ENVIRONMENTAL EDUCATION AND TRAINING USING INQUIRY-BASED LEARNING

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Abstract

Inquiry-based learning (IBL) as inductive teaching method has originated in late 1960's. IBL is student centred learning process where teacher is only a mentor / instructor and offers help when is needed. Individuals actively construct their knowledge by solving real and authentic problems and searching appropriate information. Students build their knowledge on the base of their prior knowledge using critical thinking, reasoning and problem solving skills. The role of teacher is very important at giving correct feedback. Project STRENGTH focuses on different green competence areas where acquiring of green competences considers knowledge, skills and wider competences. This paper is focused on environmental, health and safety area with a central impact of environmental education. In Primary and Secondary education students familiarize with green competences, but to a lesser extent. Project Chain Reaction makes effort to promote and to exploit IBL method to science and technology including teaching green topics. Since 2013 Faculty of Education at University of Ljubljana organizes teaching and learning of green subject matter designed for a three-day activity open learning course. Courses are aimed for learning of environmental protection and of renewable energy sources. Students were tasked with one of the following topics, namely: water turbine optimization, green heating, plants in space and smart electric car. The sample of study consists of 250 eighth- and ninth-grade students. IBL was guided by modified 5E learning cycle model, where students' satisfaction with IBL was assessed when learning was accomplished.

Keywords: inquiry based learning, technology days, green competences, students' attitude

Introduction

A “green” economy (smart energy & environment) generates jobs, businesses and investments while expanding clean energy production, increasing energy efficiency,
reducing greenhouse gas emissions, waste and pollution, and conserving water and other natural resources [1]. The green economy offers enormous opportunities for job creation, many of which are already underway in the European economy. These opportunities range from sectors traditionally associated with an environmental content - such as renewable energies or recycling - to other activities that represent emerging sectors in green jobs - such as sustainable mobility - and to activities in "established sectors" which have potential for conversion into sustainable activities. The importance of emerging green sectors can be seen in the additional benefits they have brought to the European region [1].

There are many ways to define “green” or the “green economy”. The following definition is condensed from the many definitions that have been offered. Common terms and concepts are evident in each of these definitions. For example, the words renewable, sustainable, education, compliance, and efficiency are used by all organizations.

The world strongest / most competitive economy of USA defines green economy activity as [2]:

Green or clean is any activity or service that performs at least one of the following:

- **Generating and storing renewable energy,**
- **Recycling existing materials,**
- **Energy efficient product manufacturing, distribution, construction, installation, and maintenance,**
- **Education, compliance and awareness,**
- **Natural and sustainable product manufacturing.**

A very important green activity concerns with Education, compliance, and awareness. This sector includes [2]:

- Education and Training providers for curricula such as solar panel installation, photovoltaic, renewables, energy auditing, sustainability management, and environmental careers.
- Environmental consulting
A Green Job is an occupation that 1) directly works with policies, information, materials, and / or technologies that contribute to minimizing impact, and 2) requires specialized knowledge, skills, training, or experience in these areas [2].

Green jobs in Slovenia are not systematically monitored and are not defined. Most green jobs in Slovenia caused by only five factors: renewable energy, energy-efficient construction, waste collection and waste water management, organic farming, and public transport.

Nowadays, more and more students are educating and training for green jobs career. Number of narrowly defined green jobs number in Slovenia is very low. Green jobs in total are about 7250, what present just 1% of total employment, number of widely-defined green jobs but relatively comparable with other developed countries is 2% of total employment. A negative growth rate of general employment in Slovenia is indicated and has to be considered for future green jobs evolution [3]. Majority of the new green jobs are generated in sectors such as alternative energy sources, construction, centred primarily in the construction of energy efficient buildings (increase energy efficiency), transportation both in terms of car production to alternative energy sources, as well as an improvement in fuel efficiency, production and recycling eco-friendly products and agriculture and forestry, especially in the direction of sustainable development [4]. It is worth to highlight in this context.

Green restructuring generates demand for new skills as existing producers' reorientation activities towards new markets and products. Generally, skills needs are reflected in demand for additional competences of existing workers. Greening occupations also raises demand for new competences. While this is especially significant in the energy sector as a result of major investment and expansion in renewables and energy management subsectors (giving rise to new occupations), the main need is to revise and upgrade the skills of existing workers. These new environmentally driven competences relate to new technologies (such as solar power...
for electricity and heating, new vehicles on solar power, waste management, renewables exploitation) [1].

