Virtual reality for agribusiness in the development of a maintenance simulator for agricultural machinery for *Senar Goiás*

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***Abstract*—Simulators that employ virtual reality are already used as an educational resource for agribusiness. However, such innovation faces challenges particularly regarding content and the respective educational project. This article exposes a case study on a simulator designed to provide training for the maintenance of agricultural machinery. Developed by *DOT digital group for Senar Goiás*, the product was tested by nearly 200 people at an agribusiness fair in Goiás. The study concluded the following: a need to integrate content development with software development, the importance of extensive feedback for the target audience and prior planning of the evaluative and instructional aspects of the simulator.**

***Index Terms*—virtual reality, simulator, agricultural machinery, training.**

I. Introduction

Simulators and virtual reality have been used in education and professional training for decades. Despite that, there are still challenges in planning instructional content and in evaluating the education provided, as such applications “are still performed in an improvised manner, without planning or research” [6]. This article aims to investigate the importance of developing and using virtual reality as an instructional resource for agribusiness.

II. Methodology

This article consists of a case study about the simulator developed by DOT digital group for the National Service of Rural Learning (“*Serviço Nacional de Aprendizagem Rural*”, or Senar) from the state of Goiás, Brazil. The purpose of the simulator was to increase the technical training of maintenance of agricultural machinery. At the end of this article are presented considerations about lessons learned in the project on virtual reality for agribusiness.

III. Simulators in Virtual Reality

Hancock [3] defines a simulator as any device that reproduces real situations in conditions of controlled use for educational purposes. Simulators give emphasis to realistic experience [4], as the actions performed in such controlled conditions should correspond to the real actions being reproduced. Through virtual reality, such controlled conditions prove different from “traditional media, as it provides immersion and interactivity through solutions supported by 3D.” [1].

Virtual Reality Simulators (VRS) are designed to train enactive abilities, that is, “cognitive skills originated in motor activities” [5]. VRSs can provide instruction for and evaluate enactive abilities in ways not possible through merely expository means. Using virtual reality, students learn enactive skills that are necessary in real situations within a controlled virtual environment which is free of risks and material waste.

IV. The Senar Challenges

Senar presented a demand for DOT digital group to develop the VRS aiming to make their “*Operation and Maintenance of Agricultural Tractors”* course more functional. The course has a 24-hour, in-person workload, and its target audience is comprised of individuals 18 years of age or older who work with agricultural tractors and wish to be qualified to work with such machinery.

Some of the issues presented by *Senar* were:

a) the need to concurrently instruct several students on maintenance of agricultural machinery due to the scarcity of available machines, such as tractors. The technician goes to the place where the students are. It's necessary to stand by one tractor to the classes, where the technician shows if the maintenance is done or not. This process is unpractical: sometimes is not possible to stand by a tractor;

b) the need to standardize the teaching methodology. The main goal is to teach the pipeline in detail, in the safest way and technically accurate. The pipeline can be different in some steps and it's judged in its final efficiency. In other words, there's more efficient ways to do it and it justifies the standards;

c) the need to eliminate material waste during training, such as oil and damaged parts. The maintenance always begins discarding the wastes. The simulation allows the student to do

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this without wasting oil, diesel, cooland, etc.

d) student safety risks while managing equipment. The inlife engine may be hot; if the radiator is opened in the wrong time it can throw hot gas; the engine fan can cut. All this stuff can be harmful to unprepared people.

V. ASOLUTIONS THAT WERE PROVIDED

A. *Who did it and when it was done*

The development team was composed of one project manager, two developers and one 3D artist, and was guided remotely by a *Senar* course instructor.

A 3D Unity graphic engine and C# language were used. While the project had an initial timeline of three months, the schedule was extended to five months so as to guarantee product quality and content development for future system users. It was realized between December 2018 and April 2019.

B. *How it was done*

The technical resources necessary for presenting a 3D environment and simulating real movements in a virtual setting demanded high-end hardware for the application, presented in Table I:

TABLE I. TECHNICAL REQUIREMENTS

Virtual reality accessory	Oculus Rift CV1 or latest version
Visual processing	NVIDIA GTX 1060 AMD Radeon RX 480 or superior
Data processing	Intel i5-4590 / AMD Ryzen 5 1500X or superior and 8 GB of RAM or more
Operational system	Windows 11.

Fig. presents how the system operates.

Figure 1. Individual experiencing the simulator.

Fig. 1 shows: 1) the VR glasses used together with headphones, which enriches the immersion experience by providing background noise and sound response for the tasks;

2) the screen showing the virtual reality seen by the user so an instructor may follow; 3) the computer used for simulation with sensors adequately positioned within range of the glasses, controllers, keyboard and mouse to allow the instructor access to the activity; and 4) touch controllers which capture and reproduce hand movements in the application and allow learners to trigger actions by clicking the buttons.

The developed VRS affords learners an immersion in a virtual scenario which presents challenges related to agricultural machinery maintenance through tasks.

The simulation demands that users control the situation through head and hand movements while offering them extensive audiovisual feedback as to how and why each task should be performed.

