

## A CONSTRUCTIVIST APPROACH IN ENGINEERING EDUCATION

**Baiba Briede**

Latvia University of Agriculture

baiba.briede@llu.lv

**Abstract.** A constructivist approach in education means a paradigm shift from instruction to learning emphasis based on an active self-constructed acquiring of knowledge, skills and competence. Therefore the aim of the article is to substantiate the principles of the constructivist approach in engineering education. The concept of constructivism and its principles in relation to the knowledge society which involves the intersection of related trends (the development of: information societies; IT and innovations; service economies; knowledge management; globalization, changes in demographic structures and in cultural practices, and environmental affairs) and UNESCO five pillars of education for sustainable development (to know, to do, to live together, to be, to transform oneself and society) are noted. Cognitive strategies of teaching/learning such as cooperative, exemplary and PBL which promote students learning to control their own learning and enhance student achievement, and develop students ability to learn independently are noted. Assessing of learning outcomes, the role of a lecturer and environment are noted from a constructivist perspective as well. A research method is a triangulation among conceptions of constructivism in higher education, the knowledge society trends and UNESCO five pillars of education for sustainable development for implementation of constructivist ideas in engineering education. The main result is that the study reflects a correlation among features done by the triangulation method, and it is reflected in the principles of constructivism of engineering education. The main conclusion of the study is that the constructivist approach perspective has to be related to the knowledge society developmental tendencies with the emphasis on students' learning skills.

**Keywords:** a constructivist approach in engineering education, the knowledge society, pillars of education for sustainable development.

### Introduction

A constructivist approach in education has been developed on the basis of the paradigm shift from instruction to active, conscious, purposeful learning. Self-constructed acquiring of knowledge, skills and competence is in the center of the approach. The essence of the constructivist approach is reflected in the following features: motivated, meaningful learning based on a previous experience; activity; self-constructed knowledge, skills and competence; a teacher as a facilitator and counselor; positive and supportive learning environment. Therefore the constructivists support a perspective that for each individual the most important is knowledge which is developed meaningfully by the individual based on his/her experience. Constructivists do not support imposition of knowledge when a student is a passive receiver of information.

Several theories of constructivism have developed on the basis of a constructivist approach.

Cognitive, radical, social, cultural and critical constructivist theories are the best known ones. They have common features however they have slightly different theoretical origination and features peculiar only to one theory. As regards engineering education and constructivist approach relation in the 21<sup>st</sup> century cognitive constructivist theory dominates in it.

Notion of coherence between the knowledge society and pillars of education for sustainable development (ESD) helps to highlight the importance, pluses and minuses and things to develop in relation to constructivist theories and assess the necessity of their usage in engineering education. It means usage of constructivism theories through cooperative, exemplary and problem based learning (PBL), projects and other strategies by means of which students construct knowledge and skills to the previous experience meaningfully. The students develop their ability to control their own learning, improve learning skills and assess their learning outcomes.

### Materials and methods

A research method is a triangulation among the knowledge society trends, five pillars of education for sustainable development and conceptions of constructivism in higher education for substantiation constructivism principles in engineering education. The main result is that the study reflects a correlation among features done by the triangulation method and it is reflected in the principles of constructivism of engineering education.

The knowledge society trends and five pillars of education for sustainable development are extracted from UNESCO documents and materials from The Second World Summit on the Knowledge Society.

The principles of constructivism of engineering education are concluded from nowadays constructivists' works and conceptions from the authors of previous centuries.

### Results and discussion

Sustainable development perspective is a challenge for nowadays societies because values promoting sustainability have to be implemented in all aspects of life. It means learning to think critically and taking a responsibility of creating common future both in a family and larger communities. It means further development of knowledge societies where knowledge is shared and diversity accepted. "A knowledge society is a society that is nurtured by its diversity and its capacities" [1]

The knowledge society comprises technological, social, ethical, political, economic, cultural, linguistic aspects in their diversity. Therefore such a society has to be human – centered and involved in all the aspects actively. According to this perspective "...the main resources are focused on promotion of each individual's intellectual curiosity, creative thinking and cognitive capacity" [2].

Co-operation among countries for creating and sharing knowledge and increasing welfare is a process promoting the development of humanistic and sustainable knowledge society. The conception of inclusive knowledge society means involvement of all society's groups in the process implementing transmission of knowledge in interaction among science, practice and everyday life activities. So this process can help to keep democratic values and increase a level of knowledge of our societies.