The European Union's new strategy for sustainable growth and jobs, Europe 2020, puts innovation and green growth at the heart of its blueprint for competitiveness. However, there are no explicit overarching national strategies targeting green skills needs [5]. Some Member States are moving faster than others to rectify this, with France launching its recent mobilisation plan for green jobs, and the UK government recently launching a consultation exercise, entitled Meeting the low carbon skills challenge. The EU suffers from systemic weaknesses in its skills base which limit its productivity and competitiveness in today’s economy, and reduce its capacity to exploit the opportunities offered by green growth. These deficits in management skills and technical job-specific skills (many of which are related to science, technology, engineering and mathematics are a greater concern than shortages of “new” green skills [5].

Young population in Slovenia has very low interest for enrolment in upper secondary vocational education and training (VET) programmes (STE - secondary technical education; VTE - vocational technical education; SVE - secondary vocational education). A constant drop of enrolment was identified from 15.8% population in 2007 / 2008 to 11.7% in the year 2011 / 2012. This drop is particularly noticeable in occupations of construction sector (e.g., only 4 bricklayers and 6 carpenters started the initial education in 2011) while the enrolment in the programmes of mechanical technician and fitter of mechanical installations dropped only moderately. The upgrade of curricula in initial VET is important but it cannot have a major impact on improvement of Energy Efficiency (EE) competences of blue collar workers that are on the labour market.

European Commission runs several activities and initiatives to promote Science and Technology subject matter, also considering green competences. One of them is a Chain reaction project of the Seventh frame program. As a core partner in this project, Faculty of Education at university of Ljubljana is involved since 2013. The project lasts for three years and covers several European countries (UK, Italy, Slovakia, Bulgaria, France, Germany, Greece, and Ireland) and Jordan, Turkey and Georgia. The purpose of the project is to confirm the IBL as an effective method for teaching Science and Technology. Learning content includes environmental education, science and technology. Students learn and develop attitude toward environment and renewable
energy sources. Furthermore, students develop a variety of skills which include problem-solving skills, teamwork, organization, communication and research [6]. In school year of 2013 / 2014, a three-day course was implemented at five secondary schools around Slovenia where eighth- and ninth grade students were recruited. A course format engaged five periods of IBL a day. At each school four green topics were performed, namely: Green heating, Plants in space, Water turbine and Smart electric car.

This paper presents the research which was carried out under the project Chain Reaction. The purpose of the research was to determine students' satisfaction toward the IBL and green subject matters. Perceived students' satisfaction is one of the measures of course quality and green competences acquiring [7].

**Inquiry-based learning**

IBL is constructivist and student-centred teaching method where participants actively construct their knowledge [8]. IBL is process in which students poses a questions, develop an experiment, collect and analyses data, answer the question, and present the results [9]. Method inspires students to engage in an authentic scientific discovery process. Method is useful at all levels of formal education, from Primary to Secondary school and universities. This method can be applied flexibly across different educational contexts. Tasks, designed to provide inquiry, include problem which students have to solve it. Students work collaboratively and co-operatively with peers [10]. IBL begins when students are presented with questions to be answered and problems to be solved [11]. IBL emphasises higher order thinking skills, critical thinking and problem-solving skills which are more important than simply knowing the content itself. It develops logical thinking skills, responsibility for learning and critical thinking. The teacher, who has very important role in learning process of IBL, helps students to learn the cognitive skills needed for the inquiry, problem solving and collaboration. The teacher serves as facilitator, working with student groups and help students to make connections between their ideas and relate these to important scientific concepts and methods. Students are self-directed and managing their learning goals and strategies but they are not left alone in their discovery. They are guided by a teacher who supports them [10, 11]. The method involves students discussing questions and solving problems in class, with much of the work being done by students working in groups [11].
In the literature, there are several types of IBL which differentiate depending on the levels of inquiry [10, 11, 12]:

- Confirmation inquiry-teacher provide tasks, questions and procedure for solving problems.
- Structured inquiry-teacher give a problem to students and an outline for how to solve it.
- Guided inquiry- teacher give a problem, students have to figure out the solution method.
- Open inquiry-students formulate the problems and search for solutions.

