Practical Implementation of Learning Fields in Vocational IT/CS Education – A Guideline on Designing Learning Situations

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ABSTRACT

The German vocational education is based on cooperation between training companies and vocational schools. To consider the ever-expanding demand on professional action competency, the curriculum of vocational schools also defines so-called learning fields ("Lernfelder") for the profession of IT specialist. Learning fields describe didactically reduced vocational activities using competencies and specific topics. The implementation at school occurs with learning situations which have to be developed by a team of teachers. Learning situations flesh out the learning field by the use of smaller, activity-oriented and topical teaching units. Teachers are often unsure how to develop learning situations, because there is too little material elaborating on how to create a learning situation in the field of computer science. This paper provides guidelines for designing learning situations in IT and CS and elaborates on how the guide was developed. A first experience of this guide's usage is also part of this paper. The learning situation "A marketing game: Developing a playful way of marketing in Java" was designed and evaluated for the 11th grade of IT specialist training.

Categories and Subject Descriptors

K.3.2 [**Computers and Education**]: Computer and Information Science Education—*Computer Science Education, Curriculum, Information Systems Education*

General Terms

Human Factors, Theory

Keywords

Vocational IT Education, Computer Science Education, Learning Fields, Learning Situations, Game Development

1. INTRODUCTION

1.1 The Vocational Education in Germany

The school system in Germany is diverse. Besides upper secondary school ("Gymnasium"), where students acquire general qualification for university admission, another way to start a professional life is to attend general or intermediate secondary school ("Hauptschule" or "Realschule") with more practically oriented general education. With each of these degrees they can start vocational education and training ("Duale Berufsausbildung"). There, the students pass through education and practical training at a company and part time vocational school. This system enhances the combination of theoretical and practical skills in the students. In the beginning of vocational IT/CS education, the students' previously aquired skills vary tremendously: some of the students have received no or only basic IT/CS knowledge. Many students earned a degree in upper secondary school, and some of them even took up computer science studies for some semesters. To manage those various preexisting skills, the teachers have to design their education very flexible in order to consider all different types of learners.

The curriculum of vocational education allows for flexibility, because it is based on so-called "learning fields" (Lernfelder). They do not consist of specific skills to be acquired but rather exhibit a description of different professional, social and personal competencies which the students should gain for their professional life [8, 1]. By combining theoretical and practical training, the students should be able to handle new professional situations. The focus of vocational education should be to gain professional action competency [8]. Although the curriculum consists of learning fields (LF)[1], their implementation at vocational schools is progressing slowly. It is a challenge to the teachers to split each LF into so-called learning situations (LS). LSs are small, activity-oriented and topical teaching units which impart the competencies of the LF. Each LS is based upon a working process with complex vocational problems, which can be solved by using professional action competencies [8].

Because there is too little material on how to design a LS in the field of computer science, teachers are unsure on how to implement them [10]. So this paper aims to lay out

[1]The abbreviations LF for "learning field" and LS for "learning situation" will be used in this paper

the development of a "*guideline for designing LSs*" to make it easier for teachers to create and use LSs. We also present the first usage of that guideline for development and evaluation of the LS "A marketing game".

1.2 Motivational Aspects on Designing LSs

In all teaching scenarios the question arises on how to motivate students. The "self-determination theory" of motivation by Deci & Ryan [3] establishes that the quality of motivation depends on the perceived competence to master given challenges, the relatedness to others and the perceived autonomy to decide for themselves. They distinguish between intrinsic and different stages of extrinsic motivation that vary in their relative autonomy. Extrinsically motivated actions with a high level of autonomy may be integrated into a person's self. Teachers should strive to meet their students' basic needs as closely as possible. As a consequence, the students will experience lessons as less regulated and their motivation can reach a higher level of extrinsic motivation. This will be an important argument for lessons with open teaching methods, group working and a high degree of freedom in solving IT/CS problems at school. Another way to increase the motivation of the students is to choose interesting contexts, which seems to be the broad field of game development [11]. Repp et al. related that it would also be possible to concentrate intensively on individual competency weaknesses and students' wishes. Webb et al. [14] confirm these findings by also suggesting strong gender effects. They used a pedagogical approach which is called "project-first", which avoids boredom by learning the necessary principles just-in-time by carrying out projects in game development, so students should get into the Flow [2], which is seen as an ideal condition of learning. It could be useful to develop at least one LS from the field of game development, which – depending on the training company – is an important part of an IT specialists' work and can be used to teach different aspects of software development.

2. DESIGNING THE GUIDELINE

2.1 Analysis of Existing Guidelines

To establish criteria a LS should comply to, the four main general approaches were analysed.

The criteria of the *KMK*[2] mentioned in the guideline on developing curricula for vocational education [8] only discuss some basic aspects a LS should have. The criteria of *Kremer & Sloane* [7] outline in detail the process of learning. The approach of *Wilbers* [15] is the one providing most practical hints and criteria to develop LSs, but less information about the process of learning. The main statements *Bader* mentioned in his article [1] are basic criteria on the one hand, and practical criteria on the other hand. Collating the four approaches, there are some similar statements, but also many differences. So we compared these approaches to get an overview of all criteria. We decided to consider all criteria found in our guideline. The development of the guideline was also influenced by the German IT/CS-specific open working group IniK ("Informatik im Kontext"). IniK "compiles educational material and concepts for teaching Informatics in context" [12]. On closer inspection, several links exist between the concept of IniK and LFs. These links will be pointed out in the following chapter.