The Second World Summit on the Knowledge Society [3] emphasized 11 important aspects for nowadays:

- information technologies – knowledge management systems – e-business and business, organizational and inter-organizational information systems for the knowledge society;
- knowledge, learning, education, learning technologies and e-learning for the knowledge society;
- social and humanistic computing for the knowledge society – emerging technologies for the society and the humanity;
- culture and cultural heritage – technology for culture management – management of tourism and entertainment – tourism networks in the knowledge society;
- e-government and e-democracy in the knowledge society;
- innovation, sustainable development and strategic management for the knowledge society;
- service science, management, engineering, and technology;
- intellectual and human capital development in the knowledge society;
- advanced applications for environmental protection and green economy management;
- future prospects for the knowledge society: from foresight studies to projects and public policies;
- technologies and business models for the creative industries.

There is a significant part of technological development in the aspects of the knowledge society and therefore they can serve as guidelines for improvement engineering education programs keeping them with conformity with the developmental tendencies of society and professional and social competence of future engineers.

The aspects of the knowledge society relate to the UNESCO five pillars of education for sustainable development because a human-centered approach for sustainable development of the society are in both the aspects and the pillars. Five pillars of ESD "...supporting five fundamental types of learning to provide quality education and foster sustainable human development, namely" [4]:

- **learning to know:** to recognize the evolving nature of the concept of sustainability; to reflect the ever-growing needs of societies; to acknowledge that fulfilling local needs often has international effects and consequences; to address content, context, global issues and local priorities;

- **learning to be:** to build on the principles and values that underline sustainable development; to deal with the well-being of all three realms of sustainability – environment, society, and economy; to contribute to a person’s complete development: mind and body, intelligence, sensitivity, aesthetic appreciation and spirituality;
- **learning to live together:** to build capacity for community-based decision making, social tolerance, environmental stewardship, adaptable workforce and quality of life;
- **learning to do:** to contribute to a concrete reality for all our daily decisions and actions; to build a sustainable and safe world for everyone;
- **learning to transform oneself and society:** to integrate the values inherent in sustainable development into all aspects of learning; to empower people to assume responsibility for creating and enjoying a sustainable future [4].

Looking for coherence with the knowledge society aspects and 21st century’s ideas for ESD with constructivists’ ideas is one of the ways which can develop a constructivist approach in engineering education. Constructivism is one of the three learning metaphors since the end of the 19th century: learning as response strengthening (behaviorism), learning as the processing of information and learning as knowledge constructing (constructivism) [5].

Constructivism as an education approach explains how humans construct knowledge on the basis of their existing knowledge and necessary means for the development of information construction ability. The main idea of constructivism is that an individual constructs one’s own knowledge and learning outcomes are personally important for the individual. E. Von Glasersfeld [6] substantiated that knowledge is the result of active cognizing and it is an adaptive process in relation to a particular environment and behavior, and one’s experience is crucial in this process.

Constructivists emphasize the ability to construct knowledge and their perspective is abandoning transmission of information from a teacher to a student. “.the art of teaching then consists in the skill with which messages devoid of ambiguity are transmitted, the art of learning in the ever-increasing skill with which a receiver extracts the meaning of the message picked up by his her apparatus” [7]. Therefore it is student-centered learning with a crucial emphasis on learning skills.

Constructivism ideas are reflected in its definitions, e.g. as “A theory of learning that describes the central role that learners' ever-transforming mental schemes play in their cognitive growth, constructivism powerfully informs educational practice” [8].

Constructivism has its roots in previous theories of education. It is worth mentioning J. Dewey’s [9] conceptions in coherence his between thoughts of democracy and pupils’ future development reveal that education promotes both getting of content of knowledge and learning to live. Individuals need a chance to reveal their own potential in learning process. J. Dewey notes that “With the advent of democracy and modern industrial conditions, it is impossible to foretell definitely just what civilization will be twenty years from now. Hence it is impossible to prepare the child for any precise set of conditions. To prepare him for the future life means to give him command of himself; it means so to train him that he will have the full and ready use of all his capacities “ [9].

Cognitive constructivism is a leading constructivism theory in engineering education. The basis of cognitive constructivism is J. Piaget’s cognitive developmental theory with conceptions of assimilation and accommodation and construction of knowledge through experience considering learning as an active and adaptive process. Knowledge is in external reality and an individual has a capacity to get to know it [10; 11].

