Co-funded by the
Erasmus+ Programme
of the European Union

Engineering Literacy Online - Teachers as Medium for Change

2017-1-AT01-KA201-035034

IO1 – A3 Needs and Gap Report - ELIC

Austria, Czech Republic, Germany and Italy

VSB-TUO Team – VSB - TUO

Claudia Linditsch & Eva Penz – FH JOANNEUM

Table of Contents

1 Introduction 3

1.1 Scope 3

1.2 Structure 3

2 Definition "Engineering Literacy" within the ELIC project 4

3 Methodology 6

3.1 Desk research report 6

3.2 Focus Group Interviews 7

3.3 Needs and Gap Analysis 8

4 Needs and Gaps identified in project partner regions 9

4.1 Definitions 9

4.2 Needs 9

4.2.1 Austria 9

4.2.2 Czech Republic 10

4.2.3 Italy 11

4.2.4 Germany 11

4.3 Gaps 11

4.3.1 Austria 11

4.3.2 Czech Republic 12

4.3.3 Italy 12

4.3.4 Germany 13

5 Needs and Gaps summary at project level 14

5.1 Objectives of ELIC project based on Needs and Gap analysis 17

6 Conclusion 19

1 Introduction

This report summarizes Needs and Gap analysis, which was conducted within ELIC project. The ELIC project is co-funded by the Erasmus+ Programme of the European Union and has the following project number: 2017-1-AT01-KA201-035034. The project focuses on four partner regions - Austria, Czech Republic, Germany and Italy, and all content parts were conducted by the scientific partners with the support of the school partner wherever appropriate.

The methodology that was followed is in detail described in section 3 Methodology. Generally, it can the said that it consists of the desk research, a focus group and needs and gap analysis. The aim of the analysis was to identify main gaps and needs between educational offers in terms of training courses and key features of a possible education activities for secondary school teachers. It can be therefore stated that the outcomes of this first intellectual output are the basis for the ELIC project and its future progress.

1.1 Scope

This report presents a summary and a conclusion of needs and gaps identified during the analysis conducted within ELIC project with a focus on project partner´s regions. First, an overview is given on a national basis in term of needs and gaps and then a comparison/summary is presented in the report. Project partner´s regions are Austria, Czech Republic, Germany, and Italy. Needs and gaps identified are described in detail in individual national reports which can be found on the ELIC website as well.

1.2 Structure

The structure of the document is the following. The first part, section 2, presents the definition of the term “engineering literacy” identified for the ELIC project. Section 3 introduces the followed methodology within intellectual output 1 – analysis reports. Section 4 highlights the needs and gaps identified in project partner´s regions. Section 5 summarises and compares the needs and gaps at project level based on insights received from needs and gaps analysis conducted on a national level.

2 Definition “Engineering Literacy” within the ELIC project

ENGINEERING LITERACY in ELIC stands for interdisciplinary teaching through practical examples that combine natural sciences subjects[1] AND technical sciences input[2]. This increases “functional thinking” among pupils. The link between basic natural sciences knowledge and to how to apply it for solving challenges in different fields becomes visible and makes secondary school pupils more curious, thereby increasing their interest in engineering.

We can transfer/teach this engineering literacy through the creation of practical examples, which involve at least two different areas (one from natural and one from technical sciences e.g. physics and mechanics).

In short, engineering literacy is the elaboration of a combination of natural and technical sciences based on best practice synergies among those topics from different European regions. Once pupils obtain engineering literacy it enables them to create an engineering mind-set and to benefit from the labour market offerings in this field.

