicon (Franus, 2003) we cross when thinking (intentionally or not) in order to acquire a new quality. This happens when the process of thinking gathers enough information and reflections, i.e. productive content, for quantity to be transformed into quality as per the laws of dialectics. This new quality keeps on "requiring a supply" of details, but already offers a hint of a solution to the issue. That is why the above-mentioned transitional barrier is at the same time a symbol of transitioning from analysis to synthesis, from quantity to quality, from the cognitive process to the creative one, from discovery to creative action. The issue of transition is therefore the issue of meeting the necessary conditions to resolve a problem.

Thinking aimed at resolving problems can be twofold (Franus, 2003):

- with a homogenous structure of a purely cognitive type, if this concerns an unproductive process, limited by the knowledge of the problem's content and not leading to a resolution of a new problem;
- with a dual structure, i.e. with a cognitive, creative aspect, and thus a productive outcome.

Mental work to resolve a difficult problem does not follow a simple model (it does not copy a simple model), but contains many synthetic micro-parts (micro-syntheses) which form a final creative macro-synthetic complex, like links in a chain. Apart from this, in multicomponental cases, a mental-cognitive creative or construction structure produces a "mosaic" which consists of multiple micro-synthetic parts.

According to E. Franus (Franus, 2003), technical thinking which asserts itself and is developed during the process of technical activities is:

- an integral part of a person's cultural maturity;
- a special kind of human thought;
- an activity involved in resolving theoretical and practical issues;

- a regulator of human activities in relation to technics.

Just like any other type of creative thinking, technical thinking is not only cognitive thinking, but also a two-natured complex process which respects both simple, and difficult issues, as well as the structures of micro-syntheses and macro-syntheses.

In scientific thought, creative synthesis is the crux of formulating theories as a part of scientific discovery; in technology, it is the core of inventing and creating the structures of technical objects. In both cases, we deal with concrete or concretised (object-oriented) processes of creative thinking, although the quality of these processes varies significantly. Both are developed in the sphere of concepts and notions, but the former always includes the form of words and sentences while the latter necessitates a depiction and specific material substance.

During the course of creative and analytical processes, cognitive thinking serves various functions. In scientific output, it works as a research process that prepares sets of information necessary for formulating a theory, or as a cognitive process which facilitates one's familiarisation with the content of the problems being solved. In technical output, this applies to at least four general situations: securing information in order to acquaint oneself with the problem's content; learning about scientific theories, technological principles, rules, etc.; examining the progress of production activities; examining the activities of the finished object. In each of these situations, the results of cognition (choices, decisions) are an act of creative synthesis and a key element for completing the creative process.

According to E. Franus (Franus, 2003), technical thinking as a concretised process differs from other concretised processes as it deals with creating an artificial world and constructing objects or technologies in the broadest sense of the word. Considering the procedural and psychological aspects, however, this concretised process is characterised by a typically dual cognitive and creative (construction) structure (just as other concretised processes – musical, artistic, or literary ones).

The key to cognition and creation (both closely related to electrotechnical kits) lies in the procedural structure of thinking which includes a cognitive stage of the nature of analysis, as well as a creative stage of the nature of synthesis. In terms of content, concretised technical thinking is related to a certain form of substance (matter) and to technology. Various forms of substance (matter) and production technology, operations and methods, as well as results, creations, and works of human intellect constitute the specifics of this concretised thinking. The same substance (matter), though in different forms and with the application of different methods, has been a subject of study and described in theories, used in drafts, architecture, design, or instrumental music, among other things. Specifically oriented concretised thinking manifests itself in all of these incredibly diverse forms of creative activities.

The content of technical thinking – a broadly defined term – is divided as per different viewpoints. According to E. Franus (Franus, 2003) recognises four types of technical thinking (similarly to W. Furmanek and W. Walat (Furmanek & Walat, 2002)) which, in our view, are fully apparent in the relationship to electrotechnical kits:

- practical thinking, simple routine activities controlled by thought – manipulative thinking – assembly and disassembly of technical devices, discovery–diagnostics, inspecting new products;
- visual thinking, reproductive thinking – reading technical drawings;
- intuitive thinking, improving existing structures or creating new ones;
- conceptual thinking, based on systems of terms or technical categories which are present in explanations, evidence, and planning.

