Making welding simulators effective

Introduction

Simulation based training had its inception back in the 1920s. The aviation field adopted this innovation in education when confronted with an increased demand in the number of trained pilots.

Although there are many similarities between welding and aviation with respect to the process and the challenges of building technical knowledge, welding simulators do not benefit from the same popularity as flight simulators do.

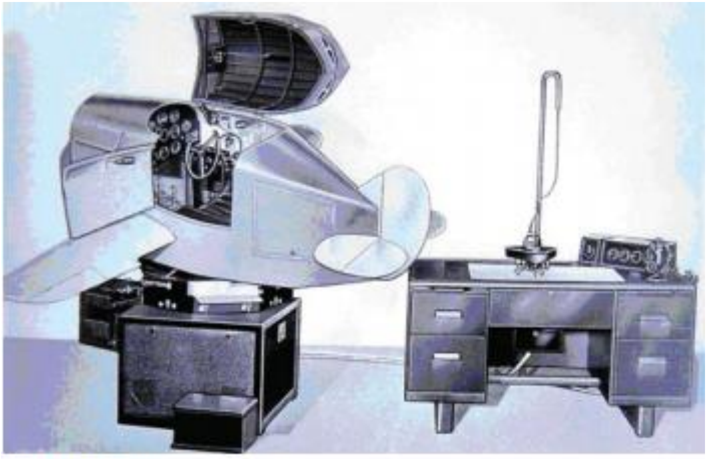
The present paper discusses the effectiveness of welding simulators as a training tool and the significant improvements that user-centred build simulators might bring to students, educational centres and industry.

A comparison with aviation training

Flight simulation has evolved to become an essential component of civil aviation operations and military capability. International standards ensure regulation of flight simulation facilities. Flight simulation has radically changed flight training and is now an established discipline in aerospace.

Link Trainer was the forerunner of synthetic training devices. Developed in USA in the late 1920s and used during the Second World War, it provided over a half a million pilots with essential training in instrument flying.

Nowadays, such a device would be a part-task trainer to Flight Simulator Training Device (FSTD) as it was optimized for a specific set of training tasks, eliminating time that would be otherwise spent in an aircraft (or, nowadays, in full flight simulator).



Link trainer and plotting table.

An FSTD.

Modern full flight simulators replicate aircraft handling characteristics with a high level of fidelity and offer a way to accelerate pilot experience which can be much more effective than airborne training. Severe weather conditions, for example, can be easily recreated in a simulation environment.

The evolution of flight simulators as well as the current status of simulators in aviation training, brings 3 relevant point to attention:

Zero flying hours concept. With processes and sub-processes being largely available for reproduction in a simulated environment, the concept of zero flying hours is no longer an exception, but has rather become

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the norm. In 1998, Herb Lacy, top of class graduate as a pilot, was accepted into Navy flight training, even though he never had flown a plane. Many of the other students had taken flight classes, and some were even certified pilots. He trained using Flight Simulator.

Low fidelity synthetic devices are accepted as highly effective.

Simulation-based training is seen as better quality than real airborne training especially in areas such as military where scenarios involving multiple forces and electronic warfare cannot be practiced in the aircraft in the time of peace.

<u>Welding simulation and flight simulation training</u>

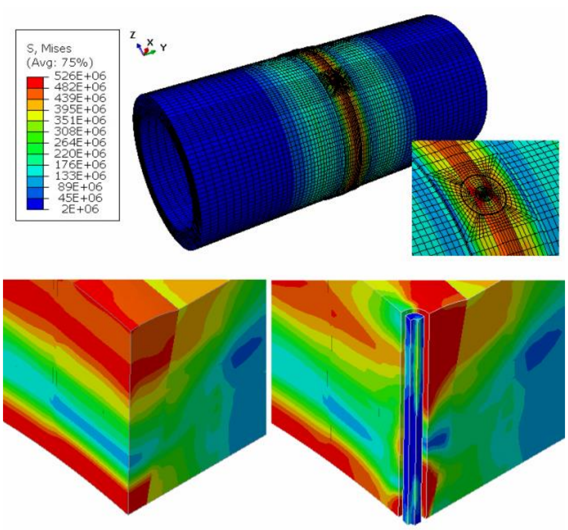
Welding and piloting have a set of common features. Both processes imply tight physical – psychological coordination. Flying a plane or doing a weld demands physical reaction as much as they require judgement and intellectual activity. Some abilities, like the speed of reaction and the hand – eye coordination become crucial for the impact and quality of output.

