E-Learning: Analysis of Different Tools for Information Management Training in University Education

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ABSTRACT
The information management discipline covers a wide range of topics and applications: Integrated business information systems (ERP-systems), data base management, business process management, knowledge management, conceptual modelling, business intelligence methods, calculations, programming and so on. If we want to support the university teaching with sophisticated e-learning tools, which go beyond the provision of information and learning material or simple multiple choice exercises we have to develop different tutoring tools for each subject area. Only such e-learning exercises that are specifically adapted to a subject area enable students to acquire and apply their knowledge in an individual and ambitious way. In this paper, we present e-learning tools, i.e. intelligent tutoring tools, of three different levels, that provide sophisticated e-learning exercises with as much degrees of freedom as possible during the problem solving process. After characterizing the different e-learning systems and analyzing their opportunities and limitations, we will focus on a tool for the data base language SQL. This tool is used at the University of Dortmund since several years in two different lectures for bachelor as well as for master degree. Evaluations of the tool’s usage in lectures show significant improvements in the understanding of SQL and the final grading.

Keywords: E-Learning, Management Training, Information Management, Tutoring Tools, E-Learning Tools, SQL Tutorial

Motivation
E-learning is commonly used for all kinds of learning where digital media are used (Wesp 2003). That means that as long as instructors or learners are using digital media in order to present, to distribute or to consume learning material as well as to organize courses/lectures or to communicate learning related we are talking about e learning (Döring & Fellenberg 2005). In general e-learning is mainly used for five tasks:

1) Administration
2) Provision/Consumption of Material
3) Practicing
4) Cooperation and Communication
5) Assessment and Grading

The administration task concerns the organization of lectures, i.e. building courses, mailing lists etc. The provision and consumption of material started about 20 years ago with the development of computer based trainings on CD-ROM, which allowed for the first time more complex forms of e-learning and practicing. It is closely connected with the practicing task. Since then, as in other areas of communication teaching has been heavily influenced by
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new information and communication technologies in recent years and decades. Since then e-learning research has always dealt with two aspects:

– Using new technologies in order to provide material that is up-to-date in a technical manner.
– Creating e-learning environments that are interesting to learners and really help them to learn and understand the lessons.

The first aspect influences the way of learning: At home or everywhere, static or mobile. There occur certain constraints or possibilities depending on the technology used for e-learning. But mostly, the concepts remain the same: Knowledge is presented via video or hypertext. Exercises consist of multiple choice, fill-in-the-blank, jumbled-sentences or wrong-false forms. But then, learners do not really need their knowledge because often they easily can guess the correct answers by systematically reducing the number of possible answers (König 2001).

Therefore, the second aspect deals with the concepts of providing information to learners: How could content be brought to learners in an interesting and didactically good way so that students or pupils do not get bored and really learn new and relevant things? Since many years, so-called intelligent tutoring tools are in the focus of research (Brusilovsky 1992; Döring & Fellenberg 2005; Patel & Kinshuk 1996; Siepermann 2005; Siepermann & Lackes 2007). These tools are developed for the purpose of providing sophisticated e-learning exercises that do not contain the solution of an exercise in a more or less apparent form. This is known to be the prerequisite for effective learning and good understanding, because learners have to find the correct solution independently, as they have to apply their acquired knowledge on their own instead of solving through the trial-error principles (König 2001). Although the use of such interactive and challenging exercises is often requested, (Haack 2002) they exist only sporadically

Requirements for E-Learning-Systems

An appropriate e-learning system should consider both aspects equally. To enable self-directed learning, which is generally regarded as the most efficient learning, (Kerres & Jechle 2002) a system should be technically up to date and use current trends. They offer numerous opportunities for e-learning tasks and tools and their interactive and multimedia nature are essential for e-learning. As a side effect, students are able to learn anytime, anywhere without restrictions via Internet.