An example to understand why engineering literacy is so important and should be improved especially at non-technical school:

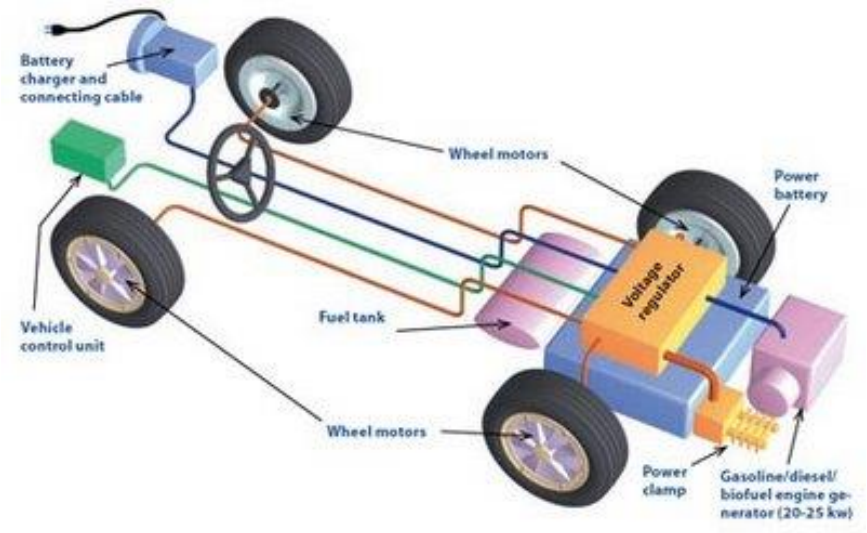

Figure 1 Car environment

[1] Biology, Chemistry, Physics, Mathematic, Computer Sciences in secondary schools
[2] Biochemistry, Mechanics, Electronics, Software, Renewable Energy

An example are components, interactions and influences on the environment of a car, described in Figure 1: from lithium to software and possible accidents in case of failure it is quickly seen that there is an interdisciplinary nature of several natural sciences subjects and engineering (technical sciences), and its importance in our daily life.

It is important that the ELIC project developed its own understanding/definition of engineering literacy to create a common understanding and make sure that the project´s outcomes and goals are reached. The definition created is based on the consortiums´ understanding of engineering literacy. Further, literature and external experts were consulted to create a final version of the definition to make sure that the definition not only reflects the view of the ELIC consortium but also the one of external experts in engineering and education.

3 Methodology

The training needs and gap analysis (TNA) was conducted as the first step of the ELIC project, as part of intellectual output 1. Analysing the training needs of target groups is a vital prerequisite for any effective training programme. Simply throwing a training at individuals may miss priority needs or even cover areas which are not essential, or are not possible to use by the teachers because of particular study plans in different partner regions.

The TNA enables the consortium to channel resources into the areas that are common in project partner regions when it comes to teaching natural sciences and its interdisciplinary connections.

The TNA contributes to the development of skills of natural sciences teachers and school managers in terms of engineering literacy and further to the interest and motivation of pupils in natural sciences and to study engineering study programmes in the future. Therefore, pupils are identified as the secondary target group of the ELIC project.

The methodology of this TNA is clustered into three essential steps, which are described in following subsections.

3.1 Desk research report

All scientific partners with the support of the school partners conducted a desk research. Efforts were shared as partners of each partner region worked co-jointly on the desk research to bundle resources. The desk research focused on deriving specific literature on innovative teaching methods for natural sciences within the respective regions/countries and also on competences in teaching plans. It did not only focus on the educational and training possibilities for the teacher, but also equally important on the regional competences that should be taught to pupils and which need to be followed by teachers on a national basis. Additionally, the training has to fit to the teaching plans and has to be based on the competences that they can provide.

Therefore, it is of utmost importance to the ELIC consortium that the MOOC that is going to be developed covers parts of the competences and teaching plans of each participating country to make sure that the training materials provided to the training participants can be

also implemented in lectures to increase the engineering literacy first among teachers and second among pupils.

Summarizing, it can be said that one desk research report was compiled by each partner region focusing on competences and teaching plans. In terms of the outputs it can be said that the consortium created four individual desk research reports and one common report at the ELIC level (covering project partner regions).

3.2 Focus Group Interviews

A focus group is a form of qualitative research in which a group of people are asked about their attitude towards a product, service, concept, advertisement, idea, etc. Questions are asked in an interactive group setting (preferably a round table) where participants are free to talk with other group members. Focus groups provide researchers with initial ideas in the exploratory part of a study, they can be useful in the process of interpretation and evaluation of results and situations and they can produce further research questions.

