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Design of learning environments for Mechanical Engineering

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Abstract

In what follows in the present paper, we firstly present an immersive learning tool that aims to help students to improve their machining skills. The experimentation highlights the use of a virtual reality environment called MecaTeam 3D by teachers. Secondly This work try to understand how they explore and use a virtual reality environment and how they adapt themselves to this teaching environment.

Keywords: MecaTeam 3D; virtual reality environment; immersive learning game; machining skills.

1. Introduction

Numerical tools for learning such as learning games have shown their performance in professional training, and in particular for teaching professional skills in technical contexts.

Our works on (Mecagenius®) [1] a learning game in a mechanical engineering workshop, showed how this learning game can accelerate the learning process. This research also highlighted that knowledge transfer could be further enhanced by taking into account the whole depth of the professional situation and reproducing real world scenarios [2].

To achieve this, the research team turned toward virtual reality. The recent advances in this field coupled with the result of research in Human Computer Interface (HCI) [3]; [4] can be used to create an immersive learning environment in which the learner have to perform tasks using his hands and natural interaction techniques while immerged in a realistic work environment [5, 6].

This article presents an immersive learning game that helps students improve their machining skills.

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2. MecaTeam3D presentation

MecaTeam3D is an immersive innovative learning game using VR headset and command levers developed by the Serious Game Research Network. It is supported by local fundings: Région Midi Pyrénées. This immersive learning game provides a virtual interactive environment representing with high fidelity machine-tools in a mechanical engineering workshop. In this environment, equipment can be manipulated throw a VR headset and control levers. Thus, user is able to control and simulate a machining ion in this virtual world. This digital learning environment offers an opportunity both to discover a machining workshop, to learn to use NC machine tools and to learn to optimize manufacturing process.

Virtual reality and new generation of interactive systems open up new prospects for learning [7, 8]. These new devices offer the possibility to reduce the complexity of real technical contexts focusing only on specific characteristics of the environment. The application aims to offer a virtual technical experience using a that support learning by training. It should facilitate a transfer of knowledge and could be re-used in a real workshop.

Fig. 1: An example of an immersive learning game.

Fig. 2. *Machining procedure mini-game*

3. Experimental protocol

Our research, concerns a didactic analysis of the first experiment using this VR environment in a learning context. The experiment was carried out with mechanical engineering teachers of the IUT GMP de Toulouse (eq. to a two-year undergraduate diploma in Mechanical Engineering). In this paper, we analyse the way teachers interpret the context of VR. The point is how they imagine to use this support to produce new courses and how they wish to adapt to this new media. In other words, teachers are the first targets of this experiment because they represent one of the main future end-users. They are the ones who will intend to practice those tools in the classrooms. Face-to-face interviews were conducted and teachers were asked to give feelings and feedback after they experiment the prototype. Questions also focus on the usefulness of the prototype according to according to their own experience and their own expertise.

The teachers were asked to perform the activity using the VR interface we offered.

The main objectives of the experiment are:

- Validate the relevance of the tool for educational activities.
- Evaluate the interest of teachers for this possible innovative way of teaching.

In this study, we choose to investigate and favour the fundamental disciplinary knowledge and know- how. To that end, we analyse the teacher's practices. As many authors [9] & [10], we think, that the broadening skills and knowledge in a virtual learning can be applied to the real world. Virtual Reality environments can be efficient tools for sensori-motor training as they enable knowledge transfer to real situations. We will first describe the methodology we followed to define indicators that allows us to quantify Mecateam3D's contributions. And then we will present the first feedbacks of the teachers after the experiment.

3.1. Methodology of MecaTeam 3D

Our study focused on two learning situations described below (turning operation learning and tailstock center setting). This experiment allowed us to catalogue the usage teachers could have and to experience digital educational supports for the teaching community. In this set of experiments we explored the user's reflection and usage of MecaTeam3D. We consider that teacher's professional gesture carries their experience and their personal style. The situations that were offered to the teachers had to reflect the reality of the usage encountered in CNC machining. The simulation embeds the "fictional" name of the machining tool, a task description and, in some cases, specific characteristics of the professional context. The goal intends to offer to the teacher a realistic representation of the professional task that fit to their expectations. This didactic exploratory research explores the "mirror effect" that takes part in teaching. The mediation which we take into account is the reflexive picture between the teacher job's representation and the way MecaTeam3D represent the job. During the experiment, the teacher's knowledge enables us to better define the skills to target. When experiencing the simulation, some criteria such as abilities, attitude, behaviours and intellectual strategies indicate whether a skill has been well targeted or not. Teacher is the prime witness of what is said and done during the students' training, as the result, their feeling, testimony and observation using this innovative tool is very important for future development. The methodology we offer is based on a systemic user- centred approach that allows us to describe the system as a whole. To gather the data we needed and understand how teachers act and react using MecaTeam3D we implemented two monitoring tools:

- A post-experiment form where they gave feedback on the pedagogical experiment they experienced.
- Live logging of observable traces during the experiment (actions, communications, performance,) that allows us to retrace the activity.

In this article, we only will focus on teachers' feedback given through the form.

3.2. Using context of MecaTeam 3D

Virtual Reality is a media that offers new way of interacting with a virtual world. Most (75%) of the participants experienced it for the first time and half (47.1%) of them had never played any video games before. As a consequence, the first stage of this experiment consists in familiarizing them to the VR world during 15 minutes. To do that, they must manipulate the devices and acclimate themselves with the VR world. In this playful acclimation step, the interactive storytelling is presented. They met a robot that brought them to interact with a diverse set of objects.

Once they are familiar with the devices and the VR world, the teachers were immersed in MecaTeam3D. They enter in a virtual workshop where they were brought to use two machine tools. In the first scenario, they used a conventional lathe. They were given a workpiece on which they had to perform first a facing operation. This operation consists of machining a plane perpendicular to the rotating axis of the workpiece. Then they had to perform a straight turning operation on the same workpiece. This operation consists in machining the cylindrical part of the workpiece. The tool movements to get the machining trajectory were controlled by the teacher. To do that he used the handwheels of the lathe to move the carriage on the corresponding axis. He had to perform the operations as they are described in the machining procedure. In case he had forgotten some machinings, a "head-up display" with all the information appeared when looking up.

Fig. 3. Scenario 1: machining operation

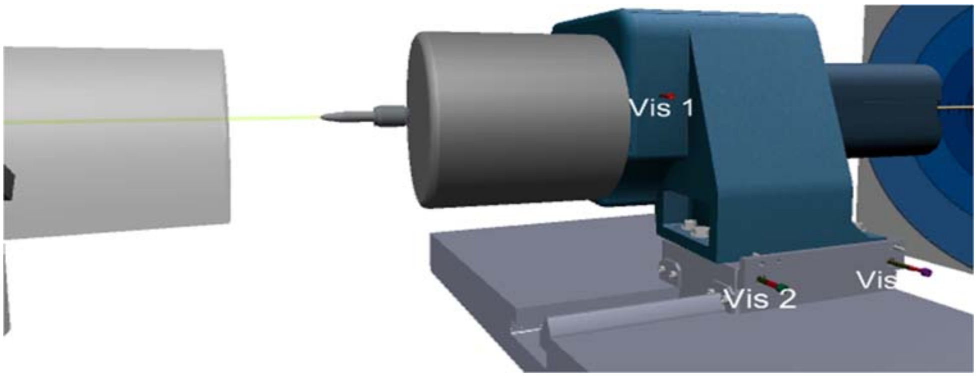

Fig. 4. Scenario 2: tailstock center setting

In the second phase, the teacher had to set up a CNC lathe. The first step was to put in place the tailstock. Then he had to adjust the tailstock center which consists of aligning the axis of the tailstock center with the one of the spindle using the three adjustment screws that enables to move the tailstock. The two axes were directly shown in the virtual world and the teacher had to use the three screws to align them (see fig. 4).

3.3. The experimentation of MecaTeam 3D

The experiment of MecaTeam3D took place with the teachers of the IUT de Toulouse in France. The population is composed of 12 participants, 80% man and 20% woman that used MecaTeam3D for half an hour. The participants were all volunteers. They were between 34 and 55 years old. They were non gamers with 47% not playing games and the rest playing less than one hour a week.

After the experiment, participants were asked to give feedback on the educational experience they lived. The online form they had to fulfill afterward aims to identify the teaching possibilities of MecaTeam3D, the perception they had of this virtual environment, the quality of this educational support and their appreciation of the overall experience.

