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Analysis of Virtual helps usage in a Virtual Environment for Learning

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Abstract

We have observed and analysed students' learning activities during a physics lab work performed in a virtual environment. Students had to learn how to measure the speed of light in the air, in a cube of resin and a tube of water. Different kinds of helps were provided: show an invisible thing, materialize an abstract concept, make explicit how it works. Quantitative and qualitative data were analyzed: we studied the case of each learner separately to point out specific behaviours related with virtual help usage. Our study showed that virtual helps must be offered so that learners could use them whenever they want. We have noticed that learners did not use them in a dynamic way and that helps were not well manipulated. Because this kind of virtual help is new for learners, virtual environment should give student some directions on the benefit they could gained when using them in their learning strategies.

Keywords: Virtual environment for human learning and education, Learner's activity, Virtual help.

Introduction

The study we present in this paper takes place in a more general project that aims to develop a Virtual Environment for Human Learning and Education (VEHLE), based on virtual reality techniques and that embed an autonomous Intelligent Tutoring System (ITS). Virtual Reality (VR) offers potentialities to ITS, such as allowing the learner to act and feel like in the real world or avoiding expensive or hazardous learning sessions by using virtual objects. To achieve learning in such an environment, the learner must be able to manipulate objects in realistic situations. In this study, we have focused on virtual artefacts that can help him to learn. In educational software, pedagogical helps are mainly online explanations or external resources, making them passive objects. In VR based environment, help could be provided by adding new active elements in the virtual world. These virtual helps change dynamically while the learner manipulates the environment.
Our study raises several questions: when may a help be given? How can the learner interpret the help? What type of help and in which form the help must be given? To answer these questions, we want to characterise the virtual helps, i.e. point out its potential interest and its condition of use in a learning context where problems are solved. To do so, we set an experiment with learners doing labs work on a virtual workbench.

In the first part of this article, we set the theoretical framework concerning the use of helps in an educational context. Then we present the experimental protocol, describing how it was designed and what was observed. We also describe the virtual workbench and the virtual helps. Finally, results are given and discussed comparing the designer and the learne**rs'** points of view.

Guided learning and virtual helps

The learning context is a guided teaching, where the learner is not alone. The guidance concerns the techniques for preparing and marking the learning path. This may involve orienting, beaconing, situating or demarcating the learner's path. But guiding is not correcting learner's mistakes (Zachary, 1986). On the contrary, one has to help the learner to build his representations without modifying the task. In many cases, helps are clues that take part in the problem solution. In our case, if the learner fails, it is assumed that he lacks information about the situation: either he lacks some knowledge or he does not perceive some elements of the problem or disregard them. Indeed, objective of the helps is to clarify the problem without transforming it by simplifying or complicating it.

Reference paradigm and theory

For this study, we admit the constructivist paradigm about learning. It means that learners build their learning by themselves (Piaget, 1974). In such a learning paradigm, helps which are given to learners must not either replace their thoughts or give the answer. Confronted to the problem, the learner needs to summon its personal resources and build action plans. In the act of problem solving, the construction of a mental representation is one of the main points (Richard, 1990). Furthermore, many didactic studies (Clément, 1994) have shown that the learners had various representations of reality and conceptions built on common sense. These conceptions are often obstacles to the learning (Bachelard, 1938), to the building of scientific concepts and to the modelling of reality as a scientist can see it. We claim that the use of virtual reality can help learners to build an accurate mental representation of the problem.

Reference context

We have started from a classical learning situation in sciences courses at university: the lab work. The lab work puts the learner into an active searching situation. He does not work alone because lab work involves a written or tutored progressive guidance.
In our study, we have reproduced a real physics work lab currently given at university. This lab work had been previously studied on the point of view of learning (Beney and Guinard, 2004). The authors have shown that the main failures came from the learners' wrong mental representations. Moreover, some studies have shown that the use of computer simulations introduced some wrong conceptions (Beaufils and Richoux, 2003). We have based our building of the virtual workbench and the virtual helps on those works.

