Adaptive Tutoring in Virtual Learning Worlds

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Abstract: To enhance the learning success of the learners in the Virtual Learning Worlds (VLW) and effective of VLW, the aspects like precognition and learning aptitude of the learners play a key role. The constructivistic approach based VLW not only offers learning, but also great experience by exploring through reality based virtual worlds. VLWs can be extended with such a Learning Environment. They are Novices or Beginner and need more explanations and instructions to understand a topic and resolve a given problem.
An Adaptive Tutoring System tries to find out the differences in precognitions and learning aptitudes and offers the learning task depending on these parameters. In the following paper a new system is designed for adapting a VLE to learners' need and presenting the learning tasks based on the recommended pedagogical approach.

1 Introduction

A Virtual Learning Environment (VLE) provides the opportunity to interact and learn in a virtual world, which is simulating the real environment, where the adopted knowledge can be used. The user of such a system learns as a result of experiencing and handling in and with different situations. The learning process in a VLE is based upon the constructivistic approach (see Bhatti, Hornung and Godehardt 2005).

Beside the constructivistic approach there are two other famous approaches which try to convey knowledge or give the learner the ability to appropriate knowledge in their own way, namely cognitivistic and behaviouristic approaches. Based on the type of knowledge the different approaches should be used for conveying knowledge (see Baumgartner and Payr 1997). Knowledge itself can be classified in three categories: declarative knowledge, procedural knowledge and Know-how (see Ryle 2003, Baumgartner 1993). But not only the type of knowledge are decisive for the best pedagogical approach. More important than the type of knowledge is the state of knowledge of each learner (see Baumgartner and Payr 1997).

To enhance the effectiveness of the learning process, a teaching system should consider the precognitions and learning aptitudes of each learner, who works with that system. Depending on these parameters the learner should be analyzed and the most effective pedagogical approach should be chosen.

This paper will describe a solution for a teaching system, which was developed in a research project (see Bhatti, Hornung and Godehardt 2005), which analyzes the learner before and while he interacts with a system and chooses the most effective pedagogical approach for that learner.
Further the transformation of the pedagogical approaches into the tutoring based teaching in a virtual environment will be described.
An exemplary scenario should clarify the operation methods of the adaptive tutoring system.

2 Adaptive Tutoring System (ATS)

The precognitions and learning aptitudes of each learner are different, so a tutoring or teaching system can be more effective, if it considers the precognitions and learning aptitudes of the learner. A system, which considers these parameters and adapts itself to the learner's requirements, is an adaptive system. If the learner gets instructions or assistances from this system, it can be called as an Adaptive Tutoring System.

To achieve such an adaptive system, first of all it is necessary to separate the learning tasks from the teaching system: This ATS is implemented in an already existing VLE (see Bhatti, Hornung and Godehardt 2005), which fulfills this requirement. The "Virtual Car Dealer" is a modular and customizable VLE solution. The VLE and the learning tasks are considered separately. Both are developed separately and then the learning tasks are integrated into the VLE. With this approach, one VLE can be used for a variety of learning tasks (see Bhatti, Hornung and Godehardt 2005).

Furthermore it is necessary to define criteria for analyzing the learner before and while he interacts with the system. After that, the ATS has to transform different pedagogical approaches, for usage with the VLE. The most common approaches are behaviorism, cognitivism and constructivism. Finally the learning tasks should be presented depending on the learner's requirement and based on the contemplated pedagogical approaches.

2.1 Pedagogical approaches

For presenting the learning tasks, the ATS uses different pedagogical approaches. The different approaches should ensure that the learning tasks neither under challenge nor overextend the learner, and it also ensures that the way of presenting the learning tasks fulfills the learners' requirements.

The most common pedagogical approach is the behaviouristic approach. It is a comparatively simple structured pedagogical approach, which postulates that the desired behavior of the learner should be recompensed and thus boosted. And a not desired behavior should be amerced or ignored (see Kerres 1998). Ignoring causes the "deletion" of the undesired behavior. (see Kerres 1998). So if a learner gives the right answer to a question, the system recompense the learner and if the learner just gives a wrong answer, the system ignores this answer and repeats the question.

