

# eLeCo – E-Learning Solution for Engineering Education to acquire Competences

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## Abstract

In educational institutions for Engineering Education e-learning platforms are more and more used to support the learning processes. In Germany there is a heated debate about the topic “competence”. The learners are expected to acquire *competences* as a result of a learning process but the term *competence* is used in different contexts and there is no uniform definition of the term. However, there are common characteristics of existing definitions of *competence*.

In this context, an innovative learning platform has been created, so that the learners can acquire *competences*. The didactical design and the interactive content produced so far are outstandingly suitable for integration into existing curricula of various educational institutions, including universities and schools for vocational education and training. Due to its flexible design, it is also suitable for self-directed learning.

An innovative e-learning solution is created inter alia for Engineering Education, which is not comparable with current e-learning platforms, and leads to a new understanding of e-learning and for this provided software solutions.

**Key words:** Engineering Education, E-Learning, Competences, Learning Process

## 1. Introduction

What is e-learning and how it is defined is very different regarding to the users and in the scientific discussion. E-learning is reflected in various forms of expression with no clear separation and the current provided and required software solutions pretend the opportunities on the one hand and limit on the other hand the possibilities of e-learning.

In the European Union and in other countries, it is demanded that the students shall acquire competences in educational institutions like universities and schools. Concerning to that, in Germany there was and there is still a heated debate about the topic competence. Such a debate can also be seen in other countries in the world.

Because of a public funding of the German Federal Ministry of Education and Research an innovative internet based e-learning platform with well performed interactive content is successfully developed. The new e-learning platform supports the training activities of trainers in the dual system of vocational education. The German dual system is part of the initial vocational education for young pupils and it is characterized by the cooperation of a vocational school as a

public school and an industrial company. That project initially looked to the vocational training in mechatronics.

The didactical concept respectively the didactical structure of the new e-learning solution allows learner to acquire competences. By working out the didactical concept it became obvious, that such an e-learning solution currently does not exist and that such a solution has enormous potential for various educational areas. It has also been found that an appropriate software solution to provide the necessary functionalities for both, the teachers and the learners, does not exist.

The results of the project and the structural layout in the domain of e-learning is unique and ideally suited for educational institutions for integration into existing curricula of Engineering Education to support teaching processes and learning processes. In addition, it can also be used in all other educational institutions and for different lectures and of course for self-directed learning. The name eLeCo for the new e-learning solution stands for electronically supported learning with the objective of acquiring competences.

Firstly the concept and the current understanding of e-learning will be considered in general. Then the concept of competence will be observed. Based on the essential aspects of the different definitions and understandings of competence and further results from the scientific discussion referring to the term competence and the didactical concept which is used in Germany for vocational schools, the structure and realization of the innovative e-learning solution named eLeCo will be presented.

## **2. Fundamentals**

### ***2.1. Concept of E-Learning***

The term e-learning came about 1999 as neologism and is seen as closely related to an e-business marketing campaign from IBM. E-learning belongs to the family of e-terms and has no scientific origin [1].

The “e” within the e-term stands for “electronic” and refers to the use of information and communication technologies. The other part of the e-term refers generally to known objects, areas or processes that are well known in the human environment. Therefore an e-term combines innovation on the one side of the term and tradition on the other side of the term [1].

Since the beginning of e-learning many realizations and definitions with a short time of maturity have been made.

The first phase of e-learning was dominated by software solutions created by IT specialists. Pedagogues were active in that area later and assessed it rather negatively. It has also been recognized over the years that e-learning solutions are not led to a cost saving, but were very costly, e.g. special productions for Computer Based Trainings (CBT) and Web Based Trainings (WBT) [2].

Currently there are a lot of and various types or forms of e-learning available on the market. These include, among other Blended Learning, Content Sharing, Computer-Supported Cooperative Learning, Whiteboard, Rapid E-Learning, Learning Communities and many more.

A combination of pure e-learning and classroom events with the aim to take the advantages of the two forms is called Blended Learning [2].