[2]KMK: "Kultusministerkonferenz" (standing conference of ministers of education and cultural affairs of Germany)

2.2 Resulting Guideline for Developing LSs

All LS should be based on the curricular *principle of situation*. It demands that all didactical decisions should be made by reflecting whether the situation is relevant for the students' life [15]. This aspect is also found at the concept of IniK, which is being developed for general education at secondary schools [4]. The guideline (see fig. 1) follows this principle and is the result of a structured analysis of the four mentioned publications. A table of comparison was established including all found criteria. These criteria were acquired by adapting methods of content analysis. Our own written conclusions of the literature were split up in smaller units. This text passages were categorized by using a category system which was developed on the basis of the existing text. Therefore, coding-sheets were used and analysed and the categories found were allocated to the single text passages. The comparison of all approaches provided several items. Afterwards, the items were transferred into specific criteria. To develop a guideline, these criteria were arranged in logical relation as shown in fig. 1. We found *four main steps* to design a LS. These steps have to be carried out sequentially while always considering the previous steps. All steps described below can be found in fig. 1.

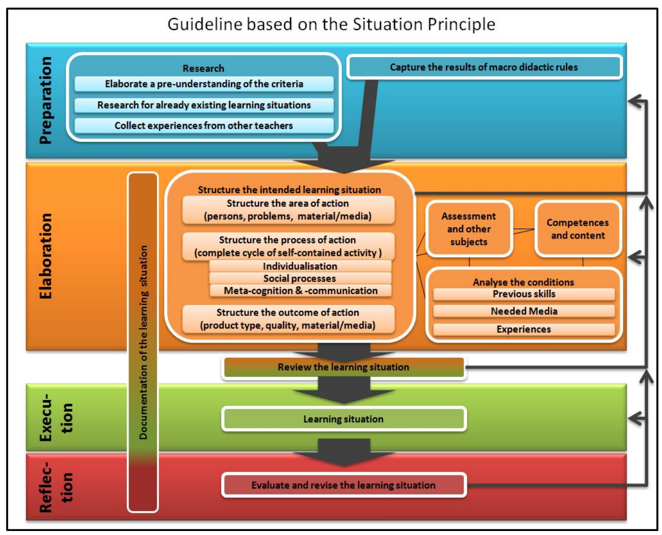

Figure 1: Guideline on developing LSs

2.2.1 *Step 1: Preparation*

Preparation includes two aspects: on one hand, macro-didactic rules signify didactic agreements between all teachers of a school. These agreements can vary from a consistent design of all worksheets to the matching of all LSs during one school year [15]. The second aspect is information research. There are three methods to gather as much information about LSs as possible. Theoretical literature can help to set up consolidated knowledge about the criteria a LS should comply with. With this knowledge, already existing LSs can be analysed and may be adapted for the given conditions. Another way to start developing a LS is to collect some advice from other teachers which may already have experiences in creating one. Both aspects only marginally influence each other, so they have no given order and can even be executed simultaneously. Unfortunately, there are only a few LS in the fields of IT/CS, so there is only little opportunity to exchange experience or material.

2.2.2 Step 2: Elaboration

The second step focuses on the *structure of the intended LS*. The structure of this step is quite complex and not linear, so each change in one aspect will probably be followed by changes in other aspects. On the contrary, there are many parallel working processes, which should lead to a valuable LS in the field of IT/CS. While structuring the area of action, it is necessary to figure out the roles of all persons who will be acting in the intended working process. Which specific problem the students should solve needs to be defined, and also what kind of material and media equipment (e. g. posters, computers, software) will be needed to find a solution. The structure of the process of action is given by the "complete action model of self-contained activity" which describes the cycle of action to solve a given problem and consists of different steps: orientation, information, strategy, execution and reflection. A specific outcome of an action should always be the result of the cycle of self-contained activity [15]. This outcome also has to be planned, e. g. the software which should be developed by carrying out the LS. The planning of the structure of the intended LS is influenced by three aspects. The first aspect consists of assessments and interdisciplinary aspects which should be included[3]. The second aspect is to consider specific competencies and content [15, 1]. The last aspect is the analysis of the given conditions, including previous skills of the students, the media needed and potential experiences of the students [8, 1]. Finally, the documentation of the LS can start during the step of elaboration, but extends until the last step of the guideline.

2.2.3 Step 3: Execution

The elaborated LS can now be applied in class in the following steps [15]: The area of action and the given problem have to be introduced to the students. One possibility is to present the complete working process to the students and to define the parts that should be worked upon, e. g. modelling of a software, testing an existing network or configuring a computer as part of a larger process. The students should handle the problem in a self-directed way and pass through the complete action model of self-contained activity. The teacher's role should be seen as adviser instead of instructor. At the end, the students present the outcome of their action. Occurring problems should always be noted in order to revise the LS for the next usage.