In contrast to the behaviouristic approach the cognitivistic approach focuses the learner as an individual and his thought as the main aspect of teaching. Activating the cognitions of the learner is the main objective of this approach. (see Kerres 1998)

The constructivistic approach focuses on the learner as an information processing individual. Not the learner and his cognitions are the focus rather his interaction with his environment. Learning is a process of interacting in the environment and different situations.

2.2 Learner levels

The ATS tries to use the most effective pedagogical approach for the learner, who wants to learn with the system. So first it is necessary to find out which approaches are recommended for which kind of learners.

The DREYFUS brothers divide the learn status into five stages, beginning with the "Novice" and ending with the "Expert" (see Dreyfus and Dreyfus 1987). For each of these stages, there is one pedagogical approach recommended. For example the Novice can learn more effective, if the teaching system uses the behaviouristic approaches, in this case the learner can always see which answer or action was the right one, he needs strict instructions and detailed annotations. In contrast to the Novice the Expert does not need this kind of instructions it is rather destructive, if a teaching system instructs him that way. He gets bored, feels under-challenged and does not continue with learning.

The following figure shows the five stages of a learner and the recommended pedagogical approach:

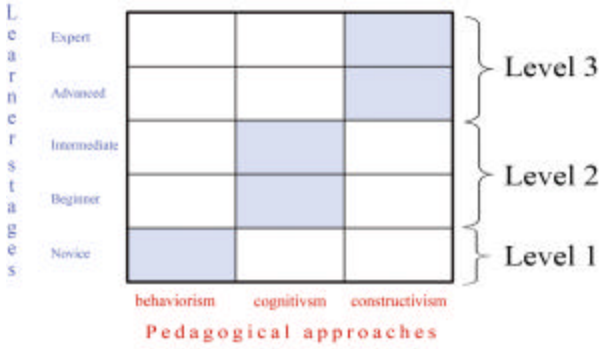

Figure 1: recommendation for the learner stages

2.3 Transformation of the pedagogical approaches

In the "Modular Learning World – Virtual Car Dealer" the learner interacts with an avatar as a representative of himself. With this avatar he is able to do all the necessary steps for resolving a problem in a virtual environment. The Tutoring System, which is described here, will attend the learner during his digression in that virtual world and support him, while he interacts with the system. The pedagogical approaches mentioned in 2.1 do not support such an interactive system, so it is necessary to adapt them for a VLE and for different kinds of system-support.

The behaviouristic approach proclaims that a right action or answer of the leaner should be awarded and a wrong one should be ignored. This pedagogical approach supports only the Novice in the Virtual Car Dealer.
The tutoring system uses the Behaviorism as follow: The system checks all actions of the learner, if the learner does a correct action e.g. fills out the right form on the right time, he gets an accolade from the system in form of text and voice. Otherwise, if his action in the system is not right, the system ignores his action, but considers the wrong action for categorizing the learner. The way of the system support is a detailed description of the procedure and the objective of a step for resolving the given problem. The tutoring system has the role of a teacher, who declares and supports the learner in every step, commending after a right step and ignoring his wrong answers and actions.

The main objective of the cognitivistic approach is to activate the cognitions of the learner. It stimulates the previous knowledge. The learner should be able to find a way for resolving the problem with its own knowledge. This approach is recommended for the learner levels Intermediate and Beginner.
The tutoring system uses for the learners in the levels Beginner and Intermediate the "Socratic Method", especially Socratic questions. With this method it is possible to activate learners' previous knowledge and stimulate him to think about the question or advice given by the system and so find out what should be done or which answer is the right one. A simple example for a Socratic question is: "What do you think is the easiest way to contact the distributor?", for a step in which the learner should phone the distributor. Of course this kind of questions only makes sense if the learner is in such a situation because the specific context is important.