E-learning is personal or organizational. It can be referred to both, the electronically supported learning of individuals and groups, as well as organizations. E-Learning is local or distributed, i.e. it can be accessed to locally available learning resources, like CD-ROM or remote resources. It is synchronous or asynchronous, for simultaneous interaction can be used for example a chat or video conferencing as communication media and web or discussion forums as an asynchronous media. E-learning is individual or collaborative, it is therefore perceived by individuals or organizations or pursued by several persons or organizations in a collaborative process. Finally e-learning is static or interactive, learning units can either be absorbed like a book or interactions are mediated [3].

On the market there are also a lot of software tools with similar and different functionalities available to realize e-learning in the internet like Moodle, Blackboard, Docebo etc.

Moodle stands for modular object-oriented dynamic learning environment, which is a free source e-learning software platform. Blackboard and Docebo are product designations for learning systems.

“Web 2.0” and “New Media” have to be also viewed referring to e-learning. “New Media” as a generic term is used in the scientific discussion since the 1990<sup>th</sup> and describes in generally all media, which are digitalized and can be used interactive e.g. by Internet, E-Mail, DVD and WBT. “Web 2.0” first appeared in the year 2004 and gives learner the possibility to create and design themselves their own websites to present their knowledge [2, 4].

The authors understand e-learning literally.

## ***2.2. Concept of Competence***

The continuous development of our society to a knowledge and information society leads to numerous social, economic and structural changes. The changes in working life are leading to new requirements on the people, especially on the employees. There is an increased self-planning, management and monitoring of their own activities in companies. An active purposeful production and marketing of their own skills, abilities and achievements etc. requires an extensive competence [5].

The certification and documentation of existing formal, non-formal and informal competences are carried out by special tests. The recognitions of competences will support the professional ability or employability of employees in the national and international job market.

It is discussed very intensively about the concept of competence in science. In the Anglo-American language area there is also an intensive discussion about that concept. There is additionally a differentiation about the spelling and sometimes in the meaning of the term competence and the term competency [6]. We are using the spelling and term competence as the singular form and competences as the plural form.

There are many descriptions available of the development regarding to the competence concept. The term competence is thereby partly set above the term qualification, partly equated. The concept of qualification regards in general especially knowledge, skills and abilities from an

objective side which can be measured unproblematic, but an subjective side and special situational options for activities or actions are not considered [5, 7].

We make a difference between the two terms and take the concept of competence as a continuation of the concept of qualification.

The term competence is used in everyday life – in private and professional life – by persons in different contexts [8].

There has been no uniform holistic definition of competence, which is why scientists call for a comprehensive system of categories for classifying competences. On the other hand, scientists in that subject came to the conclusion that the concept of competence is considered and applied in many scientific disciplines, so that there will not be a common understanding of a comprehensive competence across all disciplines [5].

Based on a scientific investigation, the essential characteristics or elements of competence were identified that occur in all competence definitions. An analysis of the various definitions of competence according to the literature has shown that competence consists of a conglomeration of the elements of knowledge, skills / abilities, motives and emotional dispositions [5]. The above elements, also called core elements of competence, are an integral part of each competence respectively of each competence definition. Competence has to be seen always in relation to actions [5]. That means that the elements exist in every context of utilization and in each dimension of competence. The core elements form the framework of the concept of competence.

These core elements are considered in the new e-learning solution and the didactical structure is furthermore partly referenced to the didactical concept which is used in German vocational education schools since 1996 [9]. It is called loosely translated “concept of learning fields”. That concept is realized in class lessons by the use of an action orientated teaching and learning process which is leading to competences [10]. The aim is to acquire a professional action orientated competence. That competence is subdivided in three competence dimensions the professional competence, the social competence and the self-competence [10].