Additionally, e-learning systems should give, if possible, direct feedback to the user, what solutions of a task were solved well or poorly (Bolliger & Martindale 2004; Haack 2002; Issing 2002; Siepermann & Lackes 2007). Otherwise the learning process slows unnecessarily and comes to a halt when the lag between processing of the task and feedback on the approach takes too long. In this case, learners might not remember exactly the problem and its solution, so that a smaller learning effect occurs. Be-sides the technical requirements, e-learning tasks should be more demanding and complex than the simple forms above (Higgings et al. 2005; Strzzbekowski & Kleeberg 2002). Otherwise, a learning process is normally difficult to be observed and measured.

One of the main reasons for the use of e-learning is the request for individual attention and guidance of the learner, based on their knowledge and skills. To ensure this in combination with time and location independently form of learning, it is necessary to provide support at any time. This should include a detailed feedback on errors, whereby not only the errors are determined, but also hints for correction are given. For individual support of the students the e-learning platform should provide milestones where students can always go into the subject. Otherwise slower students could hardly catch up to their fellow students in case of loss of connections. The knowledge gap does not necessarily increase through the use of
milestone with the progress of the course, but is limited to individual segments between milestones.

**Literature Review**

Having a look at the huge number of e-learning literature we can mainly distinguish the following streams: First, multi-media based e-learning systems were designed that used the rather new concept of hypertext and multimedia elements like videos and animations. Already in this stage, simple exercise forms like multiple-choice, fill-in-the-blank, etc. have been implemented and integrated into these systems. The predominant medium was the CD-ROM because internet connections have been too slow and only a few students really used the internet.

Many authors analyzed the success of e-learning when it is used instead of and in addition to classic teaching. There is a huge number of empirical studies showing that e-learning in addition to classic teaching is a benefit to the learner and working out the key factors of successful and satisfactory e-learning (e.g. Sun et al. 2008).

When the internet came into the focus of research, many authors designed e-learning systems for the administration of students and classrooms, learning material like lecture notes and recordings, addition-al material and also exercises, but still exercises on a quite simple level. Often, the technical aspect of integrating new media was in the focus of research. E.g. Higgins et al. 2007 give an overview over just the literature about whiteboards. Well known platforms like Moodle, OpenUSS, Blackboard (formerly known as WebCT) emerged from this kind of research. Still a few years ago, those platforms have been in the focus research (e.g. Brusilovsky et al. 2005).

Thus, creating e-learning systems has a long tradition. Already in 1987, Wenger presented a reference model for intelligent tutoring systems that was used and enlarged by several other authors (e.g. Brusilovsky 1992). Several authors investigated in the design and implementation of mathematical exercises. Patel & Kinshuk 1996 first presented an e-learning framework for mathematical calculations. They provided exercises for physical equations with multiple possible ways of solving. Lackes & Siepermann 2008 enlarged this approach for the net requirements calculation to a more complex and periodical calculation. Their tool does not prescribe any problem solving procedure. Students are completely free concerning their calculations. Other applications were designed for the logistics cost accounting and the classic cost accounting (Siepermann & Siepermann 2008).

Other authors like Higgins et al. 2002, Higgins et al. 2005 or Saikkonen et al. 2002 are concentrating on exercises for programming. This is a very difficult task because already the question if a program stops is not possible to be solved. To check the correctness, those programming exercises tools usually provide black box tests and syntax checks so that a big number of wrong and correct programs can be identified.

Starting with a framework for e-assessments (Tsintsifas 2002) graphical modelling has also come into the focus of research. Thomas 2003 presented an idea how to mark diagrams for a quite specialized application. Waugh et al. 2004 is based on this approach but does not describe precisely how the method is working exactly. Instead, different results of experiments with their system are presented (Thomas et al. 2006. Siepermann 2005 introduced the concept of automatically marking graphical models by covering the student solutions with correct parts of the reference solution and wrong parts of already marked student solutions, so-called patterns. Not recognized parts of the student solutions have to be corrected by instructors. Then, those parts can be used as part solutions during the marking of other student solutions. Thomas et al. 2006 also mentioned the usage of patterns. In 2008, they switched from ER-diagrams to sequence diagrams (Thomas et al. 2008). In Siepermann
et al. 2008 model checking was used as an alternative method for the marking instead of graph covering.