Experimental Protocol

We have realized a virtual version of the physics lab work that has been tested on first year engineer students. Using results from the Beney and Guinard experiment on the real lab work, we have designed a new guidance, trying to adjust the difficulty of the task. Some learners may be able to achieve the task with only the written terms of the problem and we suppose the others would need the help to succeed.

The learners

Fourteen learners participated in the experiment. All of them were first year engineer male students and had the same scholar background toward physics. They were all familiar with virtual environment like 3D simulators or video games. Each student participated deliberately,

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knowing he was involved in a scientific experiment, but with no knowledge about the experiment itself. Material conditions were close to those that could be set up in a classical educational environment, but the experiment was presented to the students as a research one. The experimenters were researchers.

Experimental process

Each learner worked alone with one researcher in the room that only gave a feedback at the end of each exercise. Before the experiment, a short tutorial presented the environment and its interface. The learning session was split into three exercises (measure of light speed in air, in resin and in water) and each exercise was organised in three-timed phases: (1) alone without any help, (2) alone with helps, (3) solution given by the experimenter (manipulation only). Virtual helps were all available together during the helped phase, but learners could only activate one help at the same time. To limit the effect of help order, we have randomly associated a coloured spot to each formulation of these helps and we had stuck a spot of the same colour on one key. As the helps were dynamic (cf. below descriptions), the learners were told that they could manipulate the simulation with the help enabled.

The virtual workbench

The experiment took place on a classical personal computer coupled with a video projector, a keyboard, a mouse and a space-mouse (6 degrees of freedom). Learners stayed standing up in front of the screen (at circa 1.50 meters far from it) so they could feel as they were in front of a classical optical bench.

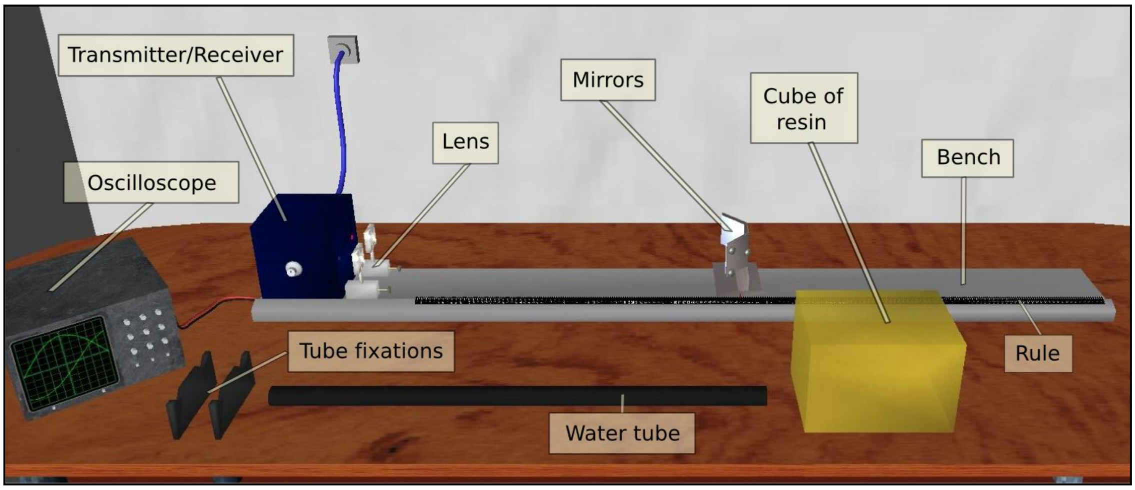

Figure 1 : capture of the virtual workbench

Due to the quite length of the experiment and to avoid learner's discomfort, we didn’t use a stereoscopic display. The virtual workbench had been built with MASCARET, a VEHLE framework designed at the CERV (Buche *et al.*, 2004). We have chosen a simple interface: it was therefore impossible for the learner to get lost in the environment, and hand gestures were quite similar to the ones made in the real experiment. We made realistic but simple 3D representation of objects and all learners clearly identified all the virtual objects: mirrors, rule, oscilloscope, lens, etc. To ensure these two points, the environment had been tested by experts and by students with a similar profile during before the experiment.

