Problem-based chemistry teaching

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This article discusses the possibilities and challenges of carrying out chemistry teaching, with the help of problem-based learning (PBL). It is possible to bring out the utility of applying problem-based learning in laboratory work in higher education of chemistry. The developed activities in environmental chemistry support the promotion of teaching about sustainable development.

Problem-based learning (PBL) is one alternative for a meaningful realization of chemistry teaching. It has been used widely in higher education both in Finland and abroad, especially in medicine (e.g. Aarnio, Nieminen, Pyörälä & Lindblom-Ylänne, 2010; Ram, 1999) and in biochemistry (e.g. Dods, 1996). In chemistry teaching, a problem-based method of learning has been in use among students working on their basic degree studies (e.g. Cancilla, 2001; Dolmans & Schmidt, 1996; Ram, 1999).

Problem-based learning is a pedagogical approach (Perrenet, Bouhuis & Smits, 2000) in solving practical problems (Kelly & Finlayson, 2009), where communal problem solving is emphasized and it builds a connection between learning and observations (e.g. Dolmans, De Graeve, Wolfhagen, & Van Der Vleuten, 2005; Girault et al., 2012).

In problem-based learning, a student's activity in data acquisition, interaction between a group, learning requirements determined by the group, a personal experience in learning, coordination and the role of the teacher shifting into the instructor, are emphasized (Vesterinen, 2001; Väisänen, 2000).

Differing from the traditional way of learning, problem-based learning tries to avoid learning things by heart. Its aim is to also develop learning skills, and in problem solving, students' prior knowledge is exploited and new information is searched (Boud & Feletti, 2000; Engel, 1997; van Kampen, Banahan, Kelly, McLoughlin, & O`Leary, 2004).

A problem-based way of learning teaches us to solve real life problems, instead of just theoretical handling. At the same time, understanding of the specific thing, the ability to plan one's own learning as well as attitude towards own learning is developed (Capon & Kuhn, 2004; Poikela & Poikela, 2005; Williams, Woodward, Symons, & Davies, 2010).

The benefits and possibilities of problem-based teaching

Problem-based teaching answers better to the needs of the working life (Woelk, 2008) than the traditional lecture teaching and it is thought of as a more motivational way to learn. Problem-basedness also develops a student's ability to solve problems (Boud & Feletti, 2000; Norman & Schmidt, 2000; Woltering et al., 2009).

Through good guiding, problem-basedness creates a possibility to do co-learning, where the learners can be there to support each other during the entire learning process (Poikela & S. Poikela, 2005). The development of skills in group work is thought of as one of the best sides of the problem-based way of learning. With the help of active discussions in group work, learners are able to learn better. The learners can freely tell about their own ideas and opinions, without having to be afraid of being wrong. Problem-based learning has been observed to develop the ability to acquire and use data (Margetson, 1991; Kelly & Finlayson, 2009; Ferreira & Trudel, 2012).

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Problem-based learning has been researched as a part of the laboratory work in chemistry in university of applied sciences and in university levels, where inquiry-based pupils' work in environmental chemistry, which supports sustainable development, was developed research-oriented (Rautiainen, 2012). It was observed in the research that a problem-based learning environment trains first year students in university of applied sciences into project-oriented work. When planning a learning environment for older students, however, the prior ways of learning should be taken into consideration. For university students, a problem-based, inquiry-based learning environment may bring a change to studying and to the practical problems in application. A problem-based learning environment has been observed to develop skills in team work as well (Koh, 2008) and the interest increases with solving practical problems (Kelly, Finlayson, 2007). Problem-based learning has increased university of applied sciences students' interest as well as increased motivation towards a studied topic (Ram, 1999; Renninger, 2000) and then the topic being studied sticks better into a student's mind.

Research-based development of higher education is needed. Good-quality higher education is student-centered (Nevgi & Lindblom-Ylänne, 2009) and it supports a student's deep-oriented approach (Biggs, 2003). It has to promote learning and know-how which aims at profound understanding (Lindblom-Ylänne & Nevgi, 2003). A problem-based way of learning as a student-centered way of learning promotes learning and know-how that aims at profound understanding (Capon & Kuhn, 2004; van Kampen et al., 2004; Väisänen, 2000).

In chemistry teaching, problem-basedness can be exploited in several different degrees. For example problem-based teaching material in teaching how to recycle plastics has been developed for upper secondary level teaching (Asikainen, 2016). In a university of applied sciences, it has been used in first year students', who are in the laboratory field, project work in the orientation to laboratory work. In university level chemistry teaching, problem-basedness has been a part of teaching of laboratory work in chemistry during the first year of university (Rautiainen, 2012).

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