Since several years, game based learning has come into the focus of research. There exist conferences (e.g. European Conference on Games-Based Learning (ECGBL)) that focused on this special topic. But in game based learning, usually the didactical approach and the presentation of content are in the main focus, not the technical sophistication of exercises.

Classification of Intelligent Tutoring Tools

We distinguish three levels of intelligent tutoring tools: The most general level concerns exercises that can be used for any topics. But because of the generality, those exercises cannot deal with special restrictions of certain applications. Simple examples of such tools are multiple-choice or fill-in-the-blank exercises. Even in this generalized case, we can create more sophisticated exercises if we link exercises and students’ answers. Then, the next question in the line of exercises is not fixed but depends on a student’s answer. If the answer was wrong or depending on the alternative chosen, we can ask a second question checking whether there is an understanding of the topic concerned or not.

On the conceptual level, we can use e-learning tools where students formalize a given problem statement by using modelling techniques they learned before. Those exercises concern especially graphical modelling techniques. The syntactical rules of a technique have to be defined once in the e-learning tool. Then, only the e-learning exercises must be defined with their specific problem descriptions and reference solutions. On the basis of the syntactical rules and the reference solution, the students’ solutions can automatically be marked.

On the specialized level of e-learning tools, specific applications can be practiced, e.g. calculations like the net requirements calculation or data base languages like SQL. E-learning tools of this level are usually quite specific and developed for a certain application. However, also on this level, applications can be generalized so that tools can be used for different purposes. For calculations for example, the marking process usually is the same even if the applications differ. Thus, for each application, the underlying application specific calculation scheme has to be defined. Then, students’ solutions can automatically be marked. As a side effect, innumerable exercises can automatically be generated by the system itself. Practicing with programming languages like SQL needs very specific e-learning tools. It is not only necessary to define the syntax of the language but also to provide a system where the language is interpreted and an immediate feedback is given to the practicing students. In such systems, the students’ solutions can be marked concerning syntactical mistakes. But a marking of semantic faults is not possible in general. The system that we introduce later therefore provides a database environment to each student. There, students can build and work on their own “private” data base. Predefined data-bases and schemes are provided for case studies and consecutive exercises so that students can compare the output of their solution to the reference output and check whether their solution covers all required information. In addition, they can always return to different milestones provided in the learning process.

Examples of Intelligent Tutoring Tools on the General Level

E-Learning tools on the general level are suitable for all disciplines but very unspecific. They provide only simple exercises that are not very elaborate. The big advantage is that any conceivable topic can be covered by these exercises. Well known platforms like Moodle already provide these simple forms. The main disadvantage is that the exercise already provides the correct solution so that learners can guess (except for fill-in-the-blank exercises). Besides, exercises that are related to each other usually are not connected in the
system. That means that if we exclude randomly chosen exercises, all learners have to answer the same questions regardless of their level of knowledge and their answers to previous questions.

To overcome this situation, one approach is to interconnect exercises in order to react on the students’ answers: If a student answered a question right, we can ask an in-depth question or proceed with the next topic. If a student answered a question wrong, then the next question can depend on the given answer or respectively the selected choices. For each selected or not selected choice as well as for combinations of choices we can define which question is asked next. Thereby, we can react on knowledge gaps and check more deeply the real knowledge of a student. This can be compared to an oral examination. If students answered a question wrong, we can try to find out what he did not understand. Or we can give hints by asking an easier question. If an answer was correct, we can ask more detailed questions that are more difficult. By this, the difficulty level of questions converges to the student’s level of knowledge.