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Virtual helps

Here we are going to describe shortly each help that were available during the helped phases. For each help, we indicate its name, its type, a short textual description (the one which was given to learners), an explanation of the help usage (with a small screen-shot), and at last, a brief explanation of the interest of the help. Even though all the helps have a visual component and were designed to assist the learner while he constructs his representations, the first three helps were more visual ones and the last three were more cognitive ones.

1. Coloured air

Type of help: show an invisible thing. Materialize an abstract concept.
Textual description (blue spot): colour the part of air where light goes through.
Help behaviour: when the blue key is pressed, a blue transparent volume appears between the source of light and the mirrors. If one places an object on the path of the light, an equivalent volume of air is pushed behind the bench (see figure 2).

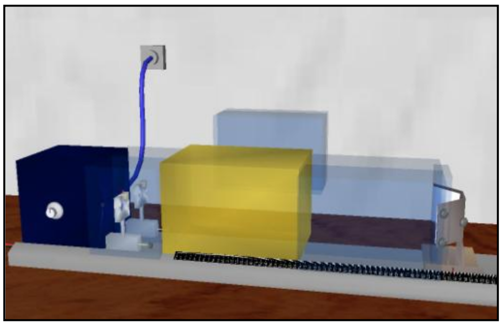

Figure 2 : "Coloured Air" help

Interest: without any object on the optical bench, this help is intended to show to the learner that the source light is neither at the beginning of the rule, nor at the side of the transmitter/receiver, but is located inside it. It also points out the distance between the two mirrors that the learner often forgets or ignores. Thus, it emphases that the actual length of the light path remains unknown. With a solid medium on the bench, some air seems to be pushed away. In this case, the help aims at pointing out the necessity of conserving the same length of air for the two measures.

2. Laser beam

Type of help: show an invisible thing.
Textual description (red spot): display the path of light.
Help behaviour: when the red key is pressed, the path of light is shown as a red laser beam (small cylinders, figure 3).

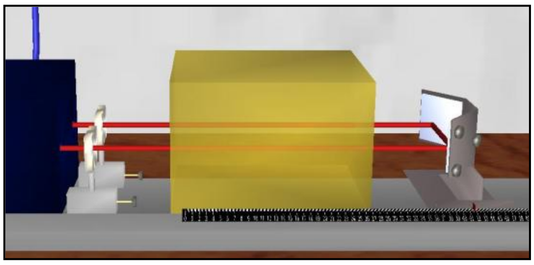

Figure 3 : "Laser Beam" help

Interest: the main interest of this help is to display the exact path of light and to point out its back and forth. Like the previous help, it also highlights the distance between the two mirrors. When the tube is on the bench, it helps to see that the light only goes once through water.

3. Slow Motion

Type of help: materialize an abstract concept.
Textual description (pink spot): Display the light move in slow-motion
Help behaviour: each time the pink key is pressed, a small red ball is created and that moves along the path of light from its source to its end. It goes 300.000.000 times slower than the light (figure 4).

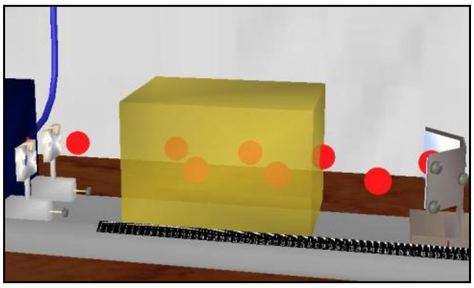

Figure 4 : "Slow Motion" help

Interest: again, it helps the learner to visualize the way of light. It clearly shows that speeds are different and constant in each homogeneous medium.

