

# Developing a meaningful chemistry learning environment in cooperation with industry

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*Learning environments outside of the classroom, context-based and a meaningful learning of chemistry are central themes in the new core curricula for basic education. Research-based approaches are needed in order to support these. This article introduces a design-based research in progress, where the aim is to develop the university laboratory ChemistryLab Gadolin into a meaningful visiting and learning environment with producing new context-based work instructions. Instructions have been produced in cooperation with companies, specialists and chemistry teacher students.*

Learning environments outside of classroom and study visits increase students' motivation and interest towards chemistry and develop teaching (e.g. Bell et al., 2009; Hofstein & Kesner, 2006; Dillon et al., 2006; Orion & Hofstein, 1991). In learning environments outside of classroom, it is possible to reach an authenticity that is not possible to reach in a classroom (Ruiz-Mallen et al., 2010).

According to Derek Hodson (1996), practical work and learning by doing have an important role in learning chemistry. The purpose of practical work is to learn the conceptual and theoretical knowledge of science, to understand the nature of scientific information and to give an opportunity to create science and to research. Aksela (2005) emphasizes in her research that meaningful learning of chemistry develops the higher levels of thinking, and increases students' motivation and interest towards chemistry. Real life situations motivate and bring relevancy and meaningfulness into learning about the contents of chemistry (Gilbert, 2006; Aikenhead, 1994). According to prior research, there is a great need for developing meaningful inquiry-based learning environments for chemistry. The attractiveness of chemistry in Europe as well as in Finland is quite low among adolescents (Kärnä, Hakonen & Kuusela, 2012; Lavonen, Juuti, Uitto, Meisalo & Byman, 2005). Generally, there are many negative images and prejudice connected to natural sciences and technology. This is explained by the fact that actual relevance of chemistry to an individual, society or professions is hardly recognized and different role models increase stereotypes. Chemistry researchers are seen for example as males, who are lonely workers and who work in an isolated workroom or a laboratory.

In hands-on teaching of chemistry in upper secondary level, a challenge for the teachers is the lack of resources in Finland. According to Aksela and Karjalainen's (2008) research, additional support is needed for facilities, tools and materials. Also group sizes and limited time are challenges. Montonen (2007) observes in her research that opportunities in carrying out practical work vary in a wide margin in different upper secondary schools in Finland. According

to Lavonen et al.'s (2005) research, the one-sidedness of assessment methods and approaches affect students' post graduate studies.

### **Answers to a problem with design-based research**

In a design-based research started in 2013, relevant and meaningful learning activities of upper secondary school chemistry that are related to everyday chemistry are produced with the collaboration of specialists from the chemical industry. Activities have been developed for visit outside of classroom to a chemistry laboratory learning environment. The study visits consists of beforehand and afterwards assignments, hands-on work in the laboratory, research group visits and using modern tools in authentic environments as well as increasing the relevance of practical work. Students and teachers' needs and the contents concerning practical work in upper secondary level chemistry textbooks have been used as background for the development work (Ikävalko, 2015).

### **Cooperative development**

Finnish chemical industry companies were chosen for the research, because specialists represent the real life of today's research and production of industry. In addition, chemistry teacher students participated in the development work. The work instruction's subject level was defined as upper secondary level, because it especially focuses on the learning contents of the learning environment's technical laboratory devices, as well as teaching ICT in chemistry. ChemistryLab Gadolin is the developed learning environment, which is located in the Department of Chemistry in the University of Helsinki and is part of LUMA-centre Finland (see <http://www.kemianluokka.fi>; Aksela & Pernaa, 2009).

The research follows the principles of Edelson's (2002) design-based research. Design-based research answers to the criticism, where it is not possible to offer practical research information to teachers working in the field. Design-based research always starts from an actual need for development (Pernaa 2013). According to Collins et al. (2004), design-based research is an effective tool for developing teaching and it was created to answer to the central needs for researching science education:

- the need to answer to theoretical questions and context-based learning
- bringing real life examples and approaches into research on teaching
- the need to extend the narrow area of learning
- the need to support evaluation

## **A meaningful learning environment for chemistry**

A meaningful learning environment for chemistry is a learning environment defined in the design-based research, which is 1) diverse, 2) relevant and 3) where it is meaningful to study in:

1. A diverse learning environment: by diverse, it is meant Manninen et. al.'s (2007) division of learning environment into five different classes:

1. a physical learning environment (facilities or a building, e.g. the furnishings of a classroom and the seating order)
2. a social learning environment (communication and interaction)
3. a technological learning environment (teaching technology e.g. gauges, software used)
4. a local/regional learning environment (places outside of school e.g. workplaces, the forest, a university campus)
5. a didactic learning environment (actions that support learning and teaching materials e.g. working instructions for practical work, hand-outs, slides).

2. A relevant learning environment: according to Stuckey, Hofstein, Mamlok-Naaman, & Eilks I. (2013) a relevant learning environment consists of contextual contents of learning situations, which have a connection to everyday life on the personal, societal and working life levels.

3. A learning environment for meaningful learning: According to Ausubel (1960), meaningful learning is relevant for students. According to Novak (2002), meaningful learning supports students' independent ability to learn new things. Non-formal learning situations have been observed to increase a student's self-assurance (Tolppanen & Aksela, 2013). In addition, it has been observed that these situations improve students' attitudes and motivation (Pedretti, 2002). As well, in these learning situations students have a better understanding of connections between everyday life and science (Goldman, 2013).

## **New courses of action and ideas for teaching**

On study visit to ChemistryLab Gadolin, teachers motivate students towards learning chemistry, to learn new approaches and possibility to observe students during work. One of the most important things, especially in the upper secondary level, working with laboratory equipment that are not to use in schools (Ikävalko, 2015). Other important benefits are supporting teacher's work, raise relevance and use computer-based technology. ChemistryLab Gadolin is a modern learning environment, which has been designed to support students and teachers in chemistry teaching and to promote relevance in society, between working life and chemical industry, Gadolin's principle is based on the Finnish National Core Curriculum for Basic Education and as well on newest research on chemistry teaching.

The aim of Gadolin is to promote a positive image of chemistry. Especially, how we can solve challenges in the future with the help of chemistry. The purpose of the chemistry class is also to encourage students from every level towards studies on chemistry and to support teachers in their work. Yearly, more than 4000 children and adolescents visit the ChemistryLab Gadolin. This laboratory class is open to all school levels and visits are free of charge.

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**Specialization:** children and adolescents' science actions, field trips to facilities outside of class, meaningful and relevant active teaching of chemistry, safe working in the laboratory, the storing of chemicals in schools as well as management of waste. The topic of the doctoral dissertation concerns research-based development of working instructions and field trips in cooperation with companies.

## Publications on this study:

- Ikävalko, V.-M. (2015). Design-Based Research on Meaningful Chemistry Learning Environment: *Context-based experimental work development with industry collaboration* (Licentiate thesis). [http://www.helsinki.fi/kemia/opettaja/ont/ikavalko\\_V-M\\_2015\\_lisensiaatintutkielma.pdf](http://www.helsinki.fi/kemia/opettaja/ont/ikavalko_V-M_2015_lisensiaatintutkielma.pdf)
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