Every process that demands learning involves a series of sensorimotor tasks, for example: “remove a screw”, “check oil reservoir”, “fill oil reservoir,” etc. The objective of the simulation is for the learner to execute each task correctly and in the adequate order demanded by the activity. Such learning occurs enactively [5]. In other words, it begins in a sensorimotor manner and consolidates itself on a cognitive level through the comprehension of what each action means.

Fig. 2 details the three activities from the simulation content:

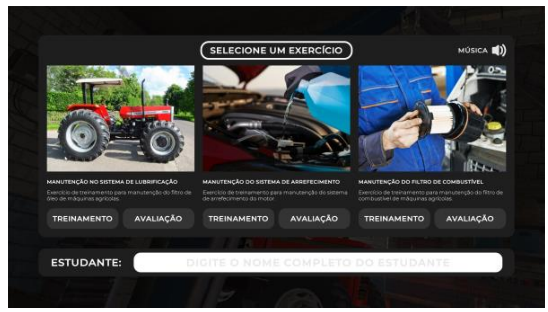

Figure 2. Activity selection screen

Fig. 2, from left to right: 1) maintenance of the engine oil system (16 tasks); 2) maintenance of the engine cooling system (17 tasks); 3) maintenance of diesel system (28 tasks).

The learner may perform each of the three activities in two ways. The assisted mode offers step-by-step application support with written instructions, tooltips and highlighting parts for “tips”. The evaluative mode is like the assisted mode but offers no help and user performance is graded: each task that is executed correctly and without assistance is worth 1 point; if the user requests assistance, that task is worth half point. If the learner decides to skip the task, no points are the earned.

Fig. 3 presents the student perspective on the simulator in first person:

Figure 3. Training mode feedback and guidance.

Fig. 3 highlights the visual feedback that is produced to guide the learner: 1) a sparkle of light on items that should be used in the current tasks; 2) a blackboard containing tips and information about the task to be performed; 3) a checklist showing the task of the current activity; 4) a resource board that reproduces instructional videos, texts and images.

Fig. 4 presents the learner perspective during simulation:

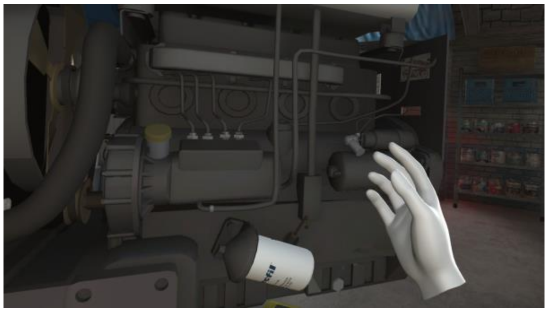

Figure 4. Oil maintenance activity in assisted mode.

The virtual representation of the learner´s right hand operating the virtual engine is seen. The movements of the virtual hand correspond to the real movements being performed.

C. Results

The VRS developed for Senar Goiás is currently in release candidate phase and cannot yet be characterized as a commercial release version. It was showcased at an institutional stand at the Tecnoshow Comigo Fair which took place between April 8th and 12th, 2019. The event is one of the largest agribusiness fairs in the country, a sector that generates close to R$ 3.4 billion and nearly 8,000 jobs [2].

Around 200 people tried the product during the fair, including the president of the Goiás Federation of Agriculture and Livestock and other Senar Goiás authorities, such as the Superintendent, the Formal Education Manager and the Regional Coordinator of the institution.

VI. Final Considerations

Although this project did not introduce any technological innovation to virtual reality use, its true challenge was in developing a pilot project. There were no benefits to planning and execution from prior findings. Therefore, the greatest gains were in recognizing and documenting aspects that should improve to serve as a reference for future projects.

The first of these was the necessary relationship between content and software developers, as some mechanical details cannot be produced in virtual reality, such as for example “pulling and feeling belt tension” (not viable due to lack of tactile feedback offered by specialized equipment). Course content must be developed considering the unique characteristics of virtual reality. This means the content developer and software developer must work cooperatively from the beginning of the project. Although the virtual reality created for this purpose can be initially strange, it's an intuitive way to learn. One session was enough to the Senar teachers learn even with the limitation of the tactile feedback. The adaptation time of the student is quick: in one session they learn enough to teach others.

The second aspect was the importance of offering extensive feedback to learners was observed (see Fig. 3), considering the target audience is likely to have little or no contact with virtual reality normally. Feedback should be communicated using interface language that is familiar to the learner so that the experience seems natural [4], such as prompts, flashing or shining lights, text boards, etc. The students didn't show much interest in the training mode, just in the evaluation mode. This can be explained by the lack of time because in just on training session they would be evaluated.

The third aspect learned from the project was the need for early instructional and evaluative planning. Delaying evaluation resulted in its disconnection from the instructional part. It is recommended, instead, that the training stage on “what will be taught” be developed in parallel with the “how to evaluate if the student has learned” stage.

Finally, as a fourth aspect, we highlight the team recommended for analog projects, which should be composed of a project manager who has experience in the area, a game designer to plan the solution, at least two developers, one 3D artist and, when a client test is not viable, a playtesting team. The authors need highlight the importance of a professional to be responsible of the training content. This professional must be present in all project to answer the questions.

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