Cognitive constructivism emphasizes whole, authentic, realistic learning. The choice of learning strategies relates to discovery, experiential, collaborate, project-based, tasked-based, etc. learning. Interaction has to be in meaningful ways with the world around the participants of the learning process. Less emphasis is on directly teaching specific skills and more emphasis on learning in a meaningful context. Cognitive constructivism approaches learning from the perspective of the individual and therefore previous experience is crucial. P. E. Doolittle and W. G. Camp [12] on the basis of constructivism analysis substantiated essential factors of constructivist pedagogy: learning should take place in authentic and real-world environments; learning should involve social negotiation and mediation; content and skills should be made relevant to the learner; content and skills should be understood within the framework of the learner's prior knowledge; students should be assessed

formatively, serving to inform future learning experiences; students should be encouraged to become self-regulatory, self-mediated, and self-aware; teachers serve primarily as guides and facilitators of learning, not instructors; teachers should provide for and encourage multiple perspectives and representations of content.

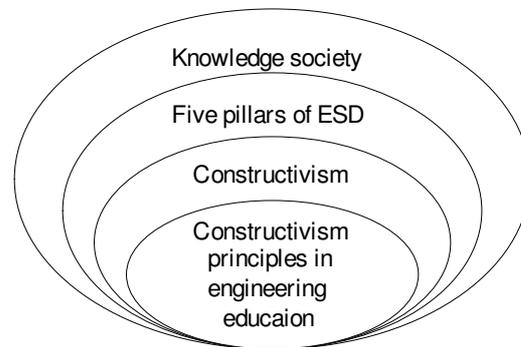


Fig. 1. **Constructivism principles in engineering education in coherence with constructivism, five pillars of education for sustainable development (ESD) and the knowledge society**

Conclusions from a constructivism approach conceptions, five pillars of ESD and aspects of the knowledge society allow to substantiate **constructivism principles of engineering education**. The principles of constructivism reveal its relevance and reflect didactic perspective of the engineering education:

- **learning occurs by merging new information with a learner's prior experience and information technologies** as information management systems;
- **learning is an active social process** and a significant part of it occurs through interaction with a lecturer and students, and it is learning together in one community where each student has a possibility to develop his/her potential creating personal knowledge and social competence consciously;
- **learning is contextual** because students learn in coherence with their experience, prejudices, fear, views, etc., therefore learning is a social process and a part of their life, and success and mistakes are a feature of learning;
- **motivated learning when students find the meaning** of learning themselves in coherence with the essence of the course information;
- **students understand the "gap" between their actual knowledge and new knowledge they need to reach** and this cognitive dissatisfaction is an internal drive to reach a higher level of knowledge;
- **students have rights to express their opinions independently from their learning experience** therefore fostering their accommodation and assimilation process and explain new material in their own words as well as promote understanding of the knowledge society aspects and values such as environment and green economy protection and management, "technologies and business models for the creative industries" [3];
- **a lecturer has a role of a facilitator, coach, motivator and democratic style dominates in studies** to create a need for new knowledge; the lecturer facilitates "significant restructuring of existing cognitive structures, successful learning requires a major personal investment on the part of the learner" [14];
- **much learning occurs through particular situations** by means of PBL, cooperative, exemplary, discovery, projects, etc. strategies **with an emphasis on learning by doing** promoting innovation, critical thinking, social and professional competence in the context of "intellectual and human capital development in the knowledge society" [3];
- **various kinds of evaluation as one of the means of developing critical thinking** is a part of a learning process: a lecturer-student, student-student and self-evaluation;

- **socially positive and updated learning environment** as learning technologies and e-learning “emerging technologies for the society and the humanity” [3] is an important factor for qualitative studies;
- facilitating students to monitor their learning process is an important means to develop their **learning skills which is a crucial feature for successful process of knowledge construction and involvement into the labor market**; employers note the capacity to learn as the most important generic competence for the university graduates [13].

## Conclusion

1. Constructivism principles of engineering education comprise learning, students, lecturers, strategies, relations, motivation, evaluation, environment and learning skills aspects in favor of the humanistic knowledge society where education for sustainable development of society is promoted.
2. Constructivism principles of engineering education show that there is a great deal of hopefulness in the capacity of individuals and entire systems to meet the challenges of the future, and they could serve as a means of the 21<sup>st</sup> century engineering education improvement.
3. Learning skills are crucially significant in engineering education necessary to implement constructivism approach principles for the development of the knowledge society including professional competence, critical thinking, problem solving and co-operation skills which help to keep successfully in the labor market as well.

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