Another approach to design more sophisticated exercises on the general level is a question-and-answer based game (Siepermann et al. 2013). There, the learning situation will be as follows: For the learner, each exercise consists of a textual description. This description comprises a characterization of the situation and the problem the learners are facing. The description of the situation, as well as of the problem, can be incomplete and imprecise. Thus, the learner firstly has to understand the exercise. This can be the first part of the exercise that cannot be solved without further information. Therefore, the learner can ask the system some questions about the situation and the problem. Then, he has to structure the situation and the problem. He has to discover what he has to do in the situation and then how he has to act. If he knows this, he has to collect the information he needs to solve the problem. In each stage of problem-solving, the learner can ask the system questions about possible missing information. At the end, the learner gives the answer to the question that was initially asked.

The advantages are that it is not necessary to assess only the final answer. It is also possible to assess the problem-solving method i.e. how the learner managed to solve the exercise. The learner asks many questions that can be useful or lead into a blind alley. Depending on how determined the learner is focusing on his task, he asks further or fewer questions. If he asks many questions, we know that he is trying to guess the solution via trial and error. If he asks not enough, we know that he is cheating because he cannot know some information that is necessary for solving the problem. Furthermore, we can take the time into account that the learner needed to solve the exercise. All these parameters can be used to compute a grade for the exercise. It is obvious that such exercises cannot be of a discussion type. We need a certain number of result values, a simple word, numerical values etc. Between the information, given in the exercise or provided via questions-and-answers, there must be some mathematical or logical relationships. Information, including the results, provided to the learner is some kind of variable. These variables are then interrelated via formulas that can easily be stored and interpreted. Thus, the underlying structure is some kind of calculation grid that can be handled via calculation rules.

**Examples of Intelligent Tutoring Tools on the Conceptual Level**

Aside from the game based learning tool described above, the sophistication of exercises of the general level heavily depends on the question and the answers defined by instructors and not on the problem and the problem solving process. More sophisticated exercises must own more degrees of freedom than a set of predefined answers. The conceptual modeling is a typical field of application for this. In this field, students are usually facing a problem description that has to be modeled with a given modeling language like ER-diagrams or event driven process chains. In the offline world, learners can freely model any
structure with any symbol. If we want to support the learning process with e-learning tools, we have to limit this freedom in modeling by providing only a set of objects that can be used. But the rest of the modeling is not restricted. While modeling, students can use any of the predefined objects, freely name and interconnect them. For the marking process, there exist different approaches. The most promising approach is the one of graph covering (Siepermann 2005). When an exercise is defined, the instructor must define at least one reference solution. This can be subdivided into parts that have different values for the assignment and grading. Then, a student’s solution is compared to the reference solution. Or in other words, we try to cover the student’s solution with the reference solution or parts of the reference solution. Because this process only recognizes correct solutions or part solutions, also wrong patterns can be defined. If some parts of a student’s solution cannot be identified, the instructor has to judge if the unrecognized parts are correct or wrong. These newly defined parts are then added to the set of wrong and correct patterns so that the data base is constantly broadened. After a while, usually all student solutions can be covered with the help of these patterns.

The main advantage of this graph coverage is that it is only necessary to define the syntax of a modeling technique consisting of vertices and edges of different types and attributes. With the help of this definition, the syntax of a solution can easily be checked. The semantic marking of the exercise always depends on the exercise definition. But the marking process itself does not depend on the exercise and can be used in general for all kind of modeling technique.

Examples of Intelligent Tutoring Tools on the Specialized Level

Complex Calculation Tasks

On the specialized level, there are those e-learning tools that are especially designed for a certain application like the net requirements calculation (Lackes & Siepermann 2008). This is a periodic calculus in the field of production planning systems. It determines the amount and points in time of products and parts that a manufacturer has to produce or to order within his planning horizon. The net requirements calculation is a prime example of calculations that can be supported by intelligent tutoring tools. It consists of a relatively simple table structure with basic arithmetic operations between the rows of each column. The columns represent different periods and the result of a column is used in the following column. Therefore, the calculations of the columns have to be computed one after the other.