In the ELIC project, the focus group interviews (regional informational round tables) are used to discuss the existing trainings and best practices on engineering literacy for the target groups, to identify the needs of the target groups in the area of engineering literacy training input and find out more about the gaps between existing trainings and training needs. Moderators should also have in mind Best Practice Examples that may come up in the discussion.

Generally, for the focus group interview it can be said that a couple of documents were developed to make sure that the implementation process is unified. Starting with the focus group guideline which includes an introduction to the planned focus group and a description of the equipment needed and the process of implementation. Moreover, a questionnaire was developed and distributed to the partners to make sure that the most important are included in each of the focus groups. Further, to ease the process of implementation also a note taking form, a template for the attendance list and a consent form which states that the information given can be used for the purpose of the ELIC project, was created and made available to the project partners to ensure uniformity.

The used approach has the aim to identify similarities and gaps by comparing competences at project level.

3.3 Needs and Gap Analysis

The needs and gap analysis consists of summary of all individual reports - desk research + focus group report. It analyses the needs and gaps identified by the desk research and by stakeholders discussed in focus group. It is essential to analyse the information gathered in the desk research and the focus groups to identify existing gaps between current teaching and learning standards and innovative methodologies for natural sciences teachers. In this final phase it is a main input to the following procedures of the project.

Based on the Desk Research and Focus Group Interviews each partner prepared a needs and gap report to identify already known engineering teaching approaches at secondary schools. It was identified which engineering approaches can be strengthen by the planned MOOC for the secondary school teachers and pupils. What is already available and what is missing in the pool to create a profound basis of the development of the MOOC.

Generally, the needs and gaps analysis is based on the desk research report of each partner region and analysis report of focus group reports on the regional level. Partners created needs and gaps analysis at the partner region level – as it is based on the results of the desk research and focus group interviews in individual region. Then this document - Needs and Gaps Analysis – ELIC Project Level - serves as summary of Needs and Gaps Analysis at partner region level and identifies needs and gaps on ELIC project level

4 Needs and Gaps identified in project partner regions

This section presents the highlights of the needs and gaps identified in the individual reports of project partner regions. The details and the full description can be found in the individual needs and gaps region reports.

4.1 Definitions

The ELIC team has analysed the current efforts in terms of engineering literacy and possibilities for implementing more aspects of engineering topics in secondary schools in accordance to teaching plans through desk research and focus group interviews. As a following step gaps were identified by the partners to ensure that the ELIC project addresses exactly these gaps. The gaps are caused or clarified by identified existing needs.

Gap is defined as some kind of difference between current situation, current state of the art, and desired situation from the point of view of the analysis originators done on the information gathered by different methods.

Need is defined as something required to be fulfilled or done. It can serve as a cause, or reason, of the gap. However, it can also be stand-alone without particularly joined gap, as there can be identified some need, where is not significant gap.

4.2 Needs

This section presents summary of needs identified in particular partner regions.

4.2.1 Austria

Analysis in **Austria** identified four main needs in further education for teachers and their competences in teaching plans. First of all, *engineering teaching materials, which can be implemented into teaching with little adaptation efforts for teachers* with focus on four main topics:

- Electromobility
- How do cars work? What are the most important parts of the combustion engine? How can I start a car?
- Autonomous driving – how will the mobility of the future change?
- Robotics – how are robots changing business strategies?

Methods identified:

- Theoretical input given in class, practical application through excursion and ending the topics in the classroom
- Combination of theory and hands-on examples – engineering to experience and touch

Second of all, work on comprehensive overview of all subjects (such as foreign languages), not only the STEM ones. It was identified among the STEM teachers, that there is a great motivation to collaborate with other subjects in order to enhance dealing with engineering aspects.

Third of all, *centre for coordinating engineering education efforts*. Meaning to expanse the range of concentration which is usually connected to organization's aims in order to increase the knowledge and skills of engineering topics.

And last of all, *Changing the perspective of pupils and teachers when it comes to STEM subjects and the integration of engineering topics.* In other words, renaming the subjects could lead to dropping the barriers tied to STEM subjects.