Activities and materials have to be close to the students. This facilitates students to learn through inquiry. Success of IBL is guaranteed if activities of IBL are based on the skills level of the students. In this process, students often carry out a self-directed, partly inductive and partly deductive learning process by doing experiments [12, 13].

Instruction in IBL begins with content and experiences likely to be familiar to the students, so they can make connections to their existing knowledge structures. New material should be presented in the context as real-world applications. Instruction should involve students working together in small groups [11]. Several meta-analyses conclude that IBL is more effective than traditional instruction. IBL improves academic achievement, critical thinking skills, laboratory skills and cognitive learning outcomes, which includes conceptual and subject learning, reasoning ability, and creativity [11].

IBL is applicable at all levels of formal and non-formal education and training, from infant schools to universities, and takes place in informal as well as formal learning contexts. Inquiry learning can be applied flexibly across different educational contexts, across all academic disciplines. There is no single design protocol and teaching strategies vary. However, the fundamental point of departure is always an authentic question or problem that may be formulated by students themselves, their teachers, or others. Tasks designed to provide a framework for inquiry include problem or case scenarios, field-work investigations, experiential learning projects and laboratory experiments as well as research projects of various kinds. Students' inquiries may be small or large in scale, involving whole-cycle research projects or only specific elements of a larger research process. Often working collaboratively or co-operatively with peers, sometimes in partnership with teachers, students are
supported by teachers and others with specialist educational roles (e.g., role models, learning technologists) to apply the scholarly and research techniques of their academic or professional discipline [10].

**Green technology days**

In Slovenia, children aged 6-15 attend nine years of compulsory primary school education. This is divided into two levels: the primary level for children aged 6-11 and lower secondary school for children aged 12-15. Students at Secondary school mostly acquire technology / engineering-related green competences using traditional instruction at Design and technology and Physics subject matter. Beside this, there are several summer schools and camps which offer an excellent opportunity to learn about green technology and other environmental issues. In Slovenia, we have also the possibility that similar content can be introduced through compulsory technology days. Since 1999, these activities have been integrated into all grades of the primary school curriculum. Three technology days are scheduled for the first triad, and four days for the successive triads in each school year. Each technology day has five periods of 45 minutes each, which cover elective topical content from the field of technology / engineering education. These activities have no specific learning objectives verified by a teacher, but play an important role in terms of integration of cross-curricular skills and upgrading students' knowledge with practical experiences [14].

On the other hand, technology days are also aimed to conduct active teaching / learning of those topics which claim more time for entire learning cycle. Active and constructivist approaches (e.g., project-based learning, experiential learning, and research-based learning) are very often conducted through technology days.

In our study, school technology days were carried out on the basis of IBL; all activities were aligned with 5E model which covers five phases [8, 15]:

1. **Engagement:** Teacher helps students become engaged in a new concept using short activities that promote curiosity and elicit a prior knowledge. The activity make connections between past and present learning experience, organize students' thinking and expose prior conceptions [15]. At the school activity days teacher assessed students' prior knowledge and motivated students. Teacher presented problem statement and research questions.
2. **Exploration:** Exploration experiences provide students with a common base of activities. Students generate new ideas, explore questions and possibilities, and design an investigation [16]. At the school activity day students in this phase looking for evidence and ideas with brainstorm 635 method.

3. **Explanation:** Student's attention is focused on a particular part of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding and process skills. Learners explain their understanding of the concept [15]. At the school activity days students testing hypothesis and ideas from exploration phase. After that, students construct scientific knowledge.

4. **Elaboration:** Students develop deeper and broader understanding, more information, and adequate skills through new experience. Students apply their understanding of the concept [15]. At the school activity day students in this phase resolved misconceptions and pitfalls. Students had to write reports and present to their teachers and other students.

5. **Evaluation:** Students assess their understanding and abilities. Teachers evaluate student progress [15]. At the school activity days in evaluation phase students make a reflection at their work and assess their progress.

This 5E model of IBL was used at each green topic which will be described in continuation.