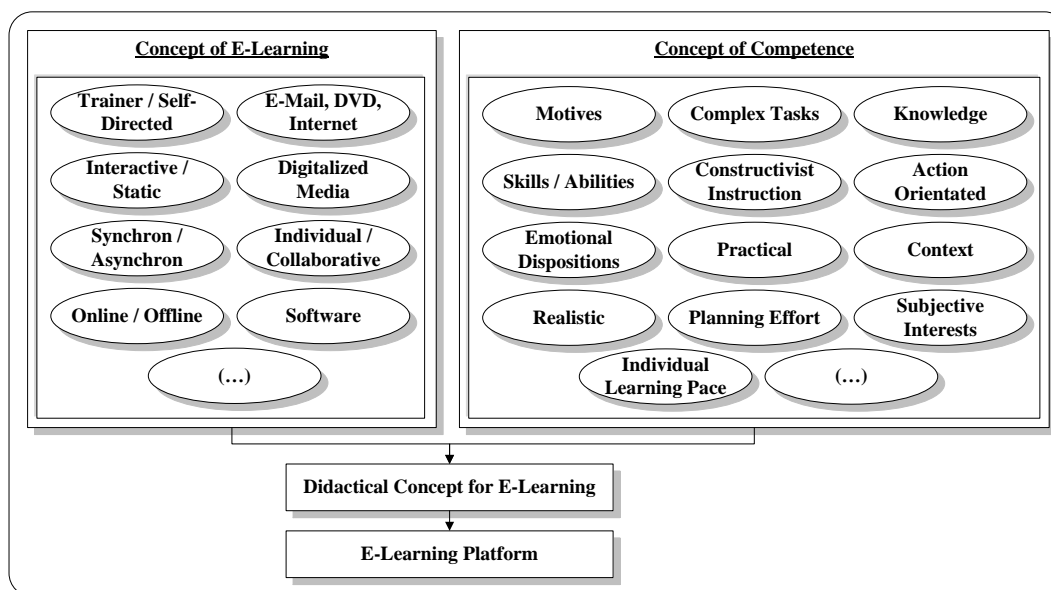
There are a lot of characteristics of an action orientated teaching and learning concept which is considered in the new didactical e-learning concept eLeCo. That concept is based on a constructivist instruction [11] and is not prior orientated to the classical structure or systematic composition of school subjects [10]. A complex professional task is necessary for an action orientated teaching, characterized by one or more problems [12]. The formulated task, which has a practical relation, has to be so complex that a planning effort is required [11]. On the solving process of complex professional tasks the corresponding theory shall be learned respectively elaborated [13]. An action orientated teaching process is characterized by the fact that media and learning situations instead of teacher activities stimulate and encourage the learning process [14]. The learner have the possibility to learn in their own learning pace [11] and actions stimulate the detection of professional reality, e.g. technical safety, economic, legal, environmental and social aspects [10]. These actions take the experience of the learners and reflect them in terms of their impact on society and taking into account social processes like statements about special interests and conflict resolution [10]. Learning takes place in complete actions as self-executed or at least retraced mentally [10].

These and many other factors are based on a learning theory and didactic findings which were taken into account in the innovative e-learning solution. The result is as very flexible concept and

a versatile applicable structure, which takes into consideration the important characteristics out of the environment of the concept of competence.

### 3. Didactical E-Learning Concept

Based on the aspects of the concept of e-learning and the concept of competence a didactical concept for e-learning has been developed. In Fig. 1 there is a loose collection of some aspects shown that have an influence on the corresponding both mentioned concepts and therefore to the didactical e-learning concept.