2.2.4 Step 4: Reflection

The last step in the guideline is to review, reflect and revise the LS. There are two different points of view:

Students involved: The whole process of experiencing the LS should be reflected, not only the students' outcome. It is important to give a consolidated feedback to the students [1, 7].

Teachers duty: Teachers should ask themselves which lessons were learnt carrying out the LS. It is also important to add these notes to the documentation of the LS.

[3]According to Koubek et al., contextual education always includes interdisciplinary characteristics [6]

Now the documentation can be finished in order to easily reuse or share the LS [15].

3. THE ELABORATED LS

We evaluated the usability of the guideline after its development and decided to develop a learning situation from the LF "*application development and programming*". This LF contains all topics of software development and is part of the curriculum in each year of training. The LS which we designed can only cover a few aspects of the LF. It has been specifically created to introduce Java as new programming language. We named the elaborated LS "*A marketing game: Developing a playful way of marketing in Java*".

Area of action: The students should imagine themselves to be employees of a software developing company, which is specialised in developing small games for marketing purposes.

Outcome of action: A small marketing game which provides information about "hypoallergenic dog food" has to be developed. The game has to be included into a webpage[4]. The players have to catch as much "hypoallergenic" food as possible and have to avoid pieces of "normal" food.

Process of action: The students should not develop the complete game, but the game objects (the pieces of food and the player). Another department of the fictitious company (represented by the teacher) provides the GUI, the game mechanism as well as the textures. Therefore the students have to consider the defined interfaces, as it is common in the field of software development. To introduce the LS (V1.0), a customer request via telephone should be played to the students. Each further version should be (depending on the type of change request) introduced by customer's or the second department's request.

The LS is built up in modules, so it can be used for different purposes and target groups. The game exists in several versions with increasing difficulty level. More challenging versions could be added for experienced students. It is possible to include more hints for students with less experience. The LS is also suitable for students of other school types. Due to the modular setting with different versions, the complete action model of self-contained activity has to be passed through several times by the students. Each version contains new competencies to be gained. The given Java code is documented in English, so English lessons could be included into CS and thereby the interdisciplinary learning.

3.1 Evaluation of the Developed LS

By trying out the LS, we were interested in the effects influencing students' motivation and interests as well as the competencies which have been gained. We tested the LS on an 11th grade class of IT specialists ($N = 17$). We used two different questionnaires for evaluation:

Development of the learning competency: The questionnaire by Schiefele & Wild (77 items) were used, which had been adapted by Wilbers [15] for the usage at vocational schools. Items are e. g. *"I think about the topic to ensure I grasped it completely"* (metacognitive strategies) or *"It is difficult for me to keep on topic"* (attention, answer has to be recoded). The questionnaire has a 5-point scale answer format ("very rarely" (1) to "very often" (5, high competency)). All answers were calculated to an average value of learning competency (internal consistency $\alpha = .95$).

[4]http://www.hypoallergenes-hundefutter.de

Subjective perceived boredom: The perceived boredom can be seen as the opposite of interest [5], but there has not been found any correlation between boredom and performance at school [13]. The questionnaire of Sparfeld et al. has been modified [9] for the usage at vocational IT/CS schools ($\alpha = .96$) and also uses a 5-point scale answer format ("never" (1) to "always bored" (5)).

We used a pre- and post-test design for both questionnaires. Our aim was to evaluate whether the students see themselves as less or more bored during self-directed work than in teacher-centred lessons and whether the students would gain learning competency by working on the LS.

3.2 Results of Evaluation

During the lessons, the students worked very interestedly on the LS. The introductive telephone call generated attention and motivation in most students. Most of the time, the students worked self-directed on the given problem. Students could work in their own speed due to the modular design of the LS. Therefore all students could have a positive experience in spite of the heterogeneity of their previous knowledge.

Table 1: Results of pre- and posttest

	Pretest	Posttest
L. Compet.	$M = 2.71$, $SD = 0.48$	$M = 2.72$, $SD = 0.58$
Boredom	$M = 3.00$, $SD = 0.75$	$M = 2.81$, $SD = 0.98$

The results of the questionnaires show values around the median (see table 1). It seems that one LS is not enough to increase the perceived learning competency. The boredom decreased between pre- and post-test, but a t-test showed that this difference is not significant. One limitation to this result seems to be the limited number of students. But we will repeat this evaluation in the next year to get more data.

4. SUMMARY AND CONCLUSIONS

Teachers at vocational IT/CS schools asked for supporting material to design LSs. The developed guideline passed the test by allowing designing of the presented LS. It was possible to create a LS in a very structured way and all necessary aspects were clearly arranged. So this guideline will be helpful for teachers at vocational IT/CS schools, especially for teachers with little experience in creating LSs. Our hypothesis was that the students' motivation would be high when designing a game, and this has been confirmed. The LS is completely documented, so it can be used as an example for interested teachers. The next steps will be to use the guideline to develop further LSs and to optimize the guideline using the experience given by the development processes for new LS. The guideline for developing LS as well as a representative collection of LS will help the teachers to implement the curriculum and to lead the concept of LF to a success.

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