**SMART ELECTRIC CAR.** The use of electric vehicle is increasingly growing, so it is important that students become familiar with this topic. Students composed cars with Fischertechnik (Figure 1). They combined electrical, mechanical engineering, and computer science. Students in pairs made their model of mobile robot, where checked the use of different sensors. After that, every student proposes solution to increase efficient use of electric vehicle, especially in the field of various options to charge the battery. Then, in group of five, students produced their solution for filling battery electric car. Students presented their solutions to their classmates [14].

**WATER TURBINE.** The learning process based on the work in small groups of 3-4 students. Students were investigating existing water turbine models and then conceiving parameter of turbine to achieve the best efficiency. Parameters were different: blade cross section, diameter, number of blades, angle between blades, and blade size. Students created their model of a turbine with their key parameter, other
parameters were constant. Groups tested their turbines and wrote results (Figure 2). After stabilisation of understanding, each group wrote a final report [10].

![Smart electric car](image1)

**Figure 1. Smart electric car**

![Water turbine](image2)

**Figure 2. Water turbine**

**GREEN HEATING.** Students carried out simple investigations to find out which colour and type of surface is best for absorbing infrared radiation so that it can be used in a solar panel (Figure 3). Before investigation, students were given information about solar panels and about infrared radiation from the Sun. The teacher should issue the students with the Student Activity Sheet which also acts as a checklist so that they
can monitor their progress; then hand out Green Heating to the students. This gives information about how solar panels use infrared radiation from the Sun to heat up water. The Activity requires students to carry out an investigation concerned with the type of surface that absorbs infrared radiation best. At the beginning of investigation students should submit their plans for approval and they carried out the investigation. They analysed evidence in groups, wrote conclusions and evaluated evidence.

![Figure 3. Green heating](image-url)
PLANTS IN SPACE. Students were asked to carry out investigations into various aspects of photosynthesis, to work out what plants could best be used in the life-support system, and into human physiology to work out what needs a crew would have for oxygen and food on the journey (Figure 4).

Figure 4. Plants in space

A note at the end of the Student Activity Sheet asks for any further suggestions for investigative work. Students may suggest testing a range of food plants to see which ones are the most efficient at photosynthesising. This may not produce conclusive results, but it could be a worthwhile experiment to try - if only to show that sometimes scientists do not get definite answers. One possible approach would be to illuminate various food plant leaves (as fresh as possible) in a closed environment with a CO2 indicator.
Methodology

The sample, instrumentation, and procedure of data collection and analysis are described in the following sections.

Sample

The sample in this study was drawn from Lower secondary school students and comprised 260 eight- and ninth grade students aged 13-14. Gender was nearly evenly distributed with 53.8% females and 46.2% males. School activity days were carried out at five Slovenian schools (Table 1).

Table 1. Schools information and students’ distribution

<table>
<thead>
<tr>
<th>School name</th>
<th>Percentage of participants</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>OŠ Ketteje in Murna, Ljubljana</td>
<td>16.9 %</td>
<td>44</td>
</tr>
<tr>
<td>OŠ Mokronog</td>
<td>16.5 %</td>
<td>43</td>
</tr>
<tr>
<td>OŠ Ivana Cankarja, Vrhnika</td>
<td>19.6 %</td>
<td>51</td>
</tr>
<tr>
<td>OŠ Antona Tomaža Linharta, Radovljica</td>
<td>20.8 %</td>
<td>54</td>
</tr>
<tr>
<td>OŠ Davorina Jenka, Cerklje na Goreniskem</td>
<td>26.2 %</td>
<td>68</td>
</tr>
</tbody>
</table>

Students were randomly tasked with one of four topics (Table 2).

Table 2. Students’ distribution across green topics

<table>
<thead>
<tr>
<th>Green topic</th>
<th>Percentage of participants</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants in space</td>
<td>16.2 %</td>
<td>42</td>
</tr>
<tr>
<td>Water turbine</td>
<td>25.0 %</td>
<td>65</td>
</tr>
<tr>
<td>Smart electric car</td>
<td>25.8 %</td>
<td>67</td>
</tr>
<tr>
<td>Green heating</td>
<td>33.1 %</td>
<td>86</td>
</tr>
</tbody>
</table>

Lower secondary schools recruited in this study were carefully selected by role models (university scientist, applied science researchers, or young researchers) in order to explore of possibilities of project Chain Reaction outcomes and results exploitation.