4.2.2 Czech Republic

In the **Czech Republic** there were identified following needs:

- *Creation of framework education plans* – ensure the didactic support of the universities educating teachers (to develop technical literacy and to integrate with the thematic units of STEM subjects.
- Next, *Emphasis on interdisciplinary education not only for pupils but also for teachers, creation of textbooks and teaching materials (web portals, currently supplemented electronic database of examples) elaborated for different forms and levels of education.*
- Following by, *the need for further, but coordinated and systematic teacher's education, ideally centrally managed by the Ministry of Education or National Institutes of Further Education of Teachers.*
- And last of all, *the inclusion of engineering topics in teaching through project teaching and optional subjects that will combine basic knowledge of STEM subjects and modern technologies.*

4.2.3 Italy

The needs associated with teaching engineering topics in Italy are tied with one main topic - lack of time and money, teachers implement they curricula on the basis of their own professional and individual motivation.

The form of offered courses and further education should be varied to cover the different needs and expectations of teachers, e.g. online courses for individual study, experience multi-day courses, common courses for teachers and students, etc. and should be coordinated among schools.

High schools, more than technical schools, need to implement a virtuous triangle (industries, universities and secondary schools) at regional and national level and there is a lack of equipment and laboratories technologically updated.

STEM are studied in a deep way but, in general, there is a lack of the interdisciplinary perspective.

4.2.4 Germany

STEM subjects taught in **Germany** are regulated and strictly given by teaching plans, more precisely curriculums. Due to this and the fact, there is a lack of equipment and laboratories at the schools, STEM subjects are often taught without any practical use of learned knowledge. There is a need for more Engineering Literacy in the classroom for more Engineering Literacy in the classroom. Schools try to apprehend this problem and usually offer weekend programs, where pupils and teachers can participate and get a better insight view on how knowledge of STEM subjects are practically used.

4.3 Gaps

This section presents a summary of gaps identified in the particular partner regions.

4.3.1 Austria

Quality of content as well as output of further trainings and education is often questionable in **Austria**.

- Output currently: training implementation with experts, very little information on didactical concepts for engineering topics, increase of knowledge

- Output aimed for: increase of knowledge on up-to-date engineering topics including adequate didactical concepts, teaching materials provided which can be directly implemented in class at various levels

Coordination of engineering literacy efforts for pupils and teachers:

- Current situation: many initiatives for engineering education in schools but no quality control of trainings and excursions offered and also no coordination
- Situation aimed for: bundling the resources that are currently invested in promoting engineering education/literacy in one centre to create a bigger impact on a regional and national level

4.3.2 Czech Republic

Although there is a wide range of offered courses and trainings for STEM teachers in the **Czech Republic**, the quality is lacking in most cases. Courses are unsystematic, not well built, and often do not include the needs of all age groups and levels of education.

The main problem lies also in the content of courses, which is uncoordinated, incomplete and far from covering all topics of “engineering literacy.”

Not only the content, but also the form of offered courses and further education should be varied to cover the different needs and expectations of teachers, e.g. interactive learning as well as practical and theoretical input elaborated on an interesting basis for pupils .

Last of all, in the Czech Republic, the Teachers Career Plan is not well respected. Teachers are not enough motivated and supported to partake in further education.

4.3.3 Italy

The following ideas as gap fillers have been identified in **Italy** and should be initiated in the future:

- Not only the content, but also the form of offered courses and further education should be varied to cover the different needs and expectations of teachers, e.g. online courses for individual study, experience multi-day courses, common courses for teachers and students, etc.

- Teachers are not able to participate in further education (either financially or in terms of study or time), they do this on the basis of their own professional and individual motivation.
- Usually individual projects are not shared with other educational institute or even among teachers of the same discipline. There is a lack of coordination among school courses.

Although the presence of good examples of trainings, it is necessary to implement a virtuous triangle (industries, universities and secondary schools) at regional and national level.