The constructivistic approach, which is recommended for the learner levels Advanced and Expert, sees learning as a process of interacting with the environment in different situations. The learner learns with and from the interaction in the given situation.
A transformation of the tutoring system is not really necessary for this approach: The VLE offers a virtual environment, where the learner interacts in different situations. Only the system-tutor should adapt his instructions for this approach and of course for this level of learner. The tutor for these levels is an expert, who only gives instructions, if the leaner asks emphatically for aid. The expert just support the learner with its own thoughts beginning with for example "If I would be in that situation, I would think about … " or "I'm just thinking about another situation, which was really similar …". The tutor is hierarchically not higher than the learner; he is in the same level and appears only if he is asked for that.

2.4 Adapting Systems

Besides the adapting of the system while the learner works with it, two more points should be considered:

Before the learner starts to work with the system, the ATS should categorize him into a level. This can be done with specific questions, which can further be used to improve the system and create statistics. The developed ATS is for the car dealer's vocational training. The system questions before working with the system should contain: status of the vocational training (in which year of training), computer skills, school education (in Germany there are three different schools which provide this vocational training) and further demographic questions. With these questions the system will first make a suggestion for the learner level and while the learner works with that system it will adapt itself to his requirements.

The second point, which should be considered, is that the learner should have the possibility to choose the level and therefore the difficulty and pedagogical approach. Additionally it should be possible to turn off the adapting system.

The main feature of an adapting system is of course the ability to adapt itself to the learner's need, but which criteria should be considered for categorizing the learner in an interactive virtual learning environment? The learner interacts in the system with an avatar as a representative. So first of all, all interactions of the learner have to be recognized and registered by the system. With this procedure it is possible to analyze the learner's actions. The Virtual Car Dealer is a modular VLE, i.e. all the objects have their own behavior and can be customized. These graphical objects are complemented with a system-feedback-action. If a user clicks with the mouse on an object or interacts with the object in anyway it informs the system about the user's interaction, no matter if the action was right or not. As mentioned in section 2 the learning tasks are separated, the system compares the action of the learner with the learning tasks and finds out whether the action was right or not and in case of failure what can be the reason for this answer or action. All the information are separated and saved in a XML-document.

Further the time is an important criterion: how long does the learner needs to find the right step or answer. The system is always checking the time and sending this information to the XML-document which contains a value for the recommended time. If the learner is faster than the recommendation he gets a point and if he reaches a specific value he gets a level up.

With the actions of the learner and the time he needs for the action you are able to suggest the level of the "Procedural Knowledge" of the learner (see Ryle 2003, Baumgartner 1997) but the level of the "Declarative Knowledge" (see Ryle 2003, Baumgartner 1997) is not considered yet.

The "Declarative Knowledge" or "knowing what" means factual knowledge. This type of knowledge should be asked separately with multiple choice questions.

The following figure shows the procedure of categorizing the learner with the system diagnostic:

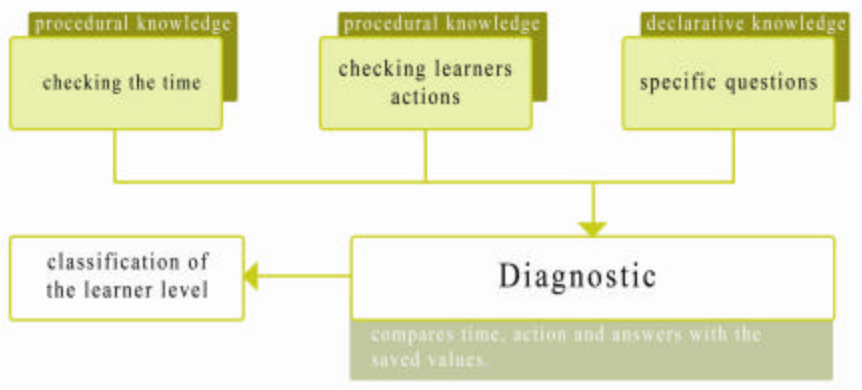

Figure 2: procedure of categorizing the learner

2.5 System Architecture

The ATS is designed as a modular and customizable VLE. All graphical objects and the different learning tasks are placed separately in the system. If a learner starts with working, the system creates a learner profile with all the necessary information about the learner in particular his learner level. If the learner chooses a learning task the ATS-Engine compares his level and suggests a pedagogical approach, which is deposited as a XML-document in a pool of learning tasks.