4. Simulator formula

Type of help: to make explicit how it works.
Textual description (grey spot): display details on the computation of the length as it is made by the simulator.

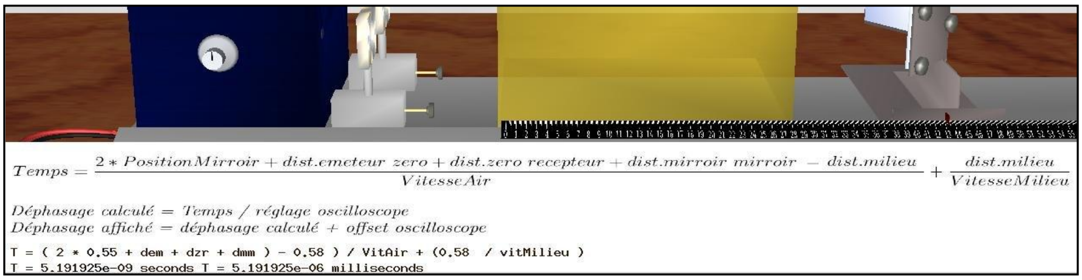

Figure 5 : "Simulator Formula" help

Help behaviour: the grey key displays the formula that corresponds to the computation made by the simulator (figure 5). The measurable lengths and computed time are also displayed and changed during manipulation.
Interest: this help helps the learner to find the good formula to compute the speed of light. It also shows that signals on oscilloscope are not predefined but really depend on its manipulation.

5. Automatic computation

Type of help: give a dynamic feedback to the learner.
Textual description (yellow spot): gives the value of the light’s speed as it could be computed, taking into account the actual position of the mirrors and their reference position.
Help behaviour: the yellow key displays a textual result on the screen. If the learner has made a well done reference, the result is stable for all mirrors’ position, and corresponds to the speed of light the learner wanted to find. If the learner has not process in the correct way, the result is variable and inconsistent.
Interest: it helps the learner to find the result without knowing how to compute the speed of light so he can focus on the manipulation problem.

6. Ghost trace

Type of help: materialize an abstract concept.
Textual description (green spot): saves and displays the position of mirrors and the corresponding oscilloscope signal at a given time.
Help behaviour: when the green spot is pressed, two new virtual objects are added to the scene: a transparent pair of mirrors, at the actual position of the real mirrors, and a purple curve on the oscilloscope screen (figure 6). Pressing another time the green spot makes them disappear.
Interest: with this help enabled, the learner didn't need anymore to remember about the mirrors' positions and phases between signals because the reference was staying on the screen. This help also points out the concept of reference and helps the user to learn it.

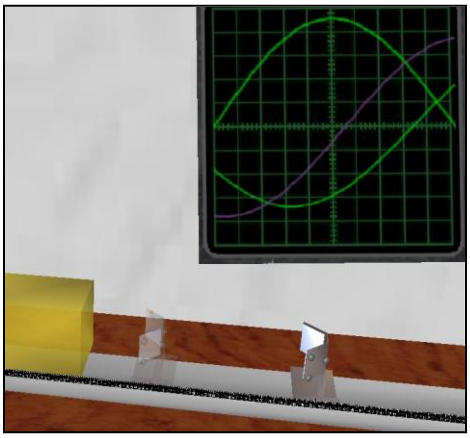

Figure 6 : "Ghost Trace" help

Results and analysis

The analysis was based on direct (almost objectives) and indirect observations (subjectives). Direct observations were: a digital log of learners, and video footages. Two other indirect observations were made: learners had a fifteen minutes oral interview immediately after the learning session and they were asked to complete a written questionnaire. The interview and the questionnaire intended to know the learner's expertise towards virtual reality, to get his feelings about the usability of the environment, to get his interests and preferences on virtual helps and to get a self evaluation of his work. We have focused on the learner's behaviour and understanding more than his learning efficiency, however, his success on each phase gave us indications on his performance.