4.3.4 Germany

The **Gap** on how to bring the training to the pupils and teachers is existing and currently difficult to close. The following ideas as gap fillers have been identified and should be initiated in the future:

- Interdisciplinary projects with university and industry could be initialized for state-of-the-art teaching.
- Short and well-prepared course training material for a 2h class (experiments, teaching material etc.).
- Voluntary project classes with resulting project works do exist and could be used for such studies. The interesting point is that the mark will influence the final A-level certificate.
- Special classes und motivational trainings especially for girls should be initialized in order to let rough diamonds shine.

5 Needs and Gaps summary at project level

This section presents a summary of needs and gaps which were identified in the individual project partner regions.

The comparison of individual needs and gaps analysis at regional level brought following findings of needs:

Table 1 Needs identified at the project level

No.	Needs

1.	Need for engineering teaching materials, which can be implemented into teaching with no or little adaptation. Need for focus on hot and emerging topics in engineering such as:
	• Electromobility vs. combustion engine
	  ○ How do cars work? What are the most important parts of the combustion engine? What are other types of engine?
	  ○ Autonomous driving – how will the mobility of the future change?
	• Robotics – how are robots changing business strategies?
	• Etc.

2.	Need for cross subject/interdisciplinary collaboration. STEM subjects and others such as English, where a collaborative collaboration could lead to the improvement of students in STEM subjects and such cooperation could also improve the practice of students and would offer laboratories the common use.
3.	Need for a more systematic further education of teachers, which allows teachers to have the latest state of the art in their education topics. It is important mainly in the engineering domain, which is rapidly evolving and teachers need to stay in touch with the latest knowledge to transmit up-to-date knowledge to their pupils.
4.	Need for actual/up-to-date national teaching plans and frameworks. There is a big need in all participating countries that teaching plans are more adapted to current developments als industry needs.

The comparison of individual needs and gaps analysis at regional level brought following findings of gaps:

Table 2 Gaps identified at the project level

No.		
1.	Gap	Quality of offered trainings actually on the market

	Current Status	• Trainings offered to STEM teachers are available to a high degree, still quality of content is often questionable as well as the output provided • There is a lack of training implementation with experts, very little information on didactical concepts for engineering topics, questionable increase of knowledge. • The content of the courses is uncoordinated, incomplete, far from covering all topics of "technical literacy", they are just individual actions
	Desired Status	• Training for teachers in high quality, focusing on quality rules • Course content based on cooperation with experts and provide real expels from universities and industry • Teaching materials which can be implemented in lectures with little adaptations
2.	Gap	Not clear aiming of trainings – teacher/pupil
	Current Status	• It is vaguely defined what kind of education is suitable especially for teachers and what kind of learning would be beneficial for joint action of teachers and students
	Desired Status	• Have a training that is applicable for the teachers and also defined what is directly applicable for pupils
3.	Gap	Course structure – not suitable for direct implementation to courses
	Current Status	• Short and well prepared course training material for a 2h class (experiments, teaching material etc.). • Not only the content, but also the form of offered courses and further education should be varied to cover the different needs and expectations of teachers and to adapt to current teaching standards, e.g. online courses for individual study, experience multi-day courses, common courses for teachers and students, etc.
	Desired Status	• Related to the Need no. 1 • Availability of teachers´ training materials for the implementation in STEM subjects with little or no adaptation
4.	Gap	Teachers career plan
	Current Status	• Teachers are not enough supported to participate in further education (either financially or in terms of study or time),

		they do this on the basis of their own professional and individual motivation.
	Desired Status	• Related to the Need no. 3 • Support systematic teachers education with a training that is EU-recognised with international certificate ○ At project level, we are not able to aim on national or regional levels of systematic teach education, but it can be coherent support
5.	Gap	Interdisciplinary projects with university and industry
	Current Status	• There are already some individual cooperation between secondary schools and university or industry
	Desired Status	• Related to the Need no. 4 • Interdisciplinary projects with university and industry could be initialized for state-of-the-art teaching • It allows cooperation on the latest project in the industry and university and getting the latest trends to the teaching of pupils • It can be also in the form of well-defined examples from the industry and the university, where teachers and pupils at secondary schools can see the use of individual STEM subjects
6.	Gap	Cross subject/interdisciplinary collaboration
	Current Status	• Engineering implemented not only in STEM subjects but also in other subjects such as languages. It was identified that among the STEM teachers there is a high motivation to collaborate with other subjects in order to create the awareness and motivation among pupils and teachers to deal with engineering aspects
	Desired Status	• Related to the Need no. 2 • Collaborative teaching of STEM subjects also with other subjects to present the interdisciplinary of particular topic, as the majority of nowadays engineering topics requires interdisciplinary view on it. • Project style of teaching, where the topic is discussed on particular project from different point of view of individual STEM and other subjects
7.	Gap	Voluntary project classes
	Current Status	• There are already voluntary project classes