The calculation consists of simple mathematical rules and relations which are both well defined in advance. Because of this, it is only necessary to know the calculation rules and the input data. Then, the result can automatically and easily be computed. This makes it easy to mark any student solution automatically. The e-learning tool needs only to check whether the learner used the correct input data. Then, the learner’s calculation can be marked step by step. Even consecutive faults can easily identified. As a side effect, it is not necessary to define exercises. Because of the strict calculation rules, innumerable exercises can be generated automatically by the system.

As the marking process depends only on the rules and the input data, it can be used generically for each kind of calculations with strict calculation rules. It is just necessary to define the calculation rules and the relations between different variables. Also in some cases, the user interface has to be adapted.

Database Language SQL

A second example for intelligent tutoring tools of the specialized level is an e-learning tool for the data base language SQL. Still until now, modern information systems are usually based on an SQL database. As with learning any other programming language practicing with SQL is essential. Therefore, in 2003 the department of Business Information Management of TU Dortmund University developed an e-learning system that allows students to learn
independently and interactively SQL. The system is called WiSQL and it provides to each student a database separated from the database of other students. There students can work without any interference with others. This enables students to improve and consolidate their knowledge, without any installation and setup of an own database server, in relation to the implementation of Entity Relationship Models (ERM) in a SQL database, and the subsequent use and retrieval of data.

WiSQL is used in two ways: First, it offers students the easy opportunity to practice outside of lecture times SQL by working on a database. Second, the system is used as part of tutorials. Mass events make individual support difficult. For this purpose, there are tutorials in small groups up to 25 students, in which students are introduced step by step through SQL. Each tutorial consists of several small tasks which are solved together first and over the time more independently of each other. It is essential that the students practice the tasks directly on a database with help of WiSQL. Sample solutions to the various tasks are not made available, however, the expected expenditure of the various tasks are supplied. So the success control is possible any time. Since the tasks in the tutorials are based on one another, it is necessary that the above-mentioned milestones are provided by WiSQL, so that in the course of the tutorials it can be placed over uniform.

The portal is divided into the main areas Web Console, Documentation and Service. The Web Console provides the main functionality, working with a database using SQL (see Figure 1). The central item on this page is the SQL text area. This makes different functionality available for the interaction with the database. Core element is the SQL Input field. Here you can enter SQL commands which are sent to the underlying database management and which are validated. If the command was syntactically correct, the command is executed and in the case of SELECT-commands the result is. If the command contains syntax errors, the students will be informed. The corresponding error description is also given, so that the SQL command can be checked and corrected. Therefore, the previously entered command is received after sending the command. In support of the input, a list of existing tables can be found on the right side of the input field. Selecting an existing table inserts the corresponding table name in the SQL Command field.
As additional support WiSQL offers below the input field, a list of common SQL commands. This adds after choosing the syntax of the selected command in the SQL text box. Especially at the beginning this help supports the learning process, since learners do not have to interrupt the process for finding solutions to look up the syntax. The intellectual challenge then includes filtering of the relevant parts of the SQL command and the correct allocation of the necessary input data to solve the specified problem. In the course of the learning process this function should be increasingly replaced by the own knowledge of the students, but offers in doubt, still a quick reference. At the lower end of the SQL text area, the various milestones of the tutorials can be selected at the „Template selection“. This allows slower students who may have lost the connection, to draw level with the other students by calling a milestone. The milestones are pre-defined database schemes and data pools, which include intermediate goods, which the students reach in the ideal case itself through the solution of their exercises.