Both disciplines assume very good knowledge and understanding of tools and process before actual practice, and require a high number of hours of exercise to build a good professional. Pilot trainers assert that students, by the time they start practice on a real aircraft, ideally should have a good basic understanding of the goals of a particular lesson. In the airplane, they should practice and refine skills that they already understand, at least at a fundamental level.

<u>Welding simulators in education</u>

However, welding simulators do not enjoy the same popularity as flight simulators. The main reason might be the fact that these simulators have been used for research purposes rather than as a training tool.

Welding simulator software outputs mainly come in the form of complex graphic representation of data as shown in Figure 1. Some very thorough interpretation might be required to reach a conclusion and this feature makes the simulator in its present form less likely to be useful in a training environment.



Currently, in India, 20 doctoral theses and 50 post-graduate annually theses are aimed at bringing significant improvement to the professional life of welding practitioners. However, there is an estimated requirement for 3.2 million welders by 2022 with an estimated talent gap of 2.2 million welders. Therefore, the effectiveness of academic research in practice becomes questionable as there are hardly welding professionals to benefit from the value of all the research.

<u>Why accept simulators as learning tools?</u>

Emotional and cognitive learning. Medical research shows that positive emotions stimulate neuron connections, therefore introducing the concept that learning as an activity might be much more efficient and effective if pursued into a positive state of mind and through an enjoyable experience.

Leverage of technology and motivation through the power of instant feedback and progress tracking. Computer interactive technology had its inception in the mathematics field as a response to students' failing to understand the syllabus taught in class. Brian Butterworth and Anna Bevan, from the Institute of Cognitive Neuroscience at the University College London in their research "Understanding and Emotions in Mathematics Learning" present the results of a study conducted to discover what causes students to fail in the mathematics class. Responses revealed that one-time occurrence of lack of content understanding creates further gaps in knowledge which are difficult to compensate for in the future. Students begin to feel left out therefore less and less positive about their learning process.

Adaptive e-learning programs came to break the vicious cycle. Designed in levels and providing constant feedback, e-learning programs deal better with the issue of lagging behind in class, through positive reinforcement of achievement. Students get to practice at their own pace, focus on the subject well and enjoy the experience of becoming successful with their tasks.

At McGill University's Schulich School of Music in Montreal, Canada, music students can take a seat with the Open Orchestra system—an elaborate simulator able to recreate a full orchestra, jazz combo or accompaniment for an opera singer.

Via high-definition screens providing a panoramic view of virtual musicians, students can endlessly practice in full surround sound, gaining the rare and otherwise very expensive experience of playing with a full complement of professional musicians.

These are just 2 examples of how simulation of a real-life scenario accompanied by feedback and progress-tracking enable skill enhancement through positive student experience.

Teaching theory while not in an aircraft / emergency room. In areas like medicine and aviation, practicing in real life is subject to important security and ethical restrictions, which makes simulators a great catalyst of the learning process.

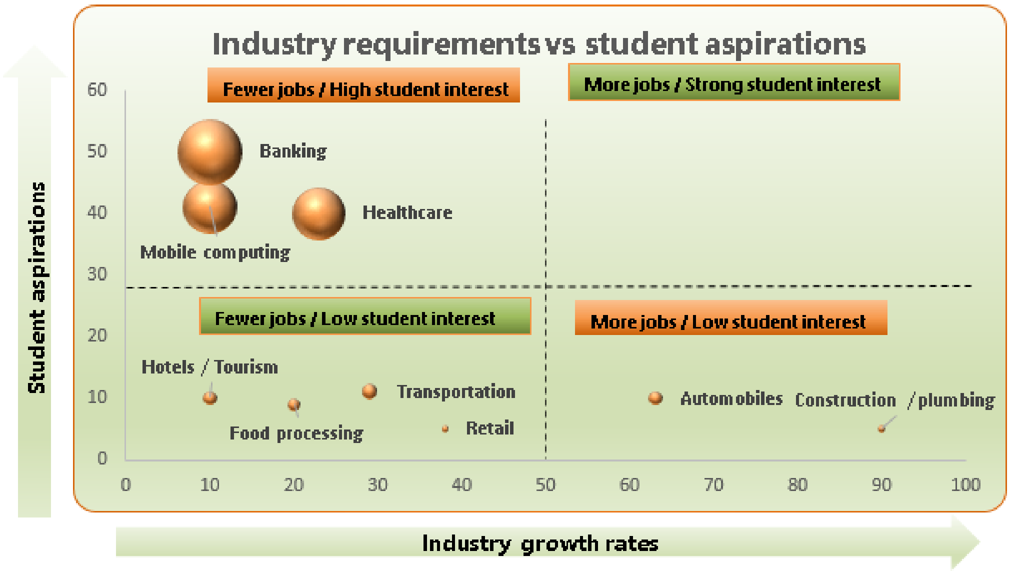
Allowing work on one concept at a time. An airplane cockpit can make for a terrible classroom, especially when the pilot is just trying to learn a new concept or skill. Flight simulators specialize in simple standard procedures, such as starting and stopping an engine, thus enabling quick progress to piloting a real aircraft.