Figure 7 shows the effectiveness of the helps from the learners' point of view. The three charts respectively correspond to the answer of these three questions: (1) what helps did you find useful? (2) What was the least useful help? (3) What was the most useful help?

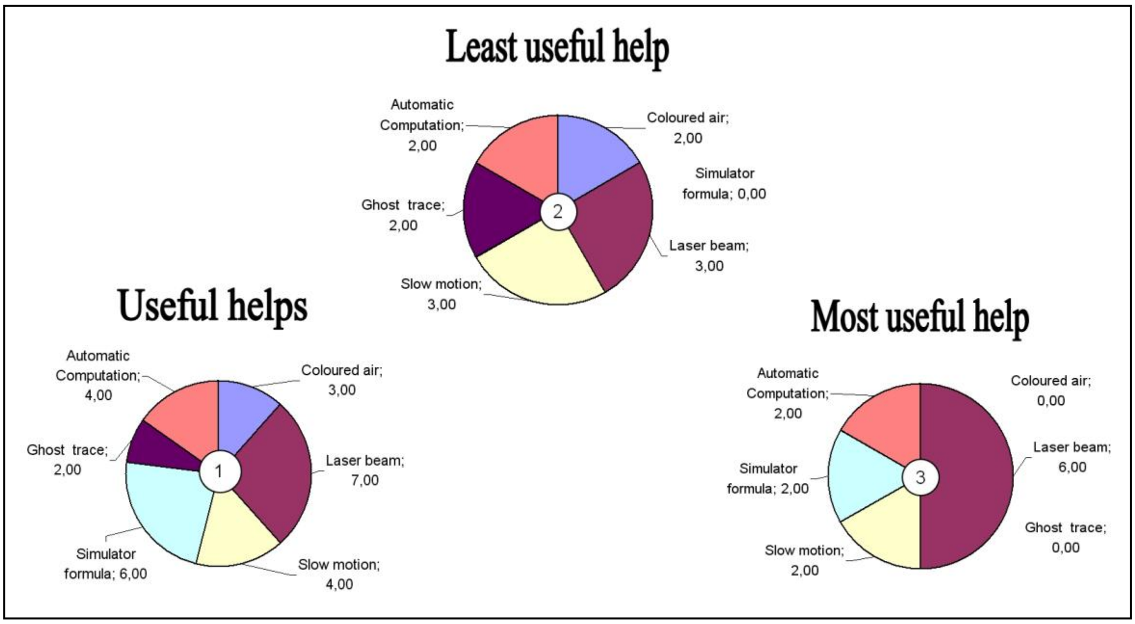

Figure 7 : answer to the questionnaire on usefulness of help

Some learners seemed to prefer the first three helps, which were more visual ones and others preferred the last three, which were more cognitive ones. The learners preferred the second and the fourth helps (laser beam and simulator formula). Each helps but the sixth (ghost trace) were at least once pointed out to be "the best help". (cf. Figure 7 - 3).

The experimenter observed that most of students displayed helps without really manipulating them, so as to observe their effects. It can explain the low score of the sixth helps, for which manipulating the mirrors was needed to observe its effect. The video footages permitted us to verify that learners had various strategies for choosing helps: some of them displayed all of the helps without selecting them by reading their textual description, others carefully read the textual description before making their choice and others just focussed on the first helps they tried without watching the others. We can hypothesize that the learners adopting the first strategy were searching for more information. For those who chose helps after reading the descriptions, we can consider that they already had an idea of their difficulties and were searching a way to go trough them. Generally, the helps that were used during the first phase were more reused during the remaining phases. It seems that the helps, which were not used in the first phase, were considered definitively as useless. Therefore the learners never used them again.