However, since errors in the design or implementation of the database schema and at the input or change of data in the database cannot be excluded, it is ensured by the use of the templates that the databases of students are up-to-date and correct, so that the learning improvement isn’t disabled by past errors. On the right side is the information part of the Web console. This includes the exact image of the current database schema, i.e. a representation of the created database tables, including data types and metadata such as the name of the parent column for foreign keys, or information about conditions not null. Clicking on each table generates a simple SELECT command so that the contents of a table can be viewed quickly at any time. At the lower end of the information part the so-called „Clipboard“, which has a history of the last ten entered SQL commands and can thus present
the course of finding solutions by clicking. The second main area of WiSQL the documentation includes instructions for using WiSQL, a quick reference and further reading. The methods of use explain the functioning of the portal and the restrictions that were made for safety reasons. The quick reference presents the most important SQL commands at a glance, explains their workings and the effect of individual parameters. The third main area service provides functions so that user databases can be backed up, restored, re-moved and analyzed. With the help of database backups, an intermediate state of its own database can be created and loaded again by using the restore function. Thus, this function gives the students the opportunity to produce an own model as you can find it in the web-console. The SQL dump (structure, data or both) offers advanced students the opportunity to export their work and to import it into a separate database server. The creation of a database schema allows students to generate the underlying database schema from their created database. Here, the native implementation can be compared not only with the desired schema, but here is also shown the immediate context of the process of database modelling and it is built a bridge between different parts of the curriculum. Furthermore in this area, all data in a database and/or the database structure can be deleted totally.

**Evaluation of the Use of WiSQL**

WiSQL is used in the lectures information management (IM) and Data Modelling and Databases (DB). Before using it in IM, lectures in IM were based on MS Access, in DB no system was used. In the winter term 2003/2004, the system was first tested in IM. In the first year there were no improvement achieved in the average score in the examination of the SQL task, but in fact worse. At first sight, this effect is surprising. Usually we expect that the usage of an e-learning tool improves the situation or at least does not change anything. But in this case, the average score declines quite much. The reason for this was that the system was instantly used in practical lectures after completion. But for lack of time, the documents for the teaching staff was not adapted fast enough. We used the system without proper documentation so that the educational aspect was not adequately adjusted. The didactical aspects were considered and integrated into the documentation just after the winter term.

After the adjustment of the documents and the preparation and adaptation of the didactic concept in the following winter term 2004/2005, there was a significant improvement in the average score noticeable (about 55% to 44-48% previously), which has since been a slight upward trend holds on the level.

In DB, the system has been used since the summer semester 2007. Based on the experiences in IM the concept was developed for this event prior to the application, so that in the first year was already observed a slight increase in the average score. Surprisingly, however, the score breaks the following year again strongly. This effect is due to two reasons. First, the considered task in the examination consisted this year not only from SQL functions, so that no perfect comparability exists among the tasks. On the other moved the supervisor of the lecture after many years. While the old instructor was able to prepare the students optimally based on years of experience for the exam, the new instructor had first to navigate in an orientation phase and was not able to point compared to before all possible pitfalls. After this familiarization phase, however, a significant increase in scores in comparison to 2007 is observed, which indicates that the e-learning system has led to significant improvements in this lecture in the understanding, too.

**Conclusion**

In summary, we can say that specifically appointed e-learning systems can sustainable increase the understanding of course content for students, if and only if the system is integrated seamlessly into the events and the educational aspect is adjusted accordingly. If
this is not the case, such a system can also act counterproductive. Additionally, an e-learning system is also not a general purpose weapon that can replace lectures or the experience of instructors. As we could see, the quality of a lecture is still largely determined by the lecturer. Students do not only learn from their own experiences that they can make when using the e-learning system. They also learn from experiences that other students made the years before. These experiences “live on” in the teaching experience of instructors. Over time, they are given from one student to another via the instructor. This procedure cannot be replaced by e-learning tools because the instructor’s knowledge is the essence of experiences of all his former students.

Concerning the satisfaction of students who are using these e-learning tools that we described above we always get positive feedback. In a survey with 170 students that was made after winter terms 2013/2014 more than 86% of the participants graded the SQL tool as “very good” or “good”.

As we can see, students greatly acknowledge the possibility of learning whenever and wherever they want to with systems that give reliable feedback to them. Nevertheless, the success of the e-learning tools has to be measured more accurately than by just evaluating the non-representative feedback that we get. Therefore, we designed a survey that measures the satisfaction of students with e learning tools as well as the success of the tools when used in addition to classic lectures.

References


