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Bridging the Gap between Industry and Academia - The Essence of Virtual Reality in Skills Development and Learning Factories

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Abstract

The need for a competent skilled workforce continues to grow as the world advances in technology. Normal training methods that require trainees to be present on-site during training sessions may, in some instances, be detrimental to the health of the trainer and trainee. Learning factories were developed to bridge the gap between university or college graduates and industry in a real live atmosphere. However, the Covid-19 era has ushered in a new dimension that forces companies and institutions of higher learning to develop appropriate environments for skilling the qualified but unskilled labour force. This research looks at the development of learning factories using virtual reality as a solution for future training and skilling requirements. A training programme targeting a lathe machine tool is explored and developed to demonstrate the applicability of virtual reality in learning factories. The development explored the application of virtual technologies such as augmented reality, virtual reality, and mixed reality to develop a user-friendly training programme.

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Keywords: Learning factory; Virtual reality; skills development; Training

1. Introduction

There has been a noticeable rapid expansion of tertiary-level education across many countries. The focus of such expansions is boosting the skilled labour force [1]. A skilled workforce and skills development are vital cogs for the success of an organisation considering that the human resource is the most basic developmental element of an organisation [2]. There is an inherent mismatch between industry and training institutions where graduates leave institutions of higher learning without the working skills required by industry. This is largely so when new graduate employees have to spend time learning the skills instead of being productive. The mismatch can be addressed through the provision of appropriate training environments. Learning factories were thus developed to answer this call, hence eliminating the mismatch. Reconfigurable learning factories create a conducive environment for skilling to satisfy industry through changeability enablers that respond quickly to changes in technology, markets; and future skills requirements [3]. This paper looks at the development of learning factories using virtual reality as a solution for future training and skilling requirements. The virtual reality platform can be reconfigured to meet changing requirements in learning factories and other training institutions. Several training methods are used in learning factories.

2. Training methods

Training has largely been conducted through face-to-face methods but using different approaches. Some of the methods used are, teacher-centred, where students get information from the teacher without having their engagement level with the subject being taught; student-centred, which is rather a concept of discovery learning, where students develop flexible student-centred methods to enhance their active learning; teacher-student interactive method, where both above methods are used [4]. The current trends, however, are using the internet.

Research shows that there has been a massive increase in online learning, commonly referred to as E-learning [5]. E-learning is the use of the Internet or other digital means for educational purposes that fully utilises modern educational technology to offer a fresh means of communication and a resource-rich learning environment to achieve a new method of learning [6]. Internet technology is, therefore, setting the stage that changes the way education and knowledge transfer are to be conducted [7]. Web-based training has grown in recent years to become a standard e-learning platform that can be delivered to learners live or on-demand [8]. Internet (online) technology provides a highly effective method of student teaching and employee training, especially on complex topics [9]. To overcome the limits of classroom-based training, a blended format was created that combines several teaching modalities and personalized information while maintaining face-to-face interaction [10]. Blended learning (BL) permits the customisation of the learning process by utilizing several physical and virtual reality learning, teaching, and research modalities [11].

2.1 Virtual reality (VR) and Augmented Reality (AR)

Virtual reality (VR), also known as immersive multimedia or computer-simulated reality, is a simulation of a physical presence in locations in the actual world or an imagined world that enables users to interact in that world [12]. Thus, it can be said that generally speaking, virtual reality (VR) is the computer-generated simulation of a 3D environment that, to the person experiencing it, feels incredibly genuine. VR is employed in training, teaching, and other fields. Studies in this subject indicate that training in simulated settings can take the place of real-world practice sessions [13]. When training in actual surroundings is not possible owing to risk or expense, this is highly helpful [13]. In addition, there is a different technology called Augmented Reality (AR), which is rather different from VR. The distinction between the two is that whereas VR provides a simulated environment to dwell in, AR simulates artificial items in the real environment. There are four types of VR and AR technologies: immersive VR, non-immersive VR, augmented reality, and mixed reality [14]. Fig 1 depicts the two used glasses. After training in theoretical learning environments, participants in VR have the opportunity to learn through transfer-oriented action activities in virtual space [15]. Thus, the link between industry and higher educational institutions forms a basis for developing learning factories that address both institutions.