4. Results

4.1. Feedback

In this section, we analyze the data collected in the experiment as described in the precedent section, questions were either open or rated on a 7-point Likert scale. Firstly, what came out of the discussions with the participants after the experiments is a sense of satisfaction for the product they tested. For each of the participants, they showed interest for VR world as a teaching tool; all of them were satisfied by the experiment and 64% of them rated their satisfaction at 7 (the maximum value) which is very encouraging for the interest aroused by MecaTeam3D (fig. 5). Furthermore 47% of the teachers think that MecaTeam3D could help them to train their students.

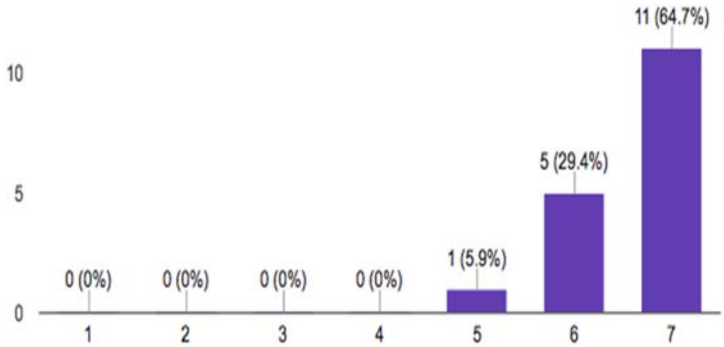

Fig. 5. *Proportion of teachers who appreciated MecaTeam 3D*

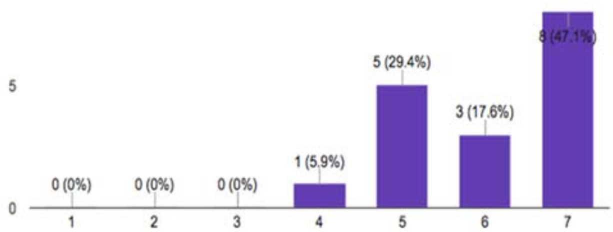

Fig. 6. *Proportion of teachers who think that MecaTeam 3D can be useful*

To study this "Mirror Effect", we examined what skills the teacher could identify in MecaTeam3D to ensure they were in adequacy with the skills that we targeted. They were then asked if MecaTeam3D was a learning vector and if it could be used to help students acquire skills in mechanical engineering. We grouped the most used terms when answering those questions and gathered the most used expressions. The three most used terms are (by decreasing order of citation): "efficient learning", "initiation", "no risk of accident". Here are two sentences:

- "I think this could be a good initiation to machining basics"
- "Yes, this could avoid destruction of equipment when making mistakes"

Those answers are bringing up two reasons to use VR in their training, the first one being the potential for teaching machining skills (71%), and the second one bringing up the risks of harm or destruction when using real machine tool (29%). Those two factors will be key to the design of future scenarios. We then sought out the didactic intentionality the teachers had for MecaTeam3D by asking them how they could use it with their students. The goal was to understand the trainer's teaching project, how they imagine they could organize their class and characterize the targeted skills. We took benefit of this experiment to check the usability of the product. Some teachers' sentences (written feedback) are mentioned below:

« When starting a cycle, can serve as a basis with no risk of destruction... »
« Machining initiation, machine setting in the first semester, machine architecture »
« Before the first contact with the machines »

The results highlight potential use of MecaTeam 3D, it is important to note that most (64.7%) of the teachers (those that voted 7 on a 7-points Likert scale) are willing to implement this tool in training context to initiate the students "before they access to real machines". The answers of the teachers allow us to validate usability [11] of MecaTeam 3D and the results show that teachers think that VR world will strengthen their performance and the performance of their students (fig. 6).

5. Conclusion and future work

Virtual reality opens new opportunities for training, lowers costs and reduces training time by removing the constraints of traditional training. Future work will try to determine if the use of virtual reality increases the training quality as suggested by recent studies [12]. The results of this first experiment show the teachers' interest for MecaTeam 3D and give guidelines for developing VR training world in mechanical engineering field. The experiment also gives us feedback to enhance the design of MecaTeam 3D. It will shape future work. The analysis of the data we gathered during the playing phases will enable us to follow the teacher's activity in details. We should be able to identify the deployed strategies and how they adjusted it or adapted themselves to this learning environment. This work should allow us to understand how they explore and use a virtual reality environment. In the next step, we will undertake a comprehensive study including students that are in different stages of their training in mechanical engineering (high school, college).

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