Instrument

After school activity day students solved questionnaire which has been drawn up with 13 questions [16, 17]. These questions have been arranged into five categories:
1. **Physical learning environment** (suitability, user-friendly, and comfort of equipment)

2. **Teaching materials** (quantity of information, modernity of materials)

3. **Learning process** (balance of independent work, co-operation and assistance, needed aid quantity, clarity of instructions and explanations)

4. **Reactions** (satisfaction with acquired knowledge, option of their own creativity, recommending a method of work to others)

5. **Content** (contemporary, attractive, clear and readable, organized)

Students are evaluated on a continuous scale from 1 to 7, where means 1-minimum and 7-maximum. At the beginning were also two demographic questions about gender, and the age of students, re-attendance at the school activity day. The test items were validated by an expert panel.

**Procedure and data analysis**

Students were surveyed once, as post-test, used a paper / pencil method after IBL. A teacher was present in the class during a survey. The data were analyzed with IBM SPSS. The basic tools of descriptive statistics, analysis of variance ANOVA and MANOVA were used. Internal consistency of the instrument was checked with method of Cronbach's alpha.

**Results**

Internal consistency of the items is regarded as high, which shows Cronbach's $\alpha = 0.91 > 0.60$ [10]. Students were satisfied with school activity day and teaching method. General satisfaction scores are expressed with M-mean and SD-standard deviation (5.36; 1.19; accordingly).

Figure 5 shows students satisfaction with IBL of green subject matters. Students were the most satisfied with learning materials and the least satisfied with physical learning environment. Students felt comfortable with time organization, with multiple-sources of information, and materials which were up-to-date. IBL enabled all type of interactions (e.g., peer-peer, teacher-student, student-content) using real-classroom and off / online means.
Overall student satisfaction with IBL is judged to be moderate. Only learning physical environment needs some modification in terms of workshop equipment, more room for effective work, and some refreshments are necessarily.

**IBL and gender differences**

Levene's test showed the homogeneity of variance ($F(1.258) = 0.12, p = 0.73 > 0.005$). Multivariate analysis of variance (MANOVA) across all factors of satisfaction revealed statistically significant differences ($p<0.05$). Male students ($M=5.50, SD=1.17$) are more satisfied with IBL than females ($M=5.24, SD=1.21$). Figure 6 shows gender differences at each category of satisfaction. Males were more satisfied almost at all categories of satisfaction, unless with physical learning environment. Significant differences ($p<0.05$) occurred just at scale of Reactions ($M_m=5.70, SD_m=1.34$; $M_f=5.31, SD_f=1.42$) and at Content scale ($M_m=5.60, SD_m=1.65$; $M_f=4.99, SD_f=1.74$) with small effect size ($0.02, 0.03$; accordingly).
Female students felt not comfortable with collaborative and cooperative learning in technology-intensive learning environments, and science and technology subject matter seems to be out of primary interest of their study orientation.

**Student satisfaction across the IBL topics**

Levene’s test showed homogeneity of variances at all green topics (p >0.05). MANOVA revealed significant differences (p<0.05) in perceived satisfaction with Teaching / learning material, Learning process, and Content considering different area of green competences acquiring. Effect size is regarded as small to moderate ($\eta^2 = 0.34; 0.44; 0.60$; accordingly). Students were the most satisfied with topic of Plants in Space (M=5.55, SD=1.22) and the least satisfied with topic of Green Heating (M=5.05, SD=1.30) (Figure 7).
Students' perceived satisfaction with green heating significantly (p<0.05) differs from all other topics at item of Content. This suggests redesign of content topic in a way of inclusion the interesting, clear and organized learning objects and more teacher involvement at IBL to reduce perceived cognitive load, especially at conceptualization phase.