Fig.1. Virtual Reality vs Augmented Reality

3. Universities and Industry link

Collaboration between academia and industry is essential for the expansion, improvement, and growth of the economy. While the industry is a sector that transforms information and technology into innovative products, academia is a repository of knowledge and invention [16]. The partnership between any divisions of the higher education system and industry with the primary goal of promoting knowledge, technology exchange, and transfer as one of the pillars of economic development is known as industry-university interaction [17]. Information transfer improves an economy's competitiveness at the national and regional levels [18]. Multinational corporations (MNCs) have turned to the internationalization of their R&D programs in response to the rise of high globalisation and fierce market competition to gain new information from various sources and compete globally [18]. Rapid technological change, shorter product life cycles, and fierce global rivalry are the viability challenges that the industry is currently facing. These factors have drastically changed the existing competitive climate for most organizations [17]. Universities, on the other hand, must find alternate funding sources, such as forming partnerships with businesses, to continue to be at the forefront of all subject fields due to challenges including the creation of new information, rising costs, and financial issues [19]. Kaklauskas et al. [20] looked at the collaboration's three main phases: formation (partner identification, contact, assessment, negotiation, and agreement signing), organizational forms (third parties, targeted and untargeted formal agreements, focused structures, and informal and formal personal relationships), and operational phase activities (meetings, communication, training, personal mobility, employment, other activities). A university-industry-higher education collaboration council (UIHCC) was established in Malaysia to improve government-university-industry cooperation for the benefit of graduate students, industries, and universities [21]. Examples of university/student industrial links include placement, staff exchanges, and more sophisticated collaborations like business and technology incubators, and industry-sponsored projects. Research and development (R&D), curriculum creation, and consulting are additional forms of collaboration. Industry may fund a university chair in a particular field of interest or commission a particular research initiative. Universities encourage technology transfer to the productive sector through prototype development, technology incubation, the creation of spin-off businesses for commercialisation, in licensing/out licencing arrangements and royalty agreements [22].

4. University Graduates Vis a Vis Industry Needs

Tradition has it that higher education institutions are places where new information is created and where a skilled labour force is generated. They are considered centres of excellence that offer venues for discoveries destined to raise societal standings. The difficulty, though, is that higher education institutions' management, professors, researchers, and students must all work together in novel ways to produce technological, economic, and social innovation [23]. In the eyes of employers, to be employable, university graduates must display certain attributes. The traditional definition of graduate employability has frequently emphasized developing the knowledge, abilities, characteristics, and behaviours that employer's value. These include the ability to carry out assigned tasks without supervision, flexibility, critical thinking, time management, willingness to learn (learning skills) leadership skills, teamwork, communication skills, organizing, and planning and conflict management, among others [24]. The drive to create a knowledgeable society has resulted in the creation of more universities, and this has come with its own challenges. In Taiwan for instance, the dramatic expansion of the number of higher educational institutions has in a way contributed a great deal to the growing unemployment rate of university graduates [25]. Similarly, the accumulated number of students who graduated in previous years and failed to find a job makes the pressure of finding a job keep growing each year. Technological changes have seen employer expectations change in line with emerging industrial trends [26]. Hence, in many areas employers argue that they are struggling to find qualified job candidates from university graduates [24]. This brings a question of the readiness of university graduates to be engaged in industry and offer meaningful contributions. The argument is that most of today's university graduates possess the knowledge and skills necessary for career success but lack the practical aptitude to start meaningful contributions to organisation they are employed in. In most cases, graduates undergo graduate traineeship in an effort to close the gap. The importance of graduate traineeship is that it acts as a bridge between university and in industry, a function that learning factories were designed to perform. Coupled with graduate traineeship is talent management. Talent management matches the right people with the correct skills, knowledge, and experience at the right time based on strategic business objectives of an organisation [27]. A comparison of graduate traineeship and talent management was developed as shown in Table 1 below. The last column indicates the effects of the graduate trainee management system (GTM) System

Table 1. Comparison of graduate traineeship and talent management (Modified from 27).