**Figure 1.** Fundamentals and Considerations of the E-Learning Concept

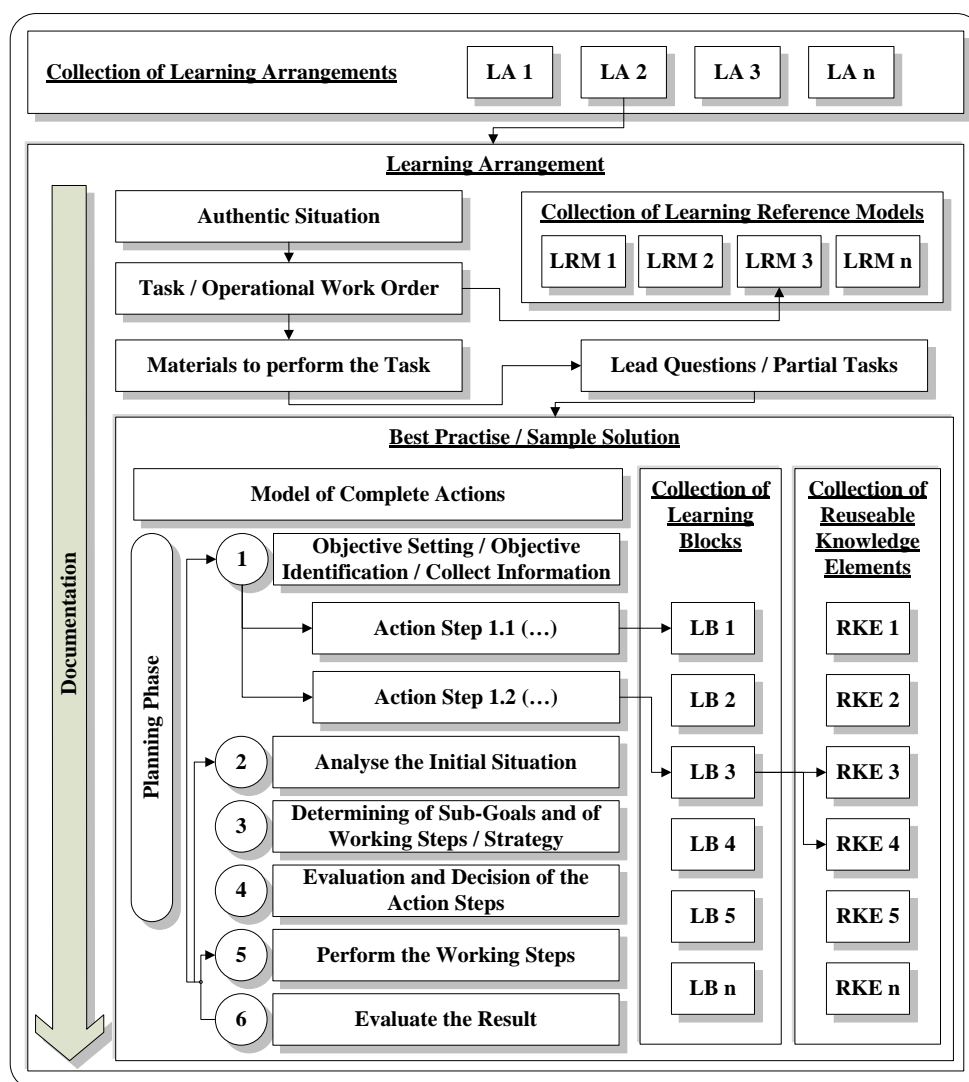
In the following, there is a description of the structure of the didactical concept and its implementation within an e-learning platform.

#### 3.1 Structure

The e-learning solution is based on didactical prepared learning arrangements (LA), which can be edited and completely new created. The learning arrangements are scalable with respect to the existing previous knowledge of the learners. By using Fig. 2, the didactical structure of the e-learning concept will be considered in more detail.

The starting point of the customizable learning arrangements is an authentic situation. It is a

context-dependent description, in which the learners can put themselves by taking account of the learning reference models (LRM). The learning reference model can be regarded in that case as without context. Only through the creation of questions referenced to the LRM and the inclusion in an authentic situation, takes place a contextualization of the LRM as a resource. The learning reference model can be used in other learning arrangements. The learning reference model represents for example a complex technical system, which can be used to specify a set of tasks respectively operational work orders. By reusing the learning reference model in other learning arrangements recognition is given and the learners do not have to re-learn new complex authentic situations again and again. The design and so the essential content of the learning reference model has to be learned and handled in one of the very first learning arrangements. The reference models are collected in a special collection area to enable an adequate assignment from the different learning arrangements.



**Figure 2.** Structure of the Didactical E-Learning Concept

Following the idea of an authentic situation, a specific problem or task has to be formulated to be processed by the learner. To perform the task all necessary information is provided as special prepared materials. Then there are lead questions for sensitization listed. It is e.g. depending on, whether a self-directed learning is planned or not and it is depending on the intention of the lecturer or the creator of a learning arrangement. The lead questions and the partial tasks give orientation and support targeted information recording.