Conclusions
The purpose of the study was how eighth- and ninth-grade students were satisfied with IBL of green topics. It was found that students were moderately satisfied with IBL and technology days. Males were more satisfied than females. It seems that topics more suit to male students. Furthermore, it is important to highlight that such way of work (method IBL) in classroom students are not yet practised. There were too much autonomy for students and less assistance by teachers. Students met this teaching method for the first time, and IBL was shock for them and caused a lot of misconceptions. A minimal guidance or no guidance during IBL was not effective. Doing right explanations and conceptualisation afterwards sometimes increased learning difficulty and this was noticed in perceived high scores of cognitive load of students.
In general, course quality is judged to be moderate to high. Some modifications are needed in terms of group design and motivation material and process for female students. A topic of green heating needs some changes as didactic modification to make learning easy and more effective, by up-to-date and multiple-source material where scaffold learning with timely feedbacks is enabled to reduce cognitive load of students.

Considering green competences, all IBL topics show potential for introduction to compulsory curriculum and learning system. Acquiring of green knowledge and skills using IBL is judged to be suitable and effective method as well for non-formal education and training. Thus, we suggest introduction of the method also to any other green subject matter considering technology and engineering. IBL should advance also at wider competences acquiring, where a lot of interactions at scaffolds during IBL in technology-intensive learning environment develops students' communication ability, self-efficacy, self-regulation and turns students' attitudes positive toward science and technology. Also, during IBL students develop competences of guidance, management, research work, supervision, and creativity which are essential at innovation process. Perhaps, introduction of IBL in primary and secondary education may change interest for study of science and technology/engineering, especially of those occupations related to green job sectors.

In paper we investigated student attitude toward teaching/learning green competencies and green topics in open settings. This content is rather seldom involved in formal primary and secondary education, but is a very important content. Many people are not aware of green jobs and green economy, but this is very important especially for our health, environment, safety and national wealth fare. Green sectors and related green jobs are the same or even more economically effective than conventional one, and contributes to preservation of natural resources and environment.

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References


THE CONNECTION BETWEEN TECHNOLOGICAL AND ENVIRONMENTAL LITERACY

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Abstract

Technological literacy is widely accepted as the main goal of technological education at all levels of school. A similar situation is in the field of environmental literacy. Both of these literacies are usually defined as a combination of factors from various dimensions: cognitive (knowledge), behavioural, affective (attitudes, emotions) etc. Just a little is known about the connection between environmental and technological literacy. This paper tries to find these “contact areas” by review of the literature aimed at definitions of environmental and technological literacy as well as recent research in this area. This analysis is partly limited by lack of empirical research work in the field of technological literacy. It must be remembered that both literacies and their development are key prerequisites of “green” society which exists in accordance with the principles of sustainable development. Despite this fact, some common elements of these literacies were found and are presented in the paper.

Keywords: technological literacy, environmental literacy, green society

Introduction

Modern society which is based on ideas of sustainable development requires from its members crucial equipment qualities that enable fulfilment of its goals. Such qualities can also be described as literacies, i.e. sets of skills and knowledge. Within the themes that can be described as green and that are directed towards the fulfilment of practices and ideas of sustainable development technological and
environmental literacy play a very important role. They represent paths that lead an individual to science, technology and environment. Despite this fact we know very little about their mutual interaction and the way they influence each other.

**Technological literacy**

Technology as one of the major means used to change the world around us has played a crucial role for all humanity as well as for each individual. Talked about in relation with technology and the processes that it represents is so-called “technical thinking”. It is a relatively broad term and it can be divided according to various criteria.

While the concept of technical thinking refers mainly to a certain quality, focus or content of individual thinking, the term technical literacy, or more precisely basic technical literacy, refers to a certain threshold, minimum or border line that must be overstepped for living in the present, technologically developed society. It is necessary to discuss the appropriate level, content focus, competences (generally emphasized is the ability to solve technical problems) as well as relations to other fields of education. Such discussion should be based on research as well as practice. The content of both these terms is only fulfilled when the knowledge, skills and habits are interconnected and it depends on the subject's motivation and creativity developing. Nowadays, the importance of critical thinking is strongly emphasized without which technical thinking is unthinkable and technical literacy is unattainable [1].

The roots of the effort to define technical literacy can be found in John Dewey's [2] work. Although this founder of pragmatic pedagogy did not use the term technical literacy, he expressed the importance of technically literate individuals and also the need of collective creation of technical thoughts so that educated citizens capable of critical thinking could be raised.