While the learner works with the system the ATS-Engine gets information about the diagnostic criteria from the VLW-Engine and compares them with the active learning task. If a learner asks for help by clicking the different help buttons in the system, this is also registered and sent to the ATS-Engine. Within the learning tasks, there are further questions for the "declarative knowledge" of the learner, which can be used by the ATS-Engine to categorize the learner too.

If the learner is too slow or makes too many failures, the ATS-Engine chooses the next lower pedagogical approach for the same learning tasks. The learner is not informed about the way of teaching and about his level, but he always has the possibility to switch to a higher or a lower level, instead there is no higher or lower level anymore. Otherwise if the learner is fast and all his interactions are right the learning task and the used pedagogical approach will be changed to a more difficult one.

The following figure shows a schematic construction of the system architecture:

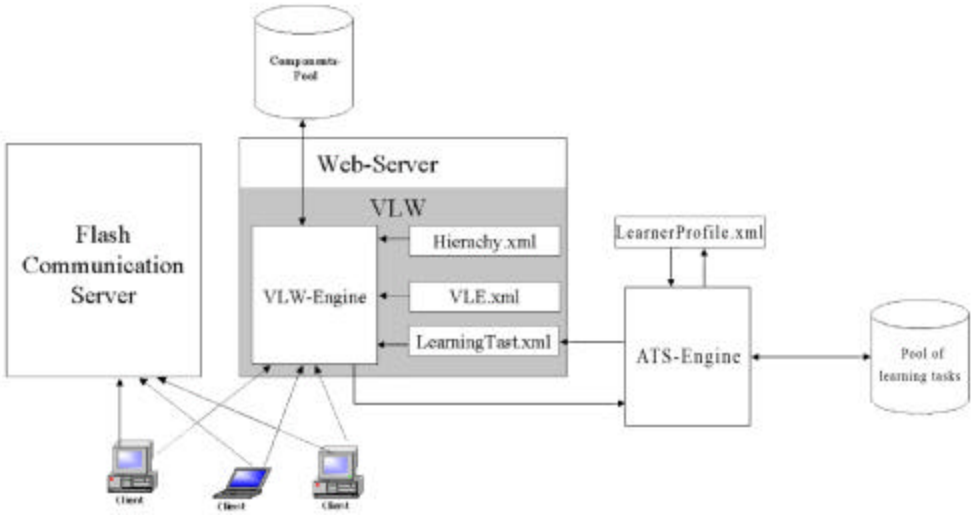

Figure 3: schematic construction of the system architecture

3 Case Study: Adaptive Tutoring in Virtual Car Dealer (VAH) based on MLW

The Virtual Car Dealer and the Adaptive Tutoring module is developed for the vocational trainees in dealer facilities with our project partners the German Federation for Motor Trades and Repairs (ZDK) and the German trade union for metalwork (IGM).
The vocational training in Germany foresees visiting vocational schools for theoretical knowledge and attaining practical experience in enterprises. The separation of theory and practical experiences offers a huge advantage. The

trainees get a broad theoretical knowledge about their profession in vocational schools as compared to work tasks based knowledge in enterprises. The business world is changing very rapidly, which requires continuous modification of theoretical knowledge. Teachers cannot prepare teaching material according to rapidly changing business world. It causes a gap transferring acquired knowledge from vocational schools into enterprises. (see Bhatti, Hornung and Godehardt 2005)

The precondition to start with the vocational training is a school graduation in one of the three German school types. But there is a great difference between these three school types: The lowest school leaving certificate can be graduated after the ninth form, the middle school graduation can be graduated after the tenth form and high school graduation after the thirteenth grade. There are also differences in the levels of difficulty between these schools. That means that trainees who begin with the vocational training have total different precognitions, are in different ages and the way they learn are different too, because of the different pedagogical concepts in the different visited schools.