A natural, important tool for developing technical thinking can be found in resolving technical issues (Kraszewski, 2001), (Tureková, Gašpercová, Brečka, & Valentová, 2017) which is both a means and an end of teaching, regardless of whether these issues are of a cognitive or application nature - a similarity between the problem-solving procedure and the process of producing or using technical equipment (i.e. technological process).

3 Conclusion

A huge boom of technical sciences helped scientific knowledge to spread considerably, greatly affecting all areas of society and impacting the way of life of any individual. It is only natural that all this must be echoed in school education, especially as it pertains to natural-scientific subjects.

Understandably, a content analysis of the education process is the best way for an educator to learn about the optimum options of choosing suitable education methods and forms, including adequate training aids, but also education programmes and didactic technical equipment. Using training aids for teaching, educators creatively apply the rule of illustrative nature, and thus increase pupils' interest in technical subjects as well as develop their concentration and participation in work. This helps ensure that a theoretical subject matter is permanently acquired.

References

Fontana, D. (2017). *Psychologie ve školní praxi : Příručka pro učitele.* Praha: Portál.

Franus, A. E. (2003). The Dual Nature of Technical Thinking. *In Technology as a challenge for school curricula.The Stockholm Llibrary of Curriculum Studies.* Stockholm: Institut of Education Press.

Furmanek, W., & Walat, W. (2002). *Przewodnik metodyczny dla nauczycieli techniki-informatyki.* Rzeszów: Wydawnictwo Oświatowe FOSZE.

Grecmanová, H., Urbanová, E., & Novotný., P. (2000). *Podporujeme aktivní myšlení a samostatné učení žáků.* Olomouc: Hanex.

Hill, B. P., & Meier, B. (2004). Technisches Denken: Theoretisches Durchdringen und praktisches Bewältigen der gemachten Welt. *Unterricht - Arbeit + Technik*.

Kraszewski, K. (2001). *Podstawy edukacji ogólnotechnicznej uczniów w mlodszym wieku szkolnym.* Krakow: Wydawnicztwo Naukowe Akademii Pedagogicznej.

Kropáč, J. (2004). K problému uceleného pojetí výuky obecně technických předmětů. *e-Pedagogium*.

Kropáč, J., & Plischke, J. (2009). Porozumnění technice v přípravě učitelů obecně technických předmětů. *XXI. DIDMATTECH 2008.* Komárno: Univerzita J. Selye.

Látal, F. (2018). *Výhody vzdáleně ovládaných experimentů (on-line)*. Retrieved from Vzdáleně ovládaná laboratoř: http://www.ictphysics.upol.cz/remotelab/vyhody.html

Levert, C., & Piere, S. (2003). Towards a Design Methodology for Distributed Virtual Laboratories. *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2000.* Stockholm: Institut of Education Press.

Nezvalová, D. (2005). *Konstruktivismus a jeho aplikace v integrovaném pojetí přírodovědného vzdělávání.* Olomouc: VUP.

Nezvalová, D. (2010). *Inovace v přírodovědném vzdělávání.* Olomouc: VUP.

Serafín, Č. (2018). *Illustrative Electrical Engineering in the Primary School Curriculum.* Olomouc: VUP.

Stoffa, J. (2000). *Terminológia v technickej výchove.* Olomouc: VUP.

Tondl, L. (1998). *Technologie myšlení a usuzování: kapitoly z filozofie techniky.* Praha: Filosofia.

Tureková, I., Gašpercová, S., Brečka, P., & Valentová, M. (2017). Risk management applied in terms of practical training at university. *11th International technology, education and development conference INTED 2017.* Valencia: IATED.

Vaněček, D. (2016). *Didaktika technických odborných předmětů.* Praha: ČVUT.

Vašutová, J. (2001). Kvalifikační předpoklady pro nové role učitelů. *Učitelé jako profesní skupina, jejich vzdělávání a podpůrný systém.* Praha: VUK.