The International Technology Education Association (ITEA) [3] considers a technological literacy to be an ability to use, manage, evaluate, and understand technology. A technically literate person understands what technology is, how it is created and how society is created in its influence and in opposite how the technology is influenced by society. Such a person is capable of all this despite the fact that the technology is constantly developing. A technically literate person is able to evaluate
the information about technology presented in media, perceive it in context and create his or her own opinion based on this context. He or she can effectively use technology to his or her advantage without a fear of it or in opposition uncritical love for it.

Technological literacy is usually divided into three main components - knowledge, critical thinking and decision making and capabilities [4]. Characteristics of a technologically literate person in these components can be found below. The visual presentation of these components and their relationship is in Figure 1.

*Characteristics of a technologically literate person [4]:*

**Knowledge**

- Recognizes the pervasiveness of technology in everyday life.
- Understands basic engineering concepts and terms, such as systems, constraints, and trade-offs.
- Is familiar with the nature and limitations of the engineering design process.
- Knows some of the ways technology has shaped human history and how people have shaped technology.
- Knows that all technologies entail risk, only some of which can be anticipated.
- Appreciates that the development and use of technology involve trade-offs and a balance of costs and benefits.
- Understands that technology reflects the values and culture of society.

**Critical Thinking and Decision Making**

- Asks pertinent questions, of self and others, regarding the benefits and risks of technologies.
- Weighs available information about the benefits, risks, costs, and trade-offs of technology in a systematic way.
- Participates, when appropriate, in decisions about the development and uses of technology.
Capabilities

- Has a range of hands-on skills, such as operating a variety of home and office appliances and using a computer for word processing and surfing the Internet.
- Can identify and fix simple mechanical or technological problems at home or at work.
- Can apply basic mathematical concepts related to probability, scale, and estimation to make informed judgements about technological risks and benefits.
- Can use a design-thinking process to solve a problem encountered in daily life.
- Can obtain information about technological issues of concern from a variety of sources.

![Visual representations of the components of technological literacy](image)

Figure 1. Visual representations of the components of technological literacy

The term technical literacy is seen in the Czech Republic as a technological education minimum that every individual should acquire. The main credit for developing this concept globally is given to Dyrenfurth [5]. In accordance with his beliefs, the requirements of technical literacy can be defined as competencies in the following areas, of course, to the extent of aims given by the individual educational institution:

- Realize the key processes in technology (what it is and how it works),
- Operate technical devices and equipment,
• Apply technical knowledge to new situations,
• Develop their own technical knowledge, skills and habits,
• Use technical information and evaluate it.

According to Bajtoš and Pavelka’s [6] publication, the concept of technological literacy includes:

• Acquisition of knowledge about technology, technical materials and acquiring technological skill at a reasonable level,
• Capability to solve technical problems,
• Creating a rational relationship to technology,
• Understanding of the relationship between science and technology and ability to apply such understanding,
• Developing technical creative thinking.

The term technological literacy includes, similarly to the concept of technical thinking, the knowledge, skill and attitudinal component [5].

There is one more important aspect of technological literacy. It is its’ cultural universality [7, 8]. Technology is, like e. g. language, pervasive and therefore less perceived. Everybody practices daily a large amount of technological decisions, from lacing to driving. Most of these activities are perceived only marginally and it brings the question if it is possible to identify everyday presence of technological literacy.

**Environmental literacy**

The concept of environmental literacy (EL) first appeared in 1968 in an article written by Roth [9]. To the awareness of the wider society it got later among others in relation with the definition of environmental education where, however, the phrase “environmental literacy” is missing [10]. The environmentally literate citizen is since then understood as a fundamental objective of environmental education. Nevertheless, the notion of environmental literacy is used in many meanings and its use loses sense as each person imagines it as a set of different qualities [11].
More significant attention was aimed at environmental literacy at the beginning of the 1990s in connection with a “resurgence” of environmental education in the United States of America. The fundamental text of that time is Roth’s [11] monograph that tries to define environmental literacy on the base of broader expert consensus and outline the possibilities of its measurement as a way to evaluation in environmental education. Environmental literacy has three levels - nominal, functional and operational. Each of these levels has a series of characteristics that can be divided into four basic strands - knowledge strand, affective strand, skill strand and behaviour strand [11]. This definition has confirmed the broad scope and complexity of environmental literacy and became the basis of a whole series of researches that focused on its individual components.