As we described in our paper (see Bhatti, Hornung and Godehardt 2005) about the Virtual Car Dealer (VAH-Virtuelles Autohaus in German) will be offered to trainees in vocational schools to learn different car dealer facilities specific tasks by applying their theoretical knowledge. (see Bhatti, Hornung and Godehardt 2005)

3.1 Pedagogic Support

Good pedagogy approach is to identify the best fit between tools/techniques and learning objectives. The design of VAH is based on the educational theories of cognitive and social constructivism. Virtual learning environment by using the constructivist approach offer great an opportunity to have powerful learning experiences through interaction within it. Learning in a VLE is an active process, the learner learns while he interacts with the virtual environments, which re-enacts a real situation, with gathering experience he is able to assure his knowledge.

The different precognitions and learning aptitudes of the learners should be considered too. This can enhance the learning success and make the developed system more user-friendly. That's why an adaptive system was developed for the constructivism-based VAH. We combined the effectiveness of the constructivistic teaching approach with the different pedagogical approaches, namely behaviorism and cognitivism, to enhance the success of learning.

Now the tutor of the system, which appears with voice-over and text, uses different pedagogical approaches, depending on the learn-level, while working or interacting with the system still uses the constructivistic approach. Only if the learner has reached a certain level, the system-tutor itself uses the constructivism approach too and lets the learner learn by exploring the virtual world.

The following figure shows in contrast to the "Model of Supplantation" (see Kerres 1998) how the system-tutor suppresses itself, when the learner reaches a higher level of learning:

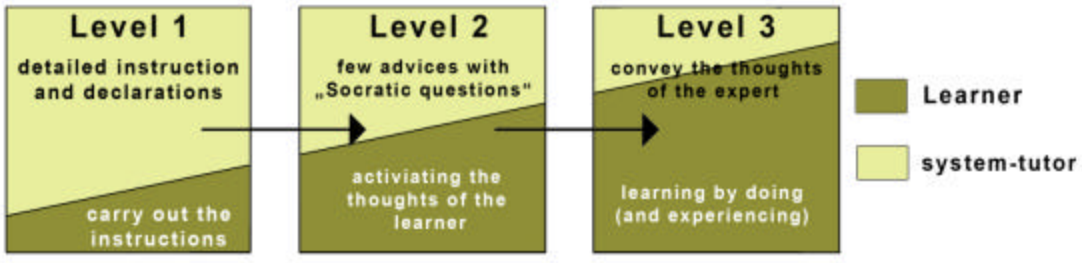

Figure 4: suppressing of the system-tutor

3.2 Virtual Learning Environment and adaptive tutoring

The VAH provides an experiential and exploratory learning environment for trainees in the car dealer facilities, which is further described in paper (see Bhatti, Hornung and Godehardt 2005). Beside an active working area, where an avatar can be controlled by the learner as his representative, there is a tutorial component for supporting the learner with instructions, advices or other types of support using the recommended pedagogical approach. The tutor uses text and voice for this support.

Every learner in every step of a scenario has the possibility to "call" the system-tutor for help; furthermore the learner of the first level has the possibility to activate the demonstration of the step. In this case the system shows and describes the step in the virtual environment. The learner has no more the control of the avatar, but can stop the demonstration-mode every time he wants. For recognizing that these actions are not done by the learner the color of the virtual environment changes and the learner sees always at the top of the screen that this is the demonstration mode.

But only the learners in the first level have the possibility to choose this kind of help, if there is a learner of a higher level, he cannot see this option and thus he is not able to activate this function. Only the most important button, the "tutor help"-button is available for all levels of learner. So not only the pedagogical approaches and the difficulty of the scenarios change but also the types of learners support.

The VAH is built up with two main components, visible for the learner: first the virtual world, where he is able to interact with his avatar and resolve given problems and second the tutorial component, where he gets support from the system-tutor and the most important information about the current scenario.