To the learner a sample solution will be offered. That sample solution reflects a possible solution, which is based on the model of complete actions, see Fig. 2. The model starts with a planning phase consisting of the first four numbers. In the beginning, the objective has to be set respectively identified. For that it is necessary to collect the needed information. Then the situation has to be analyzed followed by the determining of sub-goals and working steps. The last step of the planning phase is the evaluation and the making of decisions referring to the individual action steps. Number five refers to the performing of the planned action steps and the last number six covers the evaluation of the result. The model of complete actions contains the decision making model. Each step in the model of complete actions includes a list in the correct sequence of the individual action steps. To every significant step a learning block (LB) is assigned.

The content of one learning block is closed thematically. In the e-learning solution there is a section with a collection of learning blocks. The creators of LA's have the possibility to select out of the whole list of learning blocks. Each learning block is similar to a module that need to be learned or processed to solve the main task defined in the first part of the learning arrangement. The reference to learning blocks is not incoherently, but where they are needed. Content will be transferred or presented if it is necessary. The concept gives also the possibility to an optional assignment of the sample solution, which allows moreover the consideration of the learners' previous knowledge.

The content of the learning blocks as well as the provided materials in the context of the authentic situation are partially interactively. It contains texts, images, animations, videos and also interactive 3D modeling files e.g. 3D PDF's and 3D Via Composer files.

Each learning block concludes with a knowledge check. These are interactive tasks, story or text problems and multiple-choice questions only referring to the learning block. The results are partly visible for the teacher. In the generation of new learning blocks different content can be taken, out of the collection of reusable knowledge elements (RKE). So the elements can be used in various learning blocks. These may involve for example formulas, special instructions etc. – it may be a security alert when there are learning blocks on work machines like a drilling machine or a CNC turning lathe.

In the course of processing, it is necessary as part of this didactical e-learning concept with the objective of a competence acquisition, that learner create their own documentation about the whole learning process. That documentation can be used for evaluation and beyond that, documentation is intended to represent not just a mere of the various processing steps, but also allows the learner to write their own notes and map new contexts.

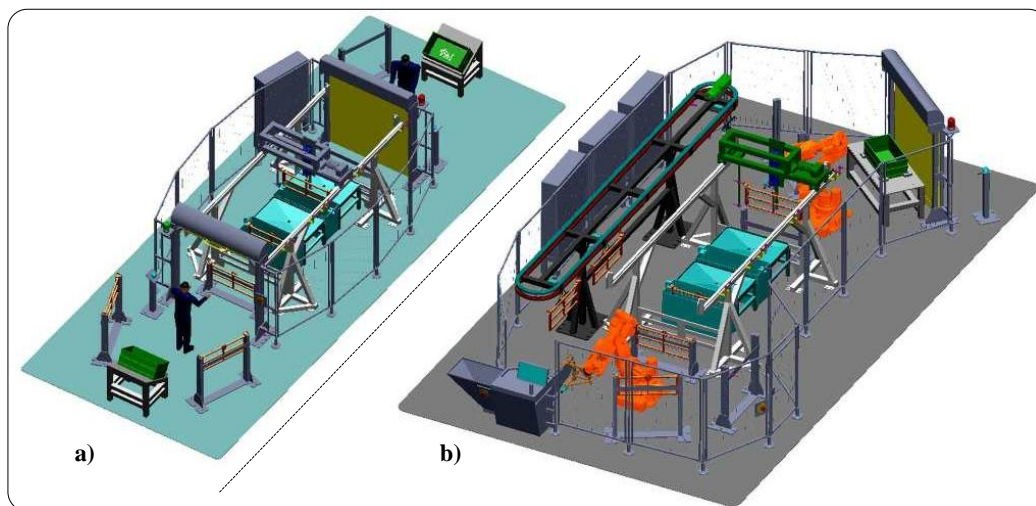
For the concept, it is essential that at each point within a learning arrangement, the learner can

take and use the provided content for documentation. For example it is necessary for learner to take formulas out of the content to describe it in their own words. Furthermore it is important for the learner to go back, to have access to previous learning blocks and already finished learning blocks need to be hidden or displayed automatically or individually.