A significant portion of these researches were used in the search for new, research-based definition of environmental education. In 2011 it was introduced by the North American Association for Environmental Education [12]. This definition of environmental literacy respects the already accepted division into several dimensions but each of them is expressed by a list of its crucial components which are measurable and can be used for evaluation of environmental activities (see Figure 2). It is not, however, realistic to capture all these aspects during measurement of an individual’s environment literacy. Ideally an appropriate combination of the aspects should be chosen so that the concept is incorporated from multiple angles. The individual elements are interconnected but the degree of their mutual interaction is not always perfectly clear.
McBride et al. [13] presented a comprehensive and detailed comparison of environmental literacy, ecological literacy and ecoliteracy terms. During analysis of available frameworks, some differences between these concepts were defined on the basis of different understanding of various authors. Nevertheless, the composition of the environmental literacy of the four basic dimensions is still accepted.
Connection between Technological and Environmental Literacy

It is obvious from the above mentioned definition of both literacies that there are a number of interfaces that they have in common. They also share a characteristic in spirit of its complexity where both environmental as well as technological literacy consist of a series of aspects which together form a complicated, mutually interacting complex.

Idea of “contact zones”, i.e. areas in which these literacies encounter within the personality of an individual can be seen in table 1. Its content presents a synthesis of the characteristics outlined in previous chapters.

Table 1. Comparison of individual components of environmental and technological literacy

<table>
<thead>
<tr>
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<th>Environmental literacy</th>
<th>Technological literacy</th>
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<tbody>
<tr>
<td>Cognitive dimension</td>
<td>Knowledge</td>
<td>Knowledge</td>
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<tr>
<td>Affective dimension</td>
<td>Dispositions</td>
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</tr>
<tr>
<td>Skill dimension</td>
<td>Competencies</td>
<td>Capabilities; Critical Thinking &amp; Decision making</td>
</tr>
<tr>
<td>Behavioural dimension</td>
<td>Environmentally Responsible Behaviour</td>
<td>Capabilities; Critical Thinking &amp; Decision making</td>
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The same moments can be observed in equipping an individual with a specific set of skills and competencies that allow one to actively and competently participate in public life and make decisions in accordance with the trend towards green society and green economy and thus respect the ideas of sustainable development. Examples of the mentioned skills follow:

- Asks pertinent questions, of self and others, regarding the benefits and risks of technologies [4].
- Weighs available information about the benefits, risks, costs, and trade-offs of technology in a systematic way [4].
- Can obtain information about technological issues of concern from a variety of sources [4].
- Ask relevant questions about environmental conditions and issues [12].
• Investigate environmental issues (scientific and social aspects of issues using primary and secondary sources) [12].

• Evaluate and make personal judgements about environmental issues (the interaction between environmental conditions and sociopolitical systems) [12].

• Create and evaluate plans at various scales / levels to resolve environmental issues [12].

An individual that is environmentally and technologically literate is able to analyse the issues and problems of contemporary society and make concrete decisions directed to achieving greater effectiveness while respecting environment.

Acquisition of such competencies is conditioned by education in all its stages and also by the affective component of a personality. Both of these variables are a challenge for further research devoted to the relationship between environmental and technological literacy and their mutual interaction. This relationship does not have a simple form and it can not be said that the individuals with positive attitudes to the environment have a negative influence on science and technology [14].

The elements of technological literacy are a natural part of the personality of a good chemical engineer, thus the connection of environmental and technological literacy is closely connected with principles declared in the project “STRENGTH” [15]. Such a relationship leads to a shift from knowledge to competencies, from education to learning. It can be assumed that searching for connections and relations as well as differences in the understanding of both literacies will lead to greater development and stimulation of both current and future works in chemical engineering as well as in other fields of human activity.

**Conclusion**

The previous text briefly introduced the most famous and generally accepted definitions of technical and environmental literacy and some contact surfaces were attempted to be found. These certainly exist and within this short paper those related with competencies of individuals that led them to erudite discussion and decision making about problems around them, were mainly brought to attention as it is one of the prerequisites for a society based on the ideas of sustainable development.
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