	Desired Status	• Voluntary project classes with resulting project works do exist and could be used for such studies. The interesting point is that the mark will influence the final A-level certificate

5.1 Objectives of ELIC project based on Needs and Gap analysis

ELIC project objectives shall lead to the closure of identified gaps and fulfilment of discussed needs, that we are able to cover. These objectives will be fulfilled in the following work of ELIC project, which aims on development and implementation of new training for teachers as primary target group and pupils and secondary target group. The aim is to increase engineering literacy.

Table 3 Objectives of ELIC project based on Needs and Gaps analysis

No.		
1.	Objective	Availability of teachers´ training materials for the implementation in STEM subjects with little or no adaptation.
	Related needs and gaps	Needs: • No. 1 Gaps: • No. 2, 3
2.	Objective	MOOC training materials are made available to the target group of secondary STEM teachers an all other interested target groups. MOOC can generate interest among teachers but also among pupils as a secondary target group
	Related needs and gaps	Needs: • No. 1 Gaps: • No. 2, 3
3.	Objective	Training materials focus on combining theory and hands-on practice. It means variety of slides, or example description, how to reproduce it in the class
	Related needs and gaps	Needs: • No. 2 Gaps: • No. 6

4.	Objective	Online training under ECQA, which allows to obtain international certificates.
	Related needs and gaps	Gaps: • No. 4
5.	Objective	Training under ECQA quality rules and procedures.
	Related needs and gaps	Gaps: • No. 1
6.	Objective	Provide real industry or university examples from the latest and emerging engineering topics
	Related needs and gaps	Needs: • No. 3 Gaps: • No. 5
7.	Objective	Focus on hot and emerging topics in engineering such as: • Electromobility vs. combustion engine • How do cars work? What are the most important parts of the combustion engine? What are other types of engine? • Autonomous driving – how will the mobility of the future change? Robotics – how are robots changing business strategies?
	Related needs and gaps	Needs: • No. 1

6 Conclusion

The analysis, which consists of desk research, focus group interviews and needs and gap analysis, identified and addressed the main needs and gaps in particular the project partner´s regions, in Austria, Czech Republic, Germany and Italy. These results are described in individual partner region reports. This report summarized the needs and gaps at project level, and definition of ELIC project objectives.

The paper presents basic definition of engineering literacy, which stands for interdisciplinary teaching through practical examples that combine natural sciences subjects and technical sciences input. It is the main backbone of ELIC project.

The paper also described the methodology of the needs and gaps analysis. The methodology contains elaboration of desk research in particular project partner regions to gather state of the art information, which is accessible for teachers today. Second part is focus group interview with representatives of main target groups, which brought inputs to the state of the art, needs and possible gaps from the important stakeholders group. The methodology finally results in the needs and gaps analysis on regional and project level.

The needs and gaps analysis at project level, which is described in section 5, presented summarisation of needs ad gaps identified. The main needs were, the need of more comprehensive overview of all subjects, not only the STEM ones is common. Teachers are motivated to collaborate with other subjects in order to apprehend more comprehensive overview and try to understand the engineering aspects in a whole package. There is also a need for courses for teachers with the aim to interdisciplinary. It could show teachers practical implementation of individual STEM subjects and empower them share and describe these examples to pupils at the secondary schools.

The needs and gaps served as the basis for objectives definition, which define main objectives to be followed in the development of the new ELIC training.