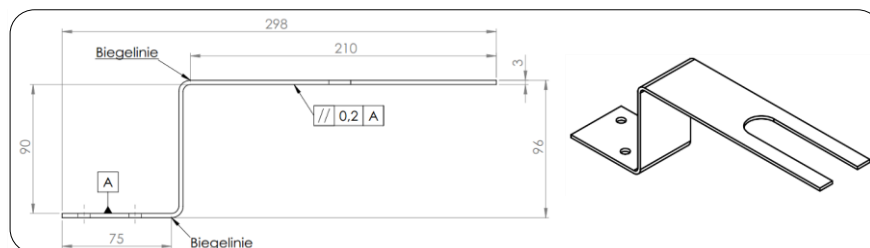
### 3.2 Implementation

Based on the structure of the new didactical e-learning concept eLeCo, the implementation in an internet based e-learning platform will be displayed by showing snapshots from the platform.

After choosing a learning arrangement the corresponding task or operational work order will be given to the learner. In this case, it comes to the manufacturing of a holder for mounting of sensors. The introduction of the learning arrangement creates a relation to a learning reference model. In Fig. 3 a) and 3 b) there are shown two different learning reference models as an example, which can be used to create complex tasks. These two production facilities are interactive and animated. The holder is used in the production facility to check the position of the moving component on the steel construction. There are also provided materials to solve the task. In Fig. 4 the drawing of the holder for mounting a sensor is shown and provided to the learner. After that, lead questions are presented.

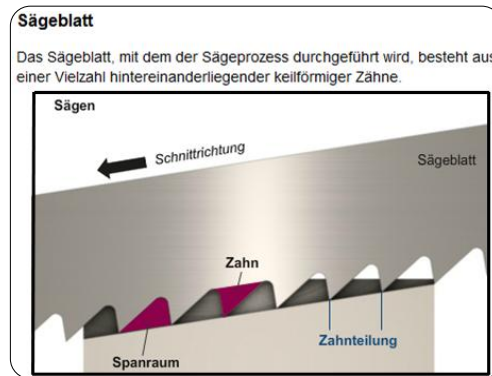


**Figure 3.** Learning Reference Models





**Figure 4.** Drawing of the Holder (drawing section)



**Figure 5.** Learning Block Sawing (image section)

The next step is the sample solution, which is based on the model of complete actions. Each action position in the model of complete actions contains a list with the relevant action steps. Each action step is referenced to a learning block. In Fig. 5, there is shown a part out of a learning block. The basics of sawing are presented by using an animation for support.

#### 4. Summary and Outlook

In the previous positions the fundamentals of the concept of e-learning and competence are described. Based on that, a new innovative didactical e-learning concept named eLeCo has been created and the implementation is partly presented. In educational institutions the e-learning solution can be implemented in current curricula and teachers can create competence-oriented courses respectively competence-oriented e-learning courses. Learners have the option to use individualized learning arrangements, so that they have the possibility to learn at their own pace regardless of time and place. Theoretical content with practical examples are linked. Existing knowledge of traditional-oriented courses are considered in an action-oriented context. Due to the didactical design, learners can acquire competences. The e-learning courses can be used in different forms, depending from the intention of teacher and course concept. As the distribution of learning arrangements is not linked to individual persons, cooperative learning is also possible. The solution of complex tasks is often done by using a solution path, which can often only be achieved in cooperation with others. By designing appropriate learning arrangements, situations can be created that make cooperative learning necessary. Further detailed contemplation leads to show of other positive aspects referring to the added value for educational institutions.

The e-learning solution considers also diversity, by each learner can learn according to his own pace, according to his previous knowledge and independent of time and place. Learning can be done individual or in groups. The aim is a holistic competence acquisition, which can be enhanced by heterogeneous groups. Diversity in that context is highly appreciated and should be viewed as a chance.

The new e-learning concept was realized in an e-learning platform by using Moodle. The implementation has shown that not all of the functionalities were available, that are necessary to

meet the requirements from the didactical concept. To realize a competence-oriented e-learning solution it is necessary that the used software solution can depict the concept in complete depth. Also it is necessary to have a special authoring system to provide the content in the required form, which is of course important in terms of recognition for the learner and to guarantee the structure.

A consideration of the new didactical e-learning concept eLeCo from the point of view of learners shows the simplicity and clarity of the concept.

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