The utility of the helps was not perceived in the same way by learners, as revealed these quotes extracted from the interviews. Here are cites from three learners who succeeded the last phase. For the seventh person, the final success did not come from the helps: *"The helps have not been useful for me. I used them but I got a wrong result.";* the twelfth person appreciated a particular help: *"I have found that the really useful help was the red one, that posted the path of the light."*; According to the fourteenth person: *"The help that colours the part of the air which is gone through by light, this one helped me."*

Here are three other quotes from learner who solved the problem of the first phase after using the helps: *"Indeed seeing the given formula helped me"* (fifth learner);*"The help, the one that was useful for me, was a real advantage. Without it, I would have spent time. I would have been stuck by time"* (seventh learner); *"It was the grey one: the calculus of time; this one help*ed *me to compare …"* (thirteenth learner).

The helps were perceived in a different manner according to the success of the persons: the students who had failed in the three steps considered that helps were not really relevant. When the learners who succeed were asked which help was useful, they did not point the same helps. We also observed links between useful helps and typical errors. For instance, learners commonly forgot that the light came back from the mirror. The second and third helps aided them to correct this mistake.

Discussion

We made choices in our experiment to test the use of help. For this, we decided to give helps just after a certain period of time, all of them at the same time and during a limited duration. Students were only allowed to use them one by one. Those constrains may have had consequences on the way students used helps.

When the learners were resolving the scientific problem, they did not react in the same way, some manipulated more the environment than others, and some preferred transforming the problem from manipulation to formula. Therefore, it seems necessary to adapt the helps to each learner's profile.

We also noticed that, in spite of learners had found the environment easy and pleasant to use, helps were globally under-used. On the first hand, several users were not ready to be helped. For these students it was a matter of time: they wanted to complete their activity and therefore did not take the time to observe and use correctly the virtual helps. For others, the use of help was seen as a personal failure: they wanted to solve the problem alone and did not want to use helps. These observations show that helps are not always useful and must be given to the learner only when he needs it. On the second hand, virtual helps were misinterpreted by learners. Helps were given all together to the learners, with just a short textual description. Some learners did not understand how to use helps or what their utilities were and others misused helps or activated them at a bad time, making them useless. We noticed that learners carefully read the textual instructions given with the helps only during the first helped phase. And they made their choice at that time. If they found a help useless then they did not try it anymore.

As we noticed some students did not use a help if they considered it useless, even if it would have been useful in an other exercise. For a better use we should have added information on the function of the help. Using virtual help is different from manipulating virtual objects and needs another prior learning tutorial, where users can learn how to use these new kinds of helps.

Conclusion

This study allowed us to emphasize that virtual helps must be offered so that learners could use them whenever they want. We have shown that learners used helps in different ways. That confirms that a VEHLE must provide simultaneously a set of various helps from which the learner can pick one out by its own. We have built our helps, distinguishing visual helps from cognitive helps. Our study showed that helps were actually chosen and evaluated on their efficiency on these criteria.

We had chosen to build dynamic helps so as they can enrich the virtual environment and integrate themselves in the learner’s activity. However we have noticed that learners did not use them in a dynamic way. Helps were not well manipulated. We suppose that this way of acting comes from a lack of habits. It seems as if an help was for learners a piece of information to be read rather than manipulated. Because this kind of help is new for learners, users need to learn how to use them. So it is necessary to anticipate a learning phase to use these helps.

Regarding interviews with learners, virtual helps can assist them to understand better the given problem and the physical concepts, but we haven’t been able to show precisely in which manner an help could be useful. There are lots of dependant variables and our panel was too small. We have showed in particular that the learners had various strategies for selecting helps, that they had preference according to whether the helps were visual or cognitive. Some helps seemed to be more effective at some parts of the exercises and in precise context. Moreover, too much helps at disposal could hardly be used because of the difficulty of the choice for the learner. So it seems necessary to select carefully a set of relevant helps and to provide them at the right time, i.e. when the learner needs assistance and perform a task for which the help can be efficient. The necessity of such an adaptive behaviour needs an acquiring knowledge about the learner’s profile and about the current pedagogical situation. We are going to concentrate our research in those directions (adaptation to learner and context) in order to characterise better the efficiency conditions of these virtual helps.

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