With these reasons in mind, it might be time for the industry and education centres to look at welding as an enjoyable learning process. But what would the main motivation triggering this behaviour be?

Industry requirements and student aspiration mismatch

A research conducted by the Centre of Advanced Study of India at the University of Pennsylvania aimed at investigating student awareness, interests and aspirations around general and vocational education reveals that there is currently a significant mismatch between student aspirations and the skill requirements of the Indian industry. Almost 50% of the students that specified a career of choice said they would like to work in sectors other than those specified as high growth by the National Skill Development Commission. This is because they do not associate working in these areas with a career path that they aspire to follow. Students may not recognize that these sectors generate employment opportunities that require skilled workers with specific competencies.

Figure 1



As a next step, innovative ways to market high growth sectors need to be undertaken in order to generate awareness and to make them more attractive and interesting for students.

Making welding aspirational

A right combination of building awareness, making the learning progress more enjoyable and bringing high-tech tools to train welders might become a good solution for what appears to be an image problem.

Bringing in elements of "serious gaming" such as interactivity, performance scoring and live feedback will keep the students engaged in the learning process, therefore enabling them to practice for extended hours.

Practical examples, wherein welding courses that did not have sufficient audience for their programs reported significant improvement in attendance after presenting a welding simulator as a learning tool, showcase that student engagement can be highly influenced by the technology used during classes.

Addressing the target audience

Designing educational programs based on an audience-centred approach is the very basic feature of any training program. And, this applies to teaching welding as well.

It is important to acknowledge the striking difference between the objectives, features and target audience in the case of simulators operated for research purposes and those used for training purposes. In this sense, there is a huge gap in terms of knowledge and skills between the users of research simulators and the training simulator as highlighted in Figure 2.

Figure 2

Category	Advanced Research Simulator	Training Simulator
Objective	Develop new advances in welding tech	Train entry level welders
Features	Highly mathematical models, high fidelity	Training effectiveness in basic skills
Target Audience	Researchers, post graduates	High School dropouts, vocational training institute students

Best practices for welding simulator

In designing a simulator for training purposes, simplicity might be the most important feature.

Some features of simulators that are available in the market might actually be counterproductive to the learning process as described in Figure 1.

A training simulator that serves its purpose should ideally focus on fundamentals. Statistically speaking, these cause 85% of the errors. At the same time, a graded approach is highly required to teach one skill at a time.

If the design isn't simple enough, trainees might struggle with a learning curve for the simulator itself. An ideal simulator should not require more than half an hour to understand so as to allow the learners as many hours as possible to practicing welding.

Last, but not least, a welding simulator should enable correlation between weld quality and welding skills.

Measuring effectiveness of welding simulators in training

There are many research papers recommending the use of welding simulators. However, they were mostly conducted in a research laboratory environment rather than on the production floor.

There is a high need for more robust research, preferably using control groups, to study the correlation between the usage of simulator and potential decrease in post-welding correction operations (such as grinding). Questions like "Have grinding corrections been reduced from 1 operator for every welder to 1 operator for every 6 welders?" and "What is reduction in occurrence of spatters?" need to be answered and supported by substantive data gathered at shop floor level in order to build further credibility of the welding simulator as an educational tool.

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Skillveri is a start-up incubated at the Rural Technology & Business Incubator (RTBI) of Indian Institute of Technology, Madras (IIT-M), engaged in building technology based products & solutions to help address the skill gap and increase employability. Skillveri has done field research and focus group studies in the field of practical training in Welding and other vocational skills, and has built the most successful and effective MIG Welding training simulator.

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