The following figure shows the design of the VAH:

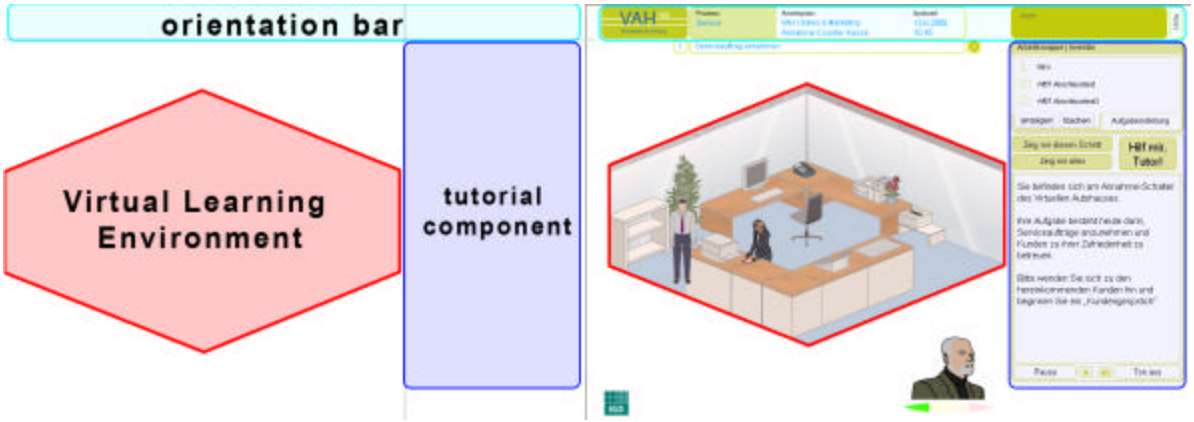

Figure 5: design of VAH

3.3 Adoption of SCORM

To enhance the re-usability and interoperability across other systems, the VAH uses for the definition of the learning tasks the ADL SCORM Sequencing standard (see SCORM). This standard gives further the possibility to create dependencies regarding the learning objects. So a learner has to learn or to know a certain learning object before starting another one.

But the sequencing in SCORM only defines one dependency to pass the object. In a virtual environment there may exist more than one way to resolve the given problem, so the sequencing of SCORM was enhanced to fulfill this requirement.

3.4 Learning Scenario

VAH offers different business processes to trainees, e.g., service and car sales etc. When trainees select one process, they can see a graphical visualization of this business process in VAH. This graphical visualization shows an overview and course of the business processes through VAH. In this way, trainees can not only learn different tasks in VAH, but also get an overview and see the course of whole business processes through VAH. (see Bhatti, Hornung and Godehardt 2005)

Figure 6: Business process Service Car repairing

The learner is always conducted by the system-tutor in his learning process. Depending on his learner level the tutor appears more or less to support the learner.

The learner begins a learning scenario with a map, which gives him the possibility to choose a training scenario. After he chose the desired training scenario, he enters a virtual room where a character represents him. Depending on the learners level the tutor gives him a first introduction into his task. For example a third level learner gets only the information about where he exactly is while the first level learner gets a detailed information about where he is, what he should do, why these tasks should be done and further information.

Now the learner has to start with exploring his environment and resolving the given task. Every action of the learner and the time these actions take are registered by the system to analyze his behavior in the virtual room. Additionally the learner has to answer some questions, which pop up. With this it should be ensured that the learner really knows what he did and why.

The system is able to jump between several levels and thus adapt to the learners requirements and the system always updates the learners profile correspondingly. It is not only for saving the status what he already did and what is recommended for him, the system also saves information about the success and how to grade the learner.

After the learner completed a scenario he gets information about what he did wrong and could it be right, what did he right but how could it be improved and statistic information about how long did he need for the scenario and how often he called the system-tutor for help.

4 Conclusion

The VAH is a virtual Learning Environment designed for trainees in German vocational schools, but also beyond that. These trainees are able to learn and train the theoretical appropriated stuff from school in a virtual environment without harming the enterprises they work in.

Because of the great differences in school education, precognition and age an adaptive tutor was designed and developed. This tutor tries to find a recommended pedagogical approach for enhancing the success in learning and motivating the learner, who works with the system. The adaptive tutor uses the most common pedagogical approaches for supporting the learner in his specific level. The way of support and the frequency of support depend on the learner's profile, which is a result of his precognitions, learning history and learning aptitudes. The system-tutor always analyzes the learner, while he is working with the system and adapts the learning tasks to his requirements. Further there are questions about the protection of data privacy, which are discussed in another paper (see Bhatti, Hornung and Godehardt 2005/ 2).

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