	Critical	Selection	Development	Reward	GTM System
Talent management	Ability to source and retain talent	Based on nature of required skills	Organisations need to develop appropriate talent through skills learned	Reward based on talent, skill, proficiency and value brought by an individual	Talent to meet new trends and technological challenges
Graduate trainee programmes	Formal work based learning that enhances training and development experience to attain work related skills	Flexible training for institutions of higher learning that prepare graduates for industry	Can be a driver for a graduate to obtain key technical skills in preparation for work place suitability	Guaranteed knowledge and experience to take up industry challenges and better remuneration	Gives organisations a competitive edge

In a study of university graduates and employer needs, it was found that while most employers are unsatisfied with the abilities of their graduate recruits, some employers were happy in a few specific areas [28]. Additionally, it was revealed that half of companies think that their graduate recruits contribute significantly more value than their non-graduate employees [28]. The study also showed that changing teaching practices could address the issue. This could be accomplished by delivering instruction in intimate, interactive classroom settings as opposed to impersonal, large lecture halls, and by using problem-solving techniques that are practical rather than theoretical. In some European nations, responses within the higher education system to the skills gap between university graduates and industry have included a gradual introduction of a competence-based learning model, which is intended to boost graduate employability and raise the levels of worker qualification and expertise required [29]. It becomes clear that a deliberate move towards building a bridge between the university and industry be undertaken to close the mismatch that is existing so that industry-ready graduates can be produced. As has been examined above, the greatest challenge with university graduates is employability. The lingering question on this is “What is employability?” On this front, in Zimbabwe Education 5.0 has been developed to change the thrust of university training, which largely was focused on employability. Education 5.0 changes the focus from the traditional Education 3.0 which looked at three pillars, namely, research, teaching and community service, to Education 5.0 which focuses on five pillars which are research, teaching, community service, innovation, and industrialisation (Ministry of Higher and Tertiary Education, Science and Technology Development, 2018) as cited by [30]. Education 5.0 emphasises industry ready students who develop new products and thus eliminates the need for retraining in learning factories. It provides a platform for producing graduates ready for industry.

Employability skills may be developed through various student learning opportunities and activities that are a part of the higher education experience, such as independent study, participation in lectures, attending specialised career-advising workshops, or taking part in work-integrated learning programs [31]. Employability is described as a collection of achievements, talents, understandings, and personal traits that increase graduates' chances of finding employment and succeeding in their chosen professions, benefiting themselves, the workforce, the community and the economy [33].

5. Learning Factories

Learning factories are facilities created as realistic training grounds for manufacturing-related education and training. Different definitions of the phrase "Learning Factory" were put forth, and the following definitions have been presented. A learning factory is described as an idealised representation of the parts of the value chain industry where informal, non-formal, and formal learning take place [34]. In a limited sense, it is a learning environment defined by authentic processes, multiple stations, organisational and technical aspects, a flexible environment that resembles a real value chain, a physical product being manufactured, and a didactic concept that includes formal, informal, and non-formal learning and is made possible by the trainees' own actions in an on-site learning approach [35]. A learning factory brings the real manufacturing world into the educational setting by giving engineering students practical hands-on experience of real-life projects through beneficial learning and training in a real practical setting [36]. Because a learning factory is an accurate depiction of a production system, students have the chance to put study findings about process improvement and other activities into practice while simultaneously watching the results. Depending on the purpose of the learning factory, learning takes place through teaching, training and/or research, with learning outcomes being competency development and/or innovation. A learning factory merges a practice-based curriculum and sophisticated production capabilities that provide an engineering educational experience, which highlights the interdependency of design and manufacturing in a commercial setting [35]. The Learning Factory offers a new approach to engineering education by providing a balance between engineering science and practice. The key element in this approach is the combination of curriculum revitalisation with coordinated opportunities for application and hands-on experience.

6. Learning Factories Training using Virtual Reality (VR)

An application of VR was used as a test case to develop a training programme for using a lathe machine. The programme was developed in the form of a training module for students during their training sessions. A minimum of 4 groups run different modules at once performing different operations on the lathe. For instance, one group runs a module on tapper turning, another group on step and parallel turning, another on screw cutting, etc. These groups rotate to be familiar with all operations. The semi-immersive system is made of a content creation module and a game engine, virtual objects are created in a blender, then imported into the game engine. The Unity module engine handles the inputs from the content creation module and the user, it also has a graphic user interface system to ensure that the user can clearly interact with the module. The scene manager responsible for graphical rendering and audio rendering makes the training module more realistic and makes it possible to come up with different animations.

The training module mimics the real live training on the use of a lathe machine and can be played strictly on the set conditions which results in a student understanding how to operate and use a lathe machine. The programme trains a student to switch the machine on and off, chuck rotation, longitudinal/crossfeed operations on the Virtual Lathe Machine. Figs 3 and 4 show different movements that a lathe operator needs to know and execute.

Virtual reality in learning factories provides solutions required in training between education, industry, and innovation growth. Any area of choice can be targeted for training to ensure that green students from institutions of higher learning are industry-ready. From an academic’s point of view, learning factories will contribute substantially to the continuous supply of relevant graduate engineering students. They continuously upgrade and update the intellectual capital of the industry’s workforce as well as initiate research that benefits the industry.

Fig 2 demonstrates the General Architecture of the System.

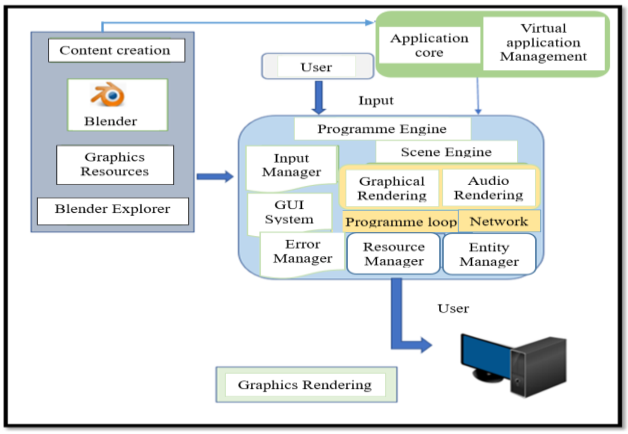

Fig. 2. General Architecture of the System

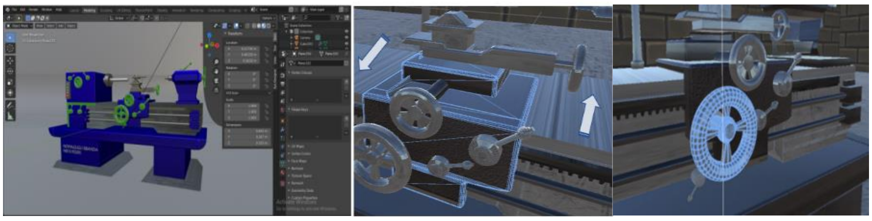

Fig. 3. Lathe Machine 3D Model Developed in Blender Cross-Feed and longitudinal Feed for the lathe machine

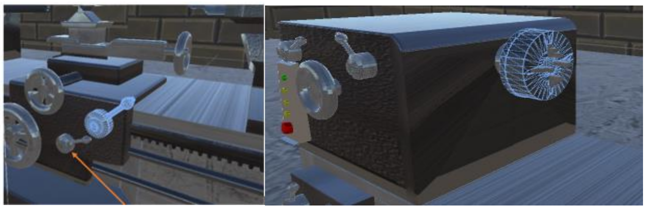

Fig. 4. Lever for Chuck Rotation; Chuck, Speed Selector, On and Off Buttons

7. Discussion

A competent skilled workforce is a vital asset for an organisation to continue to grow. Due to the mismatch between industry and institutions of higher learning, learning factories were developed to bridge this gap by providing a realistic factory environment. Learning factories provide a teaching, training, and research environment where trainees perform actions within a real live value process of a physical product. In blended/hybrid learning, learning factories benefit from e-learning platforms as they make use of the Internet and other digital means. This summarily presents the advantages of both the physical and the virtual environments. Virtual reality application in learning factories presents a live playing field for the trainees. In some cases, dangerous machines or conditions may not be conducive for face-to-face engagements. Thus, the need to use virtual reality platforms/tools as an integral part of a learning factory. Education 5.0 emphasizes the hands-on approach to the education systems in terms of product and service development. This approach empowers trainees or students to be fully and practically conversant with industry operations such as entrepreneurship, operations, technology, sales/marketing, finance, and administration, which are skills that are practically trained in a learning factory, among others. Learning factories bridge the gap between industry and academia by virtue of the kind of training and skilling they offer to graduates. The introduction of VR empowers those that may not have all the equipment required for training purposes, among other reasons.

8. Conclusion

The paper presented a training programme for a lathe machine, referred to as a game. This programme is played interactively by individual groups during training sessions. It mimics the live lathe operation in a live manufacturing environment with participants seeing their inputs through the responses of the machine. The training is not limited to one aspect but can be used for other training needs as skills requirements in the learning factory dictate. The example of a lathe machine indicates the possibility of empowering learning factories with virtual reality platforms where there is a possible limitation of resources. Learning factories stand to benefit from the digital